UNDERSTANDING TEACHER REFLECTION AS A SIGNIFICANT TOOL FOR BRINGING REFORM-BASED TEACHING TO COLLEGE MATHEMATICS

K. JEON
Institute for Mathematics and Science Education
University of Illinois at Chicago
Chicago, IL 60607
kjeon72@hotmail.com

Abstract

This paper describes a senior mathematics professor's effort to change his teaching practice in a mathematical analysis course for secondary pre-service teachers in alignment with the current reform movement. Data include semester-long observations and interviews with the professor and his students. The data were analyzed by the use of reflection as the most significant tool for examining his experience of bringing about change. The reflection was used as a bridge from theory to practice by serving as a significant point for the professor to experience the process of professional development in a real sense. Discussions include the role of teacher reflection, teacher beliefs about good teaching and their manifestation in practice, the role of students in a reform-based classroom and the professor's effort for changing pedagogy of the mathematics course and his search for continuing the effort. The researcher includes her own reflection of the processes of understanding the change process. Her views on inconsistency between the professor's beliefs and his practice, the role of reflection as a hallmark of professionalism, and the importance of environment and support for the change to be sustainable are addressed.

Introduction

As a teacher myself, I have always struggled to understand what it means to teach. As a mathematics teacher educator, I have struggled to understand how teachers understand their teaching and how they improve teaching practice. Fundamentally, I always wonder what constitutes good teaching practice? And how can I learn and teach it that way? The work by Lampert and Ball on their own studies of teaching and learning for elementary pre-service teachers clearly illustrates that learning to teach was a function of practice and experience [1]. I also realized that even to these expert teachers, teaching to practice was a complex matter. In fact, my inquiry about teaching has provided me with more unresolved questions rather than answers. As a member of a research and evaluation team, I had the opportunity to study other faculty members' teaching practices. Sometimes, I was a one-time visitor and came back with much mixed thinking about teaching as practice. Other times I did an in-depth case study thanks to

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collaboration efforts with faculty. One could easily imagine how challenging it might have been to study about teaching practice, especially someone else's. This paper is about the teaching practice of a senior mathematician, Professor L, under reform. The emphasis will be on what a journey of change looked like.

Among many faculty members that I visited, Professor L was one of the most impressive teachers that I have met. Not only did he have 39 years of teaching experience, but he was also aware of the need for change in teaching practice at the university level. While writing this reflection paper about my work with Professor L, I came to a thought that teaching must be a journey of many different routes. This relates to what Fullan points out: change is a journey, not a blueprint [2]. The journey that I witnessed in Professor L's classroom for a semester was nonlinear and it was loaded with uncertainty and excitement. I express my deepest thanks to Professor L, who spent an enormous amount of time with me talking about his day-by-day lessons, plans and changes, his thinking about student learning, his observations and thoughts about his classroom teaching.

What follows is an attempt to organize my understanding about Professor L's teaching practice represented by reflection. The word "reflection" is understood as Grant interprets John Dewey's work [3]. In the early part of this century, John Dewey made an important distinction between human action that is reflective and that which is routine. According to Dewey, routine action is behavior that is guided by impulse, tradition, and authority. He defines reflective action, on the other hand, as behavior which involves active, persistent, and careful consideration of any belief or practice in light of the grounds that support it and the further consequences to which it leads. According to Dewey, reflection involves a way of meeting and responding to problems [3]. Based on this definition of reflection, discussions will include many issues like the role of teacher reflection, teacher beliefs about good teaching and their manifestation in practice, the role of students in a reform-based classroom and a senior professor's effort for changing pedagogy of a mathematics course, as well as his search for continuing the effort, through the eyes of a researcher, with the inclusion of her own understanding and those of his students.

Professor L's Change Project

I first met Professor L in the fall of 2001. At that time, he was planning to launch a change project for his teaching practice of a mathematical analysis course for 21 secondary pre-service teachers for the semester. In the summer of 2001, he had participated in a series of

professional development activities. His plan included mathematical activities that would develop qualitative properties of functions. His plan was originally to work with one unit about function concepts. However, it was expanded to pursue a semester-long effort to change his teaching practice for a broader theme, "curricular and instructional improvement in calculus focusing on oral and written communication of mathematics and numerical methods." I became a regular member of his class for the entire semester as a participant observer, and Professor L regularly visited me more than twice a week during the semester.

In my initial conversations with him, Professor L described himself as a typical mathematician who taught mathematics courses for college students. He said that this was going to be a challenge for him because he used to be quite a conservative teacher in the past. I found the opportunity extremely valuable. I was aware of the kind of limitation that William Kyle, Jr. mentioned about an unfortunate dearth of teacher education research at the college level in comparison to much effort on educators' understanding of teaching and learning in K-12 learners [4]. Anderson and Mitchener also described that the big advances in understanding about student learning have not been matched by equivalent advances in understanding about teaching [5]. Due to Professor L's recognition of the importance of reform-based mathematics teaching in the college classroom for the well-being of the mathematics community, I found myself in the middle of a unique setting for observing university mathematics teaching.

Being critical about his past way of teaching that he called "theorem-proof," he initiated a new way of teaching that he named, "qualitative understanding." He strongly believed that in the past, his teaching was not necessarily focusing on conceptual understanding of the mathematical content. He speculated that there existed qualitatively different ways of teaching the same contents. Over the semester, I often found Professor L struggling to find his next steps for teaching the course. For example, one day after doing an activity-based lesson using a beaker problem from the professional development activities, he wondered what would be the best way to evaluate students' learning. He believed that the conventional methods of evaluation would not work, but he had not thought of new methods yet. He did not know which problems would be good to assess the qualitatively different learning that he expected his students to experience. In the meantime, I found Professor L becoming more reflective because he recognized a need for an alternative to the traditional assessment method. He was not guided by tradition. Instead, he took a careful consideration of alternatives in light of the grounds that support his goal for teaching for

qualitative understanding. Later, he came back to me with his plan to give the students an essay question. This was the first time that he asked his students to write about mathematics.

His world of teaching required a constant interplay between constraint and choice. As a result, the position was taken that it was necessary for Professor L to be reflective. He took our conversations related to his questions to his rethinking and reshaping process and then brought it out to his practice in the classroom. I, as well, needed to reflect on what he said that actually went on in his mind so that I came to understand the process of his reshaping and its manifestation in practice. The following are examples of the kinds of change that Professor L made from my point of view. These changes are the results of the process of rethinking, reshaping, and manifestation in practice that he tried to communicate with me.

- *Instruction and assessment influenced by student responses:* Designing tentative exams, he modified them based on his understanding of students and the course. He thought hard on how to design activities for the other topics in his syllabus. He and his students started using the word assessment rather than exam and there was a shared feeling for the use of the word.
- *Utilizing collegial network to look for ideas and insights:* He realized the need for technological help, such as a visual presenter, for the first time in his teaching and sought assistance. He also needed more resources, especially mathematical activities that he might consider using in the later part of the course. He then went to other faculty members in the university who were experts in these areas.
- *Becoming flexible with the course syllabus and content:* I often heard him say, "Everything I am doing is building up." He was not constrained by the syllabus. Rather, he redefined the syllabus not as a collection of chapters to cover, but as teaching for conceptual understanding.
- *Changing his implicit theory on students' learning of mathematics:* The change happened from not seriously thinking about how students might learn mathematics to thinking deeply about the difference in the way students learned mathematics. As a result, he tried to listen to students. He realized that students learned mathematical concepts in a different way than a mathematician might learn. Therefore, they might take a different route for understanding some concepts that would not look reasonable to the mathematician's eye. The more he listened to the students, the more he heard from them in and outside of the classroom.

- *Facing challenges with assessment:* Assessment was an unresolved matter even though he tried many new ways of assessing the students. While emphasizing conceptual understanding, he noticed that his students did not do well on the formal definition part of the final exam. He was concerned about the result and wondered whether he balanced the two, conceptual understanding and formal aspect of mathematics learning, in his words. Professor L's plan for the following year is to pursue the balance although he does not know exactly how he will be able to achieve it.

Once Jalongo suggested that educators' stories about teaching and their reflections upon them are a deceptively simple way of addressing significant issues about what it means to teach and learn [6]. His suggestion was, needless to say, applicable to both Professor L and me. I found reflection was the most significant tool for Professor L so that he could continuously keep motivating himself to pursue his change project successfully. Reflection was being utilized by Professor L because he wanted to bring change. Professor L and I both understood reflection in the way John Dewey described it: reflection as a way of meeting and responding to problems by making active, persistent, and careful consideration of belief and practice, and the further consequences [7]. The opportunity for reflecting on teaching experience was significant enough to shape a teacher's belief system that affects teaching and learning [8]. As reflection allowed him to perceive his practice as problematic, initiation of reflection became easier for him. The reflection provided a link between his daily teaching practice and the development of his ability to reflect on his teaching. Most of all, this method of reflection addressed Professor L's personal experiences as a teacher and their influence on shaping his beliefs about good teaching practice.

Very often, reflection resulted in more and deeper questions. Professor L often started out talking about a topic that he felt comfortable to talk about with me. Then, he came up with a connection to another topic that turned out to be the "real" issue to him in implementing his change project. He discussed how he could design problems for the midterm assessment so that he could really assess the students' qualitative understanding of the function concepts rather than asking them to do theorems and proofs. While he often engaged me in discussions on various issues in teaching and learning, he sometimes ended the discussion without making a specific decision. After spending more time on reflecting on those issues, he always came back to me with, he believed, exciting plans for further steps for the course. After reflecting on his teaching for several weeks, for example, he said, "My mind is developing."

As Fang pointed out about teachers, Professor L also started possessing his own theoretical orientations that organize and trigger his instructional behaviors over the semester [8]. For example, his theory that students learned mathematical concept *differently* than mathematicians was expanded to another theory that all of his students were learning in a different way. Naturally, he solicited for different approaches to an answer. With a problem for getting the area of a small pond that Professor L assigned as a project, he listened to eighteen different students who all gave different approaches to the problem. Professor L's reflection process was often used as a prompting moment when he became aware of conflicting aspects of his thinking and actions to be planned for the course. He realized that what he believed to be right for the students was not necessarily conveyed to them after paying more attention to his students' voices from the classroom, their homework, or their group discussions. His reflective action, however, kept him open to new choices that took into account students' views and understanding.

Changes in Professor L's Students

Professor L taught the students differently from other mathematics professors that they had. I heard the students frequently saying to him, "What do you want us to do?" especially in the beginning of the course. Almost all students seemed to feel that they needed a structure. Professor L tended to stop talking and wait for student thinking and responses. Yet, the students were trained to depend on professors for good grades and they did not know how to make sense of this new kind of setting where responsibilities for learning should be shared by both the teacher and themselves. As Canning mentioned, student teachers had a voice, but they had learned to withhold it [9]. Particularly in the beginning, the students had a contradictory view of a mathematics teacher. They described their past mathematics professors as masters of subject matter content knowledge who delivered information and partially decoded the information. Therefore, it was not the responsibility of the students to make connections and understand concepts while being in the classroom. However, when they were exposed to Professor L's teaching which emphasized thinking processes and conceptual understanding rather than memorization, they resisted. They often argued that they needed to be told what to study for on the exams, and they asked for clear definitions of concepts and specific steps for proving theorems.

His students, however, changed. After the midterm assessment, a student said, "I did not know what to expect. But it seems this professor has a good sense of coming up with good problems. They are not too easy, not too difficult... challenging enough." Another student said,

"It didn't test something like cramming, memorization. It really tested what I learned and understood. I think I will be able to write the same as I did today in a week." Those who felt the most uncomfortable about the fuzziness of their tests and assignments started capturing their expected roles in this teaching and learning process. They were finding out the importance of their responsibilities. They started actively asking questions in the classroom. Professor L's focus was mainly on teaching, not on students' learning. But once he started reflecting on his teaching, he began to incorporate students' learning into his reflection. This illustrates Rhine's argument about using students' thinking as a source for personal reflection as exemplified in Professor L's case [10].

My Reflection

What was my role for Professor L? I believe I tried to provide daily feedback on his teaching so that he was able to offer instruction which was consistent with his beliefs concerning good teaching practice. At the same time, I tried to understand how he could apply his beliefs and philosophies within the constraints imposed by the complexities of his classroom life. His thinking about his role as a teacher (a facilitator for students' active involvement in the process of teaching and learning) and the beliefs about the nature of mathematics (emphasizing conceptual understanding as well as doing theorem and proof), helped shape his pedagogical decisions. Professor L's implicit theories about students, the subjects they teach, and their teaching responsibilities influenced his reactions to students and their teaching practice [11]. As Canning suggested, Professor L found reflection an intra-personal experience leading to insight about himself as an actor in his world [9]. It prompted changes in self-concept, changes in perception of an event or a person(s), or plans for a change in some behavior.

Another important part of Professor L's journey of change was the issue of consistency between his professed beliefs in the dialogue with me and his teaching practice in the classroom. A study by Readence, Konopak and Wilson with elementary and secondary teachers on reading indicated that the relationship between beliefs and instructional practices varies from very consistent to very inconsistent [12]. This issue of consistency in Professor L's beliefs and practice became more complicated along the time line. In his class with the beaker problem, not only was his instruction found to be consistent with his beliefs about the nature of mathematics, but his interactions with the students were also coherent with his beliefs about mathematics learning.

But in the classes after the unit long project was over, it seemed Professor L's beliefs and his actual instructional practices lacked consistency. This inconsistency between beliefs and practice seemed to stem from two factors: assessment and resources. He did not have enough knowledge about assessing students in the way he designed his instructional change process. Also, he did not have enough mathematical activities that could support him in teaching the other concepts of mathematics, such as limits and formal proofs as he did for the function concepts. This inconsistency between Professor L's beliefs and his practice was not unexpected, but the problem for me as a researcher was that the inconsistency was happening in one person at different time points. A future study is being planned as an effort to better understand this issue of inconsistency with Professor L for this year when he will teach the same course.

It is notable that Professor L believed that the informal and qualitative aspects of learning mathematical concepts is important. He also believed that mathematical activities are a vehicle through which students construct meaning in a rich way. In many ways, it seemed that he was one of the reform-oriented mathematics teachers. On the other hand, he believed that the mastery of concepts, (i.e., theorem-proof) must be learned before the meaning of the concepts can be qualitatively understood by the students. Fang pointed out that the instructional techniques utilized in the classroom were not mutually exclusive. Asking people to choose one lesson plan as opposed to another imposes the researcher's categories on those who do not normally utilize them [8]. Therefore, the problem might have resided in me because I expected in some sense that Professor L's change process could be well shaped in a semester-long effort. Anyway, this issue of possessing two comparable perspectives along with the issue of inconsistency became critical to me in understanding the role of a teacher's beliefs and practice.

Regardless of the unanswered issues that I posed, this opportunity to work with Professor L, unlike many other studies on beliefs and practice in their separate way, captured what was actually done in the classroom rather than what should be done. And I reached at least one conclusion about the identity of a teacher: *A teacher is a reflective professional whose teaching practice develops in a profoundly different way when reflection becomes active.* A supporting argument comes from Schon's view on reflection not only as a way of thinking, but as a hallmark of being a professional [13]. The reflection process was a time intensive process both for the researcher and the professor. However, as Wenzlaff and Cummings suggested, the ability to think about what one does and why, and assessment of past actions, current situations, and intended outcomes, is vital to intelligent practice—practice that is reflective rather than routine [14]. The

method of reflection provided a bridge from theory to practice by serving as a beginning point for the mathematics professor himself to experience the process of professional development in a real sense.

As a researcher, I learned the importance of the environment and support for a university faculty member to learn to be reflective about his teaching and about his students' learning. During the reflective process, he became thoughtful so that he could reflect on his own professional thinking and continue as a lifelong learner. The reflective process served as an encouragement and structure for the change to happen in his teaching practice. Finally, reflection was an effective process for making Professor L's teaching a continuously evolving process. An implication of this study is that incorporating this teacher reflection process may be a way to provide university faculty members with a richer knowledge about the complex nature of teaching and possible methods for change and improvement in their practice. Once they have an understanding of the nature of teaching via reflection, then they may seek better ways to organize their practice and eventually to begin to change their practice. I, then, wonder whether the two of us have a shared meaning for the word *reflection*? Another plan for this year is for the two of us to communicate the meaning of reflection in a more visible way. I will consider adopting different ways of collecting classroom data other than my observations and interviews, such as videotaping the lessons. I also wonder about the role of interactions between Professor L and me in his process of change. Professor L and I spent a great amount of personal time outside of the classroom and this seems to be critical for him as opportunities for being more reflective and analytical about his practice. ■

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