CHANGE IN IN-SERVICE TEACHERS' DISCOURSE DURING PRACTICE-BASED PROFESSIONAL DEVELOPMENT IN UNIVERSITY

Hiroshi Iwasaki, Takeshi Miyakawa

Joetsu University of Education, Japan

This paper explores in-service mathematics teacher learning in a practice-based professional development program. Through an analysis of daily journals written by an in-service teacher during practicum, we try to identify changes in his discourse over the course of a two-year Professional Degree Program newly implemented in Japanese universities. We classify the teacher's daily reflections on observed mathematics lessons and/or on taught lessons into four categories according to the teacher knowledge: empirical discourse, practical discourse, quasi-theoretical discourse, and theoretical discourse. The analysis results show a considerable change in discourse between the first and the second year.

INTRODUCTION

The forms of professional development of in-service teachers in Japan vary from those facilitated through teaching practice such as lesson study (cf. Stigler & Hiebert, 1999, ch. 7) to those having no direct relation to classroom instruction, such as university mathematics courses. The most common form would be the one-day participation in a research lesson open to colleagues organised inside or outside teacher's own school (cf. Miyakawa & Winsløw, 2013). Another relatively common form especially for 'active' teachers is long-term professional development in a university setting. The teacher is detached from his/her own school for a certain amount of time—varying from half a year to two years—and often enrols in a graduate program to obtain a master's degree.

Teachers' professional development in university is often criticised as being removed from actual practice and, consequently, incapable of allowing participants to acquire practical knowledge or skills useful for teaching. This criticism led to the creation of a new graduate program for professional development in the faculties of education of several Japanese universities in 2008. The Ministry of Education is now conducting a reform to expand this program to all faculties of education for teacher training in some years. This program, the 'Professional Degree Program', is a two-year graduate program comparable to a master's program. Field practice is emphasized, and it includes long-term practicums. A master's thesis is not required for graduation.

This program was also created in our university, and the first author was involved in it as an educator. We think it works effectively to some extent for in-service teacher training. However, it is not obvious, from the mathematics education research perspective, what kinds of learning are realised and what kinds of knowledge are acquired in different forms of professional development. Characterisation of teacher knowledge and learning is a big issue in our research area (cf. Ball, Thames, &

2015. In Beswick, K.., Muir, T., & Wells, J. (Eds.). *Proceedings of 39th Psychology of Mathematics Education conference*, Vol. 3, pp. 89-96. Hobart, Australia: PME.

Phelps, 2008; Margolinas, Coulange, & Bessot, 2005; Steinbring, 1998). We are, as mathematics teacher educators and researchers, interested in the nature of teacher learning during practice-based professional development programs, specifically during the ones organised by our university, in order to clarify the role of university and researchers (educators) in teachers' professional development.

This paper explores the nature of in-service mathematics teacher learning through the analysis of a case in which, from an educator's viewpoint, an in-service mathematics teacher certainly acquired some knowledge or learned something during our university's two-year Professional Degree Program. From the daily journals kept by students noting their reflections on lessons observed and/or taught during practicum, we identify changes in discourse over the two years of the program.

FRAMEWORK FOR TEACHER KNOWLEDGE

In this paper, we explore the evolution of teacher knowledge through changes in discourse. We examine how teacher knowledge can be characterised, in particular the knowledge in daily journals, and propose a framework to categorise discourse.

Some researchers characterise teacher knowledge by explicitly taking into account mathematics teachers' activities inside and outside the classroom. Steinbring (1998) believes that a teacher's role is not to make subject matter knowledge comprehensible to students, but to understand students' construction of personal knowledge in context and create learning environments (pp. 158-159). Based on this idea, he proposes the notion of *epistemological knowledge of mathematics in social learning settings*, which is required for the above activities. Margolinas et al. (2005) call *didactic knowledge* teacher knowledge specific to the mathematics to be taught, and characterise it according to different levels of teachers' activities. They investigate *observational didactic knowledge*, which 'grows from the teacher's observation and reflection upon students' mathematical activity in the classroom' (p. 205). Miyakawa & Winsløw (2013) also take into account teachers' activities around 'open lesson' and identify teacher knowledge from the perspective of the Anthropological Theory of the Didactic.

In our study, as data, we have teacher's written reflections (discourse) on observed lessons and/or taught lessons. Observation is about not only students' mathematical activities, as in the case in Margolinas et al. (2005), but also someone's teaching activities. We believe, therefore, that the teacher knowledge explored in our data is *observational systemic knowledge* of the teaching and learning system in classroom.

As a way to characterise the evolution of teacher knowledge during practice-based professional development, we propose the following categories that classify teachers' discourse according to the knowledge behind observation: *Empirical discourse*; *Practical discourse*; *Quasi-theoretical discourse*; *Theoretical discourse*.

Empirical discourse denotes the most naïve description of teaching and learning activities in the classroom and their reflections, made without professional

knowledge of mathematics teaching. The latter three categories are for the discourse based on the professional knowledge of mathematics teachers. In Japan, mathematics teachers use some technical terms specific to mathematics teaching, which are not for students' use in the classroom. For example, 'measurement division' and 'partitive division' are technical terms for identifying different problem situations related to division. Similar terms have developed for the sake of communication among teachers, seen in teachers' national curriculum guides and textbook guides. These terms principally allow teachers to draw attention to significant facts—the nature of mathematical problems, teachers' acts, students' acts, etc.—in the complicated teaching and learning situation and apply some labels to them. We define *practical discourse*, including the above terms based on the practical knowledge mainly developed in teachers' community. We define *theoretical discourse* based on the theoretical knowledge or theory developed in mathematics education research to understand the mechanism of mathematics teaching and learning system. This distinction between practical and theoretical relies on the distinction proposed by Margolinas (1998) between *fact* and *phenomenon*. Theory is a coherent structure that provides a meaning to a *fact* that can be verified and transforms it into a *phenomenon* that can be produced by that theory and understood at the level of mechanism. Therefore criteria to distinguish theoretical discourse from practical discourse are the use of theoretical terms and the way one regards teaching and learning activities: as a fact or phenomenon. One may sometimes use theoretical terms just to label some isolated facts without taking into account the structure of theory. This is why we further dissociate *quasi-theoretical discourse* from theoretical discourse.

METHODOLOGY

We explain here the nature of the data first and then the analysis process. One Professional Degree Program year at our university consists of two semesters. The first semester is devoted to course work, which is aimed at allowing graduate students to acquire, through typical instructional cases, theoretical viewpoints on teaching and learning developed in mathematics education research. The second semester includes four months of practicum and post-practicum report writing. Since it is a two-year program, graduate students take practicum twice. Practicum is carried out as a part of a school support project, which is conducted under the supervision of university professor by a team comprising graduate students including in-service and prospective teachers, and cooperating teachers of the school. In this practicum, the cooperating teacher is not a student teacher supervisor, but a team member who aims at improving his/her own instruction in collaboration with other members. There are 150 hours of practicum a year. During practicum, graduate students visit school three days a week, and the rest of week is used for reflection on observed lessons, lessons to be taught, lesson they taught, etc. They keep a journal consisting of one-page reports on each day of the school visit. Each report includes the timetable of classes attended and the rubric 'Reflection'. The author of the daily journals we are going to analyse is an in-service teacher, Hiro, enrolled in this program and supervised by the

first author of this paper. He was a mathematics teacher with eighteen years of experience in junior high school. His practicum was carried out in elementary school in both the first and second year.

In the analysis, we, the two authors, separately code Hiro's journal day by day, especially the rubric 'Reflection'. Then, we discuss the results of each coding and reach an agreement for all reports. The procedure of coding is as follows. We first identify whether there is a reflection on specific mathematics lessons observed, taught, or to be taught. Some writings are not always about a specific lesson, but might be about future project plan, schedule of units, results of interview with cooperating teacher, etc. Then, among the qualifying reports, we look for technical terms of practical discourse and theoretical terms of theoretical discourse, and count the number of reports (days) using such terms. Technical terms are those shared in the Japanese mathematics teacher community that can be found mainly in teachers' guides, but not in students' textbooks or in everyday life. We include in this category the terms locally shared in Hiro's teacher community. Theoretical terms are those that are not shared in the teacher community, but in the mathematics education research community. Among the reports using theoretical terms, we identify how these terms are used. If they are used just to label an isolated fact, such a report is classified into quasi-theoretical discourse. If the fact labelled by a theoretical term is considered in relation to other theoretical objects, this is a clue that the teacher regards a fact as a phenomenon in a coherent structure, and such a report is classified into theoretical discourse. Reports using neither practical nor theoretical terms are classified into empirical discourse. However, non-use of these terms does not necessarily imply non-use of practical or theoretical knowledge. Finding more accurate criteria is a further issue to be tackled. In this paper therefore, we will not go into the details of empirical discourse which will probably be more useful for analysing prospective teacher knowledge.

RESULTS

There are reports of 46 days in the first year and 51 days in the second year, among which 43 days and 47 days respectively are qualified for coding. Quantitative results are given in Table 1. Empirical discourse is exclusive from others and quasi-theoretical discourse and theoretical discourse are also mutually exclusive. However, practical discourse is not exclusive from the other two theoretical discourses; that is, a report might be coded as a practical and theoretical discourse at the same time.

Year	No. of days	Qualified days	Empirical discourse	Practical discourse	Quasi-theoretical	Theoretical discourse
2010	46	43	13	26	8	0
2011	51	47	12	17	16	12

Table 1: Quantitative results of teacher discourse

In Table 1, one may find a considerable change in Hiro's discourse between the first and the second year: the use of theoretical or quasi-theoretical discourse is more

frequent in the second-year journal. In what follows, we provide examples of discourse, except empirical discourse, in order to show how Hiro's discourse changes over two years of program and to discuss teacher knowledge in the next section.

Practical discourse

In almost half of the reports (26 days) of the first-year journal—more frequently than in the second year—one finds technical terms of practical discourse. The following excerpt translated into English shows an example from the first-year journal.

> First year: 19 Oct. 2010
>
> For third period, I taught a grade 6 class with a graduate student, Ms. K, in the form of team teaching. The main goal of the lesson was to teach students a method for calculating 'whole number ÷ fraction'. Ms. K taught mainly until the moment of summarising the calculation method for the case of *unit fraction* as a divisor (÷ 1/2, ÷ 1/3, ÷ 1/4, ÷ 1/5). I was, as her supporter, in charge of manipulating the interactive whiteboard, distributing worksheets, and providing individual support to students based on the *Mitori* of their individual resolution. In the second half of the lesson, the teacher roles were switched. (…) Due to time shortage at the end of the lesson, students who could solve all problems comprised 77 % of the class. However, there was no student who could not solve any problem, and the rest 23 % could solve one or two problems. Based on these facts, I think these word problems of *measurement division* were easy for students to understand, and the diagram worked well as a support for students to tackle these problems. (…)

Hiro describes what happened in a grade 6 class first, and then describes students' performance on some problems with some personal comments. The terms in italics are technical terms of practical discourse. One may think the term 'unit fraction' is just a mathematical term. However, we assumed it was a technical term, because it is not a term for students that can be found in Japanese mathematics textbooks. Practical discourse is based on professional knowledge in addition to knowledge found in students' textbooks. 'Mitori' is a term used by elementary and lower secondary school teachers in Japan. It means the act of identification of students' different ideas in order to determine the flow or structure of the discussion phase (*neriage*), in which mathematical ideas are elicited and converge to the one aimed at teaching. 'Measurement division' is the term we mentioned earlier. Hiro pays attention to some specific events or facts he considers significant, in a complicated teaching and learning situation where so many different things happen. This should be allowed by means of technical terms associated with practical knowledge. Technical term labels a fact and provides a particular practical meaning to it. Without such term, one may not get what to see and what to convey to colleagues.

Quasi-theoretical discourse

While a few reports (8 days) use theoretical terms in the first year, more than half (28 of 47 qualified days) do it in the second year. Additionally, 12 of 28 days are coded as theoretical discourse. The following excerpt is an example of quasi-theoretical discourse taken from the second-year journal.

Second year: 22 Nov. 2011

In grade 6, I held a second introductory session on 'proportionality'. When asked to find the value for a *quasi-general number* in the table of correspondences, students were trying to find the value of y using the pattern of correspondences between concrete numbers. One could say that students were working for a *supporting contact*. Additionally, they could formulate the method as $x + 1 = y$ or $x \times 2 = y$. However, they could not arrive at the accurate formulation of the method for finding the values of y based on the idea of *Bai-hirei*. (…)

This reflection was coded as quasi-theoretical and practical discourse. Hiro uses two technical terms that label some mathematical ideas used in teaching. The first one is 'quasi-general number'. This is a term locally used in Hiro's teacher community, which means a relatively big number that requires the use of a general pattern to find the corresponding number. The second is 'Bai-hirei', the term used in Japan's teachers' community to denote a method of solving a proportionality problem without finding the quantity per unit. In addition to these terms, a theoretical term is used. It is Polya's term, 'supporting contact', which means the activity of checking whether a conjecture holds true for the general case by exploring specific cases (Polya, 1954, ch. 1). This theoretical term allows him to simplify the complicated teaching and learning situation and pull out from there a specific fact whose significance might not be perceived through technical terms of practical discourse. Hiro draws attention to students' activity of finding the value of y and labels it as 'supporting contact'. The theory usually provides a particular meaning to the identified fact, and allows understanding in relation to other facts. In Polya's theory of induction, 'supporting contact' is related to 'suggestive contact'. However, it is not clear in this report how identified students' activity relates to 'supporting contact' and how 'supporting contact' comes into being in relation to teachers' acts. It seems that the fact stays isolated and is not understood in the structure of teaching and learning system. If he described how teachers' action of 'ask[ing] to find the value for a quasi-general number' relates to students' 'suggestive contact' and 'supporting contact', then the reflection would have been coded as theoretical discourse.

Theoretical discourse

In the second year journal, theoretical discourse could be identified in 12 reports. Hiro not only describes or labels specific facts from an observed lesson, but also interprets them as a phenomenon in a coherent structure of theory.

Second year: 26 Sep. 2011

In grade 3 classes, what I liked about teaching acts of cooperating teacher are as follows.

There is a scene where the teacher joins in with the student's *incomplete idea* and tries to get the discussion going. This act triggers a counter opinion from students. In this lesson, one could observe it in the scene where the teacher explained that the second biggest number is 78654321 by replacing 8 with 7 in the biggest number 87654321, in the task of making an eight-digit number with the cards from 1 to 8.

(...) Behind these two points, there would be an important teaching act that related to *students' control of 'the goal level'*. I hope we will be able to intentionally use this act in future instruction.

Hiro uses two theoretical terms to label the cooperating teacher's act and students' mathematical activity, respectively. The first one is 'incomplete idea' and the second is 'students' control of "the goal level"'. The former is derived from John Dewey's idea 'indeterminate situation', which is a condition for starting inquiry (Dewey, 1938). The teacher's act of agreeing with the students' wrong answer, '78654321', is labelled as 'join[ing] in with student's incomplete idea'. The latter term is from S. Mellin-Olsen's idea of knowledge control referring to students' independence from the teacher when solving a problem in the classroom: three levels of control—tool, choice and goal—are considered (Mellin-Olsen, 1991). In this report, 'a counter opinion from students' (not from teacher) is interpreted as a starting point of 'students' control of "the goal level"', meaning students are responsible for the problem they are going to solve—the problem of finding the second biggest number has not been resolved yet. We coded this reflection as theoretical discourse, because we consider that Hiro not only pulls out these significant facts from the theoretical viewpoint, but relates them together in a structure of mathematics teaching and learning system. To understand this, we need to clarify his theoretical background. These terms are not adopted from pre-existing theories, but from the framework developed by Hiro and his team based on other theories. They extended Mellin-Olsen's idea in order to deal with Japanese lesson and integrated into it the idea of devolution of intellectual responsibility (Balacheff, 1990) and Dewey's idea in order to describe the mechanism how students establish independence in problem solving situation (Iguchi, Kuwahara & Iwasaki, 2011). In this framework, one of the conditions that provokes students' control of 'the goal level' is the teacher's act of joining in with students' incomplete ideas. Hiro therefore saw this phenomenon in the class of making some numbers with the cards from 1 to 8.

DISCUSSION AND CONCLUSION

Through the analysis of Hiro's daily journals, one could find technical and theoretical terms in both the first and second years. These terms belongs to teachers' professional knowledge that allows teacher to simplify the complicated teaching and learning situation and pulls out some significant facts. In particular, the theoretical terms allowed him first to identify the facts whose significance have not been perceived previously—as he learnt these terms in the university—, and second to understand them in relation to other facts from theoretical perspective. We consider that the knowledge at stake in Hiro's theoretical discourse is a kind of professional knowledge that is comparable to *epistemological knowledge of mathematics in social learning settings* (Steinbring, 1998). It enables teachers to 'become aware of the specific epistemological status of the students' mathematical knowledge' (p. 159). In Japan, this kind of knowledge is needed for experienced teachers who play a leadership role for instructional improvement in the teachers' community. For

example, in lesson study, the role of leading teachers is not to criticise observed lessons but to understand what happens at the deeper level of structure of mathematics teaching and learning system and communicate this to their colleagues. One may also see here the crucial role of university and researchers for in-service teacher professional development.

Regarding Hiro's more frequent use of theoretical discourse in the second year, what is remarkable is that most of the theoretical terms relate to the mechanism of knowledge control and intellectual responsibility. This is because Hiro and his team developed their own framework. They analysed data collected in the first year practicum with this framework, and even wrote a research paper at the end of the first year (Iguchi et al., 2011). Therefore, in order to place theories at teachers' disposal, it would not be enough to provide course work to learn them and long-term practicum.

Notes and acknowledgements

Both authors contributed equally to this paper. We thank Mr. Hiroshi Iguchi, who provided us with his journals. This work is supported by KAKENHI (26381185).

References

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389–407.

Balacheff, N. (1990). Towards a Problématique for Research on Mathematics Teaching. *Journal for Research in Mathematics Education, 21*(4), 258-272.

Dewey, J. (1986). Logic: The Theory of Inquiry. In J. A. Boydston (Ed.) *John Dewey: The Later Works, 1925-1953 Vol. 12: 1938*, Southern Illinois University Press.

Iguchi, H., Kuwahara, E., & Iwasaki, H. (2011). Realizing the Devolution of Intellectual Responsibility in Mathematics Class Interaction. *Journal of JASME Research in Mathematics Education, 17* (2), 103-126. (in Japanese)

Margolinas, C. (1998). Relations between the theoretical field and the practical field in mathematics education. In A. Sierpinska & J. Kilpatrick (Eds.) *Mathematics Education as a Research Domain: A Search for Identity* (pp. 351-356). Dordrecht: Kluwer.

Margolinas, C., Coulange, L., & Bessot, A. (2005). What can the teacher learn in the classroom? *Educational Studies in Mathematics, 59*, 205-234.

Mellin-Olsen, S. (1991). The double bind as a didactical trap. In A. J. Bishop et al. (Eds.), *Mathematical Knowledge: its growth through teaching* (pp. 39-59). Netherlands: Kluwer.

Miyakawa, T., & Winsløw, C. (2013). Developing mathematics teacher knowledge. *Journal of Mathematics Teacher Education, 16* (3), 185-209.

Polya, G. (1954). *Induction and analogy in mathematics.* NJ: Princeton University Press.

Steinbring, H. (1998). Elements of epistemological knowledge for mathematics teachers. *Journal of Mathematics Teacher Education, 1*(2), 157-189.

Stigler, J. W. & Hiebert, J. (1999). *The teaching gap: best ideas from the world's teachers for improving education in the classroom.* New York: Free Press.