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How Do Pre-service Science Teachers Develop Their Teacher Knowledge?: A Qualitative Study Focusing on Teaching Practice in Schools

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This study aimed to explore the facts of what knowledge student teachers acquired/developed through teaching practice in schools, along with the primary factors behind this. First, a framework for interpreting teacher knowledge was stipulated through analysis of previous studies. Next, one teaching-practice group that trained student teachers in Lower Secondary School B Attached to National University A was selected to perform field work as a case. And also, we observed lessons, participated in reflective meeting/conference, and conducted interview survey. Then, the data that was gathered through the interview survey was analysed qualitatively with SCAT (Otani, 2008b, 2011).

The results gained through analysis were classified from three viewpoints: the influence of the mentor, observations on other student teachers' lessons, and reflection on their own practice. Discussing with the model of teacher professional knowledge and skill by Gess-Newsome (2015), the followings were pointed out: (1) knowledge base is acquired/developed by capturing reflectively their own classroom practice, reflective meeting/conference and observations of other student teachers based on their view of (science) lessons, which is begun to construct through educative mentoring and observations lessons by the mentor; and (2) collaboration with other student teachers enables to conduct teaching practice more reflectively.

Key Words: Science Teacher, Pre-service Teacher Education/Training, Teaching Practice, Teacher Knowledge, Pedagogical Content Knowledge

1 Introduction

Up until the 1980s, research on teacher education/training focused on what were the necessary qualification and/or abilities to be a teacher by utilising behavioural science approach. From the 1980s onward, it focused on what knowledge and/or thought patterns were needed for teachers by utilising cognitive psychological approach (Abell, 2007; Akita, 1993). In other words, the paradigm in teacher education research shifted from ‘how teacher should behave and what they should be able to do’ to ‘what teacher should know and how they should think’.

This is why current teacher education research is beginning to have a big tide of research based on teacher knowledge (e.g., Lederman & Lederman, 2015), as Shulman (1986, 1987) proposed in his presentation on pedagogical content knowledge (PCK). Although PCK is still highly evaluated as a useful idea over twenty years after it was first put forward, PCK has many unclarified points such as the process of being acquired/developed (Abell, 2008; Großshedl et al., 2015). Even in Japan, there are demands that teacher education research is done from a PCK viewpoint (e.g., Tokuoka, 1995). However, not all would agree that there has been sufficient research on it.

When capturing professional growth as a teacher from the viewpoint of continuing professional development (CPD), teaching practice is an introduction in this context. This study especially focused on teaching practice, which forms the core of pre-service teacher education/training. On that point, in view of today’s situation wherein there are demands to establish ‘the ideas of teachers who continue to learn’ (Central Council for Education, 2012), this study inquired in depth the process of how PCK is acquired/developed through teaching practice as an initial stage of CPD.

Upon further consideration, since PCK is also perceived as what is enriched through teaching experiences, there is research that sees PCK as something that those with little teaching experience, such as novice teachers and/or pre-service teachers, are not familiar with at all (e.g., Sato et al., 1991; van Driel et al., 1998).

Nevertheless, some researchers have attempted to investigate the facts of novice teachers’ and/or pre-service teachers’ PCK (e.g., Nilsson, 2008; Nilsson & Loughran, 2011; Großshedl et al., 2015). A study by Loughran et al. (2008) was not research on PCK itself, but used PCK as a tool to reveal pre-service teachers’ ‘learning to teach science’.

This study cited the ideas of Loughran et al. (2008) and aimed to explore the facts of what knowledge student teachers acquired/developed through teaching practice in schools, along with the primary factors behind this.

2 Theoretical Framework

2-1 Pedagogical Content Knowledge

The interpretation of PCK differs depending on the researcher; therefore, we needed to interpret PCK as employed in this study. As first definition by Shulman (1986), PCK is seen as knowledge utilised in order to transform subject matter into a comprehensible form for students.

Similar to PCK itself, there are various interpretations of what knowledge base that composes PCK is, and many models have been demonstrated (van Driel et al., 2014). Among these, a consensus as to what constitutes PCK or what knowledge influences PCK has been reached on the following three knowledge categories (e.g., Grossman, 1990; Gess-Newsome, 1999): subject matter knowledge, which is (speaking of science) knowledge of science; general pedagogical knowledge, which is knowledge of curricular, school management, and so on; and context/contextual knowledge, which is knowledge of students, school culture, and so on. PCK model have been divided into almost two types (Gess-Newsome, 1999). Either as integrated model in which dynamic knowledge of PCK is only demonstrated when knowledge base is utilised in classroom practice (e.g., Bishop & Denley, 2007) or as transformative model representing one interdisciplinary area in which there is no clear boundary between categories of teacher knowledge, and each teacher knowledge category mutually influences

the others (e.g., Grossman, 1990).

It is not that either of these two models is superior to the other, however it is important to understand the nature of each model. Namely, in capturing PCK as knowledge that is represented in classroom practice, it is better to consider from the viewpoint of integrated model. On the other hand, in capturing what knowledge that teachers utilise in classroom practice is derived from, it is better to consider from the viewpoint of transformative model (Gess-Newsome, 1999).

Much of the research on science teachers' PCK so far has employed the model presented by Magnusson et al., (1999) as a framework for interpretation of PCK (e.g., Nakata et al., 2012; Fraser, 2015; Hume & Berry, 2011). However, some problems have also been indicated, such as the idea that concepts related to teacher beliefs are treated as being on the same level as other knowledge base (e.g., Gess-Newsome, 2015; Friedrichsen, et al., 2011). As stated earlier, it is hard to say that student teachers, which are the focus of this study, possess a sufficient level of PCK. To think of what student teachers themselves do possess or perhaps to think of knowledge they acquire/develop through teaching practice as part of what constitutes their overall teacher knowledge would comprise a model that takes the standpoint of transformative model and utilising this model makes it possible to hone in on the facts of this question.

On that point, Gess-Newsome (2015) is developing a structured model (as seen in Figure 1) of a teacher professional knowledge and skills, which constitutes teacher professional knowledge base (TPKB), topic-specific professional knowledge (TSPK), and knowledge used in 'classroom practice' as well as 'amplifiers and filters' of teacher, 'amplifiers and filters' of student, and 'student outcomes' that mediate all of these knowledge. PCK is defined within this model as 'Personal PCK is the *knowledge of, reasoning behind, and planning for teaching a particular topic in a particular way for a particular purpose to particular students for enhanced student outcomes*' (Gess-Newsome, 2015, p.36, italics are in the

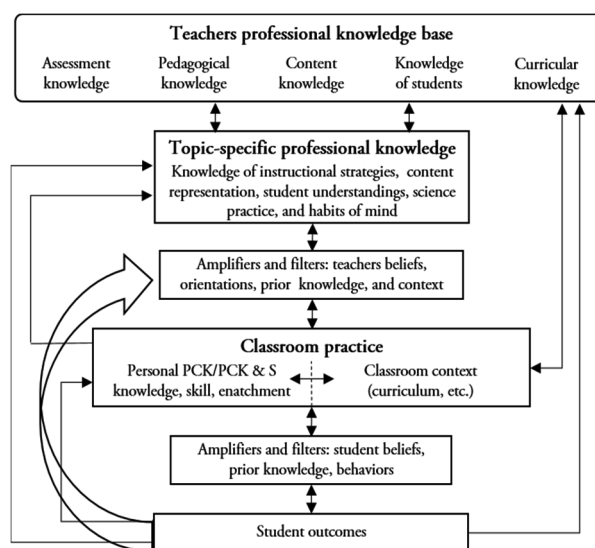


Figure 1: Model of Teacher Professional Knowledge and Skills

Source: Gess-Newsome (2015, p. 31, Figure3.1).

original). And also, PCK is perceived as dynamic knowledge that combines static knowledge base such as TPKB and TSPK.

Based on the above arguments, this study employed Gess-Newsome's (2015) structured model of teacher knowledge focused on PCK as the framework for interpreting teacher knowledge.

2-2 Development of Teacher Knowledge

Some primary factors in development of teacher knowledge are said to be collaborations with other teachers such as observations of others teachers' lessons, educative mentoring¹⁾ and coaching, reading books and/or periodicals, and reflection on their own classroom practice (e.g., Wellington & Ireson, 2008; Akita, 1993). What are the specific ways that teacher knowledge is developed through these opportunities?

In Nilsson (2008), for instance, student teachers held reflective meeting/conference where they watched their video-recorded lessons. The student teacher who conducted the lesson was able to share what they had been thinking during the lesson. And then, they came to grasp context knowledge, and as a result, this indicates a connection to the development of PCK. Nevertheless, it

cannot be said that there has been sufficient research of student teachers overall or what knowledge student teachers acquire through which opportunities.

Therefore, it is necessary to discuss the specific ways that collaboration with other teachers (in this case, teachers belonging to the attached school and other student teachers) and reflection on their own classroom practice contribute to development of teacher knowledge in teaching practice.

3 Research Questions

In order to achieve the aim stated earlier, this study focused on the following two research questions (RQ).

1. What do student teachers learn through educative mentoring, observing other teachers' lessons and reflection on their own classroom practice?
2. How it be perceived when capturing the answer of RQ1 from the viewpoint of teacher knowledge?

4 Research Methods

4-1 Research Design

We employed qualitative research method in order to achieve the aim of this study. Qualitative research from an interpretivist standpoint interprets the meaning of participants' experiences from the intrinsic viewpoints. It is hard to establish condition controls for events that occur in classroom that are targeted educational research and/or professional growth (the target of this study) because of parameter excess. Rather than employing quantitative research with an intention to generalise, there are some cases where qualitative research is more suitable for singling out the inherent meanings in the events (Flick 2002/1995; Creswell, 2007/2003; Treagust et al., 2014; Taylor, 2014; Otani, 2008a).

Therefore, this study employed qualitative research in an attempt to single out the inherent meanings in what student teaching means to the survey participants.

4-2 Outline of the Survey

This survey was conducted from 16th September, 2015 to 2nd October, 2015. It was targeted teaching practice where conducted at Lower Secondary School B Attached to National University A. In the survey, observations lessons, participation in reflective meeting/conference and interview surveys were done. At University A, in order to get secondary teacher's certificate, each student teacher need to be dispatched to two out of the four attached schools, where from approximately September to October, they teach for two weeks at each attached school. This study was conducted at one of these attached schools, and first-time student teachers were the survey participants.

4-3 Data Collection and Procedures

There are four survey participants, all of whom were acting as student teachers at Lower Secondary School B during the period we conducted the survey. These four were all teaching under the same mentor ²⁾ (hereafter referred to as Teacher C), so they make up one group of student teachers. This research analysed teaching practice conducted by these four student teachers and their mentor, Teacher C, as a single case.

A simple profile of the four student teachers and Teacher C is shown in Tables 1 and 2. Teacher C possesses specialised teacher's license, and before being hired as a teacher, he spent two years as a upper secondary school teacher and a specially appointed assistant professor at a university respectively. This is Teacher C's first year at Junior High School B, and the school he was previously assigned to was an upper secondary school with an attached lower secondary school.

The four student teachers (who are also the survey participants) were subject to a roughly thirty-minute semi-structured interview once all of their classroom practice at Lower Secondary School B was completed, and they were ordered to talk about what they had learned through teaching practice and their challenges.

Teacher C was also subject to a roughly thirty-

Table 1: Student Teacher Profiles

ID	Gender	Faculty	Science Background
ST1	Male	Education	Physics
ST2	Female	Science	Biology
ST3	Male	Education	Physics
ST4	Female	Science	Biology

Table 2: Teacher C Profile

Gender	Faculty	Science Background	Teaching Experience
Male	Education	Chemistry	7 Years

minute semi-structured interview once all of teaching practice for 2015 was completed and was ordered to talk about Teacher C’s view of science lessons and teaching practice, and what was deval point for teaching practice.

The contents of these interviews were subject to analysis once they had been transcribed. In conducting interview, questions were asked based on information gained through fieldwork.

Before the survey, its intentions were thoroughly explained and informed consent was gained from all participants. Consent was also gained to use the contents of the surveys in research.

4-4 Analysis

As to analysis, SCAT (Steps for Coding and Theorization: Otani, 2008b, 2011) for analysing qualitative data was utilised. SCAT is an analytic method with explicit procedures (which will be described later) used for analysis has a high falsifiability (Otani, 2008b).

In SCAT, storylines are described through four steps of coding. Transcribed, textual data was used for the analysis. This textual data was segmented in advance to consolidate meanings. In <1>, noteworthy words and phrases within the text of each segment are written out. In <2>, the words and phrases are rephrased into different expressions. To further explain <2>, concepts from outside the text are entered in <3>. After completing these steps, statements concerning the themes and core concepts of the

text are written in <4>. Next, by extrapolating from <4>, a storyline of the entirety of the interview data is described. The method of selecting noteworthy words and phrases in <1> produces great changes in the resulting storylines.

For this study, the noteworthy words and phrases were selected based on RQ1. The underlining in the storylines quoted below is meant to indicate the themes and core concepts of <4>.

The interview with the mentor was analysed multilaterally to triangulate the connection between what student teachers learn, and educative mentoring. Therefore, this was done to increase the validity of the results.

5 Results

The results gained through analysis and based on RQ1 were classified from three viewpoints: (1) learns from the mentor; (2) observations on other student teachers’ lessons; and (3) reflection on their own classroom practice.

5-1 Learns from The Mentor

What do student teachers learn from their mentor? Part of ST4’s storyline is shown below as one example of that.

From their mentor’s advice and the view of lessons based on their mentor’s model lesson, that is to say, the influence of the mentor’s view of lesson she learned to seriously consider the nature as points on making lessons. (Omission) From listening to their mentor’s advices in reflective meeting/conference, she learned how their mentor viewed lessons, and became to capture targets of the lessons and/or the core of the lessons as the viewpoints of assessments of lessons.

(Quoted from ST4’s storyline)

In short, through educative mentoring and observations of the mentor’s model lessons, she learned that science lessons should focus not on how to solve problems or formalise methodology but rather on the nature parts of the teaching material. And also, she became to capture that these points are seen as something that should be paid heed to when making a lesson. In addition,

by listening to the mentor's advices on the student teachers' lessons in reflective meeting/conference, it is seen that she got the viewpoints of observing lessons that were the goals of lessons and/or 'what was the core of the lesson'.

As to this, Teacher C said that when making lessons, the point that should be emphasised is that 'It is vital to clarify for myself in advance what I want the students to learn from this lesson'. This suggests that Teacher C himself has always stressed the importance of clarifying the goals of a lesson.

This indicates that student teachers, through educative mentoring and observation of the mentor's model lessons, learn what science lesson is together with acquiring the viewpoints of observations of lessons.

5-2 Observations on Other Student Teachers' Lessons

What do student teachers learn from observing other student teachers' lessons? Part of ST1's storyline is shown below as one example of that.

In observations of lessons, he was watching from a third-person point of view so he was able to objectively observe the students. He was able to pick up on how the students reacted to the lesson, which is something he was not able to notice when giving a lesson himself. Consequently he could find out strategies for students who cannot follow the lesson.

(Quoted from ST1's storyline)

In other words, observing other student teachers' lessons allows for study of student reactions, which is something that one cannot notice when giving a lesson themselves and enables one to think of how to deal with a wide variety of actual students.

It may be thought that when observing lessons, the focus of the observation is to learn how to give a lesson. As one reason why observations on lesson did not lead to that, part of ST3's storyline is shown below.

Because of fully cooperating with the other student teachers, he was able to understand the aim of before and after lessons and was able to complete teaching practice collaboratively.

(Quoted from ST3's storyline)

This suggests that ST3 was able to grasp beforehand the details of what kind of lessons other student teachers were conducting. As a result, it can be thought that they are focusing more on 'how will students react to this lesson?' rather than what kind of lesson to conduct.

This indicates that student teachers, by observing other student teachers' lessons, are able to study and discuss the ways in which the students react to the teacher's actions.

5-3 Reflection on Their Own Classroom Practice

Next, we consider what student teachers learned from their own classroom practice. Part of ST1's storyline is shown below as one example of that.

ST1 evaluated, based on comments given in reflective meeting/conference that are strategies for time management that lesson should spend time fully into make the core part of the lesson, the factors of learns from his own successful lessons during teaching practice that is to make what is core of the lesson in order to give lessons with clarified goals. Specifically, he reflected that suggesting its goals at beginning of the lesson enables to clarify its tasks.

(Quoted from ST1's storyline)

From this, we understand that upon his reflection on their own lesson, and after taking in what was said in reflective meeting/conference about how time should be spent on the parts that are the core of the lesson, the reflection caused him to realise that within their successful lessons, there was one part of the material that formed the core of the lesson, and this clarified the goals of the lesson for him. In other words, it can be seen that clarifying the goals when making a lesson and managing time to focus on the parts that make up the core leads to the success of a lesson.

Therefore, this indicates that student teachers, through making and giving their own lessons and being assessed in reflective meeting/conference, are learning the

necessity of clarifying goals of the lesson and strategy for time management.

5-4 Conclusions to RQ1

As seen above, there are three points that can be indicated as answers to RQ1.

- Through educative mentoring and observation of the mentor's model lessons, student teachers learn what science lesson is together with acquiring the viewpoints of observations of lessons.
- By observing other student teacher's lessons, student teachers are able to study and discuss the ways in which the students react to the teacher's actions.
- Through making and giving their own lessons and being assessed in reflective meeting/conference, student teachers learn the necessity of clarifying goals of the lesson and strategy for time management.

6 Discussion

6-1 What Student Teachers Learn and the Primary Factors in This from the viewpoint of teacher knowledge

In order to answer RQ2, we would now like to discuss, based on the answers to RQ1, student teachers' learn during teaching practice and the primary factors from the viewpoint of teacher knowledge by utilising the model of Gess-Newsome (2015).

First, since student teachers learn what science lesson is from educative mentoring and observation of mentor's model lessons, it could be interpreted that they influenced their 'teacher beliefs', and then they started to form their own views of (science) lessons.

Next, since student teachers learn how students react to teachers' actions through observations on other student teachers' lessons, this falls under the general 'knowledge of students' category of TPKB. One can also perceive student teachers as acquiring how to transform teaching contents into the understandable form for students, which is 'content representation' in TSPK; they are also acquiring knowledge to use when dealing with specific students, which is 'classroom practice'.

Further, when student teachers have classroom practice and are assessed at reflective meeting/conference, they are learning specific instructional strategies; therefore, we can think of this as acquisition of knowledge used for 'classroom practice'.

These knowledge are not acquired independently from each opportunity, but rather it is thought that the opportunities of educative mentoring, reflection on one's own classroom practice, and reflective meeting/conference all lead to, little by little, mutually acquisition/development of teacher knowledge. In this research in particular, 'amplifiers and filters' of teachers that includes a view of (science) lessons is perceived as something that mediates between the knowledge used in 'classroom practice' and static knowledge that is TPKB and TSPK. As a result, the view of (science) lessons that forms from the influence of the mentor serves as proof that reflective opportunities for classroom practice and reflective meeting/conference promote acquisition/development of various knowledge. Furthermore, starting with reflective meeting/conference and observations on lessons, the collaboration with other student teachers serves as proof that it is possible for teaching practice to be conducted even more introspectively.

When teaching practice is done reflectively like this, it becomes possible to provide feedback on each territory of knowledge based on 'student outcomes' during the lessons.

By the way, constructing teacher knowledge is differentiated into what one can accomplish individually and what they gain from collaboration with others (Akita, 1993). In the case of teaching practice, however, opportunities advised by other (student) teachers such as reflective meeting/conference promote, as indicated, their own reflection. In other words, collaboration with others during teaching practice causes results that are greater than what one could achieve individually.

As can be seen, there are two points being indicated as primary factors in what student teachers learn from the

viewpoint of teacher knowledge. First, knowledge base is acquired/developed by capturing reflectively their own classroom practice, reflective meeting/ conference and observations of other student teachers based on their view of (science) lessons, which is begun to construct through educative mentoring and observations lessons by the mentor. Second, collaboration with other student teachers enables to conduct teaching practice more reflectively.

6-2 Evaluation of this Study as A Qualitative Research

This study does not intend to generalise the process of learning during teaching practice; it was an attempt to get suggestions by utilising qualitative research methods to explain individual details in depth. Although qualitative research cannot guarantee the generality of its results as quantitative research can, to secure generalisability and applicability the suggestion that is got, it is necessary to guarantee comparability and translatability of the results (Otani, 2008a).

What student teachers learn from educative mentoring and observing the mentor's model lessons, for instance, will differ based on the view that the mentor possesses towards teaching practice or (science) lessons. Nevertheless, there are enough possibilities that student teachers acquire/development various teacher knowledge based on the view of (science) lessons, which is constructed because of the influence from his/or mentor. In this way, it is sufficiently possible that the suggestions indicated through this study can be applied to other cases.

7 Conclusion and Implications

This study analysed qualitatively what student teachers learn through teaching practice and considered this from the viewpoint of PCK as a framework of teacher knowledge.

If teaching practice is viewed as the initial stage of CPD, then it is vital for student teachers to learn the way of learning from their own classroom practice. As indicated in this study, collegiality, which is one of the important factors identified in previous studies into

professional development, becomes particularly important in teaching practice through educative mentoring and collaboration with other student teachers.

Meanwhile, as University A's teaching practice is needed to conduct in two attached schools, it becomes necessary necessarily to be guided under two or more mentors, although this study cannot make any comment regarding that. It is necessary to inquire in detail in what way conducting teaching practice in different schools (under different mentors) leads to the acquisition/development of teacher knowledge over a one-month teaching practice programme. This is a topic for future discussion.

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Notes

1. In mentoring, teaching 'what to teach and how to teach it' has come to be considered as more important than the traditional way of mentors (refer to note 2) instructional strategies and the reasons for their choices. However, the words "educative mentoring" that convey the meaning of student teachers' ability to learn and grow from their own practice is coming to be used (Barnett & Friedrichsen, 2015; Brabury, 2010). The mentoring in this case points to the meaning of educative mentoring.
2. Normally, the teachers who coach the student teachers are not referred to as mentors but as guided teachers. Mentors have the role of supporting the student teachers and collaboratively thinking through the complicated processes of teaching (Isozaki, 2014; Barnett & Friedrichsen, 2015; Bradbury, 2010). This study also takes this standpoint, so the teachers who instruct the student teachers are referred to as mentors.

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