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A SCIENCE TEACHER'S PCK IN CLASSES WITH DIFFERENT ACADEMIC SUCCESS LEVELS

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Abstract
Teachers are usually considered to be the most essential elements in student learning. Teachers' Pedagogical Content Knowledge (PCK), whether pre-service or in-service, is one of the most important factors that affect learning process. The purpose of the study is to investigate an experienced science and technology teacher's PCK on the topic of fluid pressure in physics in two classes with different academic success levels at an elementary public school. The study can be defined as a qualitative case study. Purposeful sampling method was used to explore an elementary science and technology teacher's PCK. Timeline for the data collection is divided into three parts; conducting pre-interview, classroom observations, and conducting post interview. All the interviews and audio recordings of the classes were transcribed verbatim. To establish inter-rater reliability of the data analysis, pre-interview transcriptions were coded by three researchers independently. The rate of agreement on the coding results between three researchers was found as 85%. The results of this study showed that the participant teacher was knowledgeable about the goals and objectives of the science curriculum, students' prior knowledge, and what the students will learn in future regarding the liquid pressure topic.

Key Words: Pedagogic content knowledge, Science teacher, Fluid pressure.

INTRODUCTION

Teachers are usually considered to be the most essential elements in student learning (Committee on Science and Mathematics Teacher Preparation, 2001). Teachers' Pedagogical Content Knowledge (PCK), whether pre-service or in-service, is one of the most important factors that affect learning process. Central questions in teaching literature emphasize how teachers manage their classrooms, organize learning activities, use time and turns, give assignments, decide which levels of questions they ask, plan lessons, and assess general student understanding (Shulman, 1986). Effective teachers do not attempt to transform content knowledge in a rigid manner but do attempt to investigate what the students already know, recognize students' alternative conceptions, and organize a proper educational setting for different academic success levels of students. Shulman defined PCK as "understanding of how particular topics, problems, or issues are organized, presented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (1987, p.8). PCK has been an important issue for science researchers, in both in-service and pre-service teaching study areas (Friedrichsen & Dana, 2005).

In the past few decades a significant number of research has highlighted the impact of PCK on science teaching and learning (Abell, Rogers, Hanuscin, Lee and Gagnon, 2009; de Jong, van Driel & Verloop, 2005; van Driel, de Jong, & Verloop, 2002). There are many international studies that investigated the components of PCK, the relationships between these components, and pre-service and in-service teachers' PCK (Avraamidou & Zembal-Saul, 2010; Friedrichsen, Van Driel, and Abell, 2011; De Jong, Van Driel, and Verloop, 2005; Henze, Van Driel, and Verloop, 2008; Van Driel et al., 2002). In the last ten years, the number of studies investigating the teachers' PCK has also significantly increased in Turkey (Aydin & Boz, 2011; Cambazoglu, 2008; Karakoc, 2003; Usak, 2005). Aydin and Boz (2011) revealed in their research that more than 80 % of the studies were conducted about pre-service teachers' PCK whereas very few studies (three out of 28) were conducted with in-service teachers in Turkey. This situation is similar in the international research arena about PCK (Abell, 2007; Loughran et al., 2004). The research conducted with pre-service teachers does not provide the essential information about how a teacher with sufficient PCK plans and carries out education (Loughran et al., 2004). Thereby, there is a need for studies about in-service teachers' PCK in order to shed more light on the literature. The purpose of the study is to investigate an experienced science and technology teacher's PCK on the topic of fluid pressure in physics in two classes with different academic success levels at an elementary public school in Cankaya district of Ankara, Turkey. Following research questions will guide the present study;

1. What is the nature of an experienced science technology teacher's knowledge about science curriculum in fluid pressure topic for eight grades?
2. What is the nature of an experienced science technology teacher's knowledge about different academic success level student groups' understanding of fluid pressure topic for eight grades?
3. What is the nature of an experienced science technology teacher's knowledge about assessment in fluid pressure topic for eight grades?
4. What is the nature of an experienced science technology teacher's knowledge about instructional strategies for teaching fluid pressure topic to different academic success level student groups?

THEORETICAL FRAMEWORK

Magnusson et al. (1999) provided five components of PCK as teacher (1) orientations toward science teaching (2) knowledge about science curriculum, (3) knowledge about student understanding of specific science topics, (4) knowledge about assessment in science, and (5) knowledge about instructional strategies for teaching science. These components give a broader perspective of PCK than the previous models that focused on subject-specific case knowledge (Abell, 2007). Magnusson et al. (1999) PCK model has been the most common in usage by the researchers in recent years because it is easy to use the components of the model at all steps of education (Aydin & Boz, 2011). Hence, we have used Magnusson et al. (1999) PCK model in conceptualizing the current study.

Based on the work of Magnusson et al. (1999), we make the concept of PCK as including four components: (1) knowledge about science curriculum, (2) knowledge about students' understanding of specific science topics, (3) knowledge about assessment in science, and (4) knowledge about instructional strategies for teaching science. In this section, we give the corresponding theoretical framework for each component.

Knowledge about Science Curriculum

This element of PCK includes two parts: knowledge about the goals and objectives of the science curriculum and knowledge about special programs in the science curriculum (Magnusson, Krajcik, and Borko, 1999). The first part involves the teachers' knowledge about the ruling goals and objectives of the science curriculum that they teach in the class along with the delivery of these goals and objectives throughout the topics taught

(Magnusson et al. 1999). The second category of science curriculum knowledge involves the general knowledge about the science curriculum and certain materials and programs that are pertinent to the topic being taught in order to accomplish these goals (Magnusson et al. 1999).

Knowledge about Students' Understanding of Science

This component has two categories: knowledge about the requirements for learning and knowledge about areas of student difficulty. The prerequisites of the science topics, such as the required abilities and skills for the students to be able to learn the certain science topics are involved in the category of knowledge about the requirements. In this category, the knowledge that students might have different abilities and or learning styles is also included. Teachers should be alert about students' varying abilities and react favorably in order to be effective. Knowledge about areas of student difficulty involves the knowledge about the parts of the topics that students have difficulty in learning.

Knowledge about Assessment

Limited numbers of study (Duffee, & Aikenhead, 1992; Pine et. al, 2001) have attempted to directly study teachers' knowledge about assessment (Abell, 2007). This element also contains two categories: knowledge about the science learning that is important to be assessed in a specific unit and knowledge about the assessment methods (Magnusson et al. 1999). In the first category, the teachers should be aware of the aspects of scientific literacy to be able to assess students' conceptual understanding, interdisciplinary ideas, and scientific reasoning and investigation in a specific unit (Champagne, 1989). The second category includes the knowledge about assessment tools that can be used to assess the important dimensions of students' science learning along with knowledge about the advantages and disadvantages of using these tools in a specific unit.

Knowledge about Instructional Strategies

Elementary science teachers are important participants of science teaching process. Not only do elementary science teachers need subject matter knowledge for specific topics that are covered in science classroom, but also they need to know about effective teaching and learning strategies to transform these knowledge to pupils. To be able to transform knowledge to pupils, teachers need to know students' naïve ideas about scientific phenomenon. Teachers' knowledge about instructional strategies has been studied by many researchers (e.g. Jones, Thompson, & Miller, 1980; Odom, & Settlage, 1996; Flick, 1996).

METHOD

Participants and Setting

Qualitative inquiry generally focuses on small samples, even single cases, selected purposefully to let inquiry into and understanding of a phenomenon in depth (Patton, 2002). Purposeful sampling assists the researchers to comprehend the problem and the research question (Creswell, 2009). Thus, present study used purposeful sampling to explore an elementary science and technology teacher's PCK. This study included one elementary science and technology teacher who has graduated from art and science faculty at the department of biology in 1992. He has been teaching for 17 years as a science and technology teacher. According to Rosenholtz (as cited in Ubuz & Yayan, 2010), the advantages of experience in teaching become stable after around five years. Thus we consider the participant in this study as an experienced teacher as he has been teaching science and technology at an elementary level for more than five years. This teacher was selected for three reasons: 1) He works as an elementary science and technology teacher at a public high school 2) He is an experienced teacher in science teaching 3) He volunteered and was enthusiastic to participate in this study. Therefore, he suited well for the purpose of the current study.

Data Collection

Data for the current study was collected from an experienced elementary science and technology teacher at the fall semester of 2011-1012 academic year. Timeline for the data collection is divided into three parts; conducting pre-interview, classroom observations, and conducting post interview. In order to collect and triangulate information The following tools are used in this study to collect the relevant data about the teacher's PCK in fluid pressure topic in classes with different academic success levels: Content Representation form (CoRe; Loughran, Berry, & Mulhall, 2006), lesson preparation method, semi-structured interview forms (Friedrichsen, Abell, Pareja, Brown, Lankford, & Volkmann, 2009) and classroom observations.

Data Analysis

All the interviews and audio recordings of the classes were transcribed verbatim. To establish inter-rater reliability of the data analysis, pre-interview transcriptions were coded by three raters independently. The rate of agreement on the coding results between three researchers was found as 85%. Remaining papers were assessed by the first and second raters.

Knowledge of Curriculum

We analyzed the data in two parts: knowledge about the goals and objectives of the science curriculum and knowledge about special programs in the science curriculum. Teacher's knowledge about curriculum objectives for the current topic that s/he is going to teach in the class, knowledge about the students' prior knowledge and what the students will learn in future regarding the topic being taught is first part of the science curriculum knowledge.

Being a seventeen year experienced teacher, the participant teacher for the present study knows students' prior knowledge about the fluid pressure topic. Although it is not possible to make sharp distinction between knowledge of student understanding and knowledge of curriculum (students' prior knowledge part) common quotations can be used both of the situations.

"Students generally have difficulties to understand depth and density of liquids for this topic. They assume that depth and density is the same and they have difficulty to understand amount of water and depth of water is different. They complain about the ignorance of the amount of liquid during the pressure calculation. Firstly we aim to teach them the amount of liquid and the shape of the container are not the issue for pressure, but the height and density of the liquid. These points are the most difficult parts of this topic" (Post interview).

The goals of the curriculum are listed in lesson plan and the restriction of the curriculum is highlighted in content representation forms. In lesson plan, teacher pointed out that he is going to teach liquid pressure, gas pressure and the usage of these issues in technology.
"Objective 2-5: Students are going to discover the fluid pressure and gas pressure, the transition of this pressure to every part of the container.

The second category of science curriculum knowledge involves the general knowledge about the science curriculum and certain materials and programs that are pertinent to the topic being taught in order to accomplish these goals. Teacher is aware of the general goals of the curriculum he also aware of the limitations for the application of it.

"The major aim of the curriculum is to make students to discover the issue, make inferences, to teach the subjects in an unforgettable way. But it is difficult to reach these goals in 8^{th} grade. Why? It is because of the exam (SBS) reality. It is difficult to teach in May. Because students are generally absent in May and June. They take medical certificate and go to "special educational intuitions- dershane" (Pre-interview).

Knowledge about Students' Understanding of Science

We analyzed the participant teacher's PCK on the liquid pressure topic based on the following two categories: The requisites for learning the liquid pressure topic and the areas in the topic where the students have difficulty in learning. The first category also involved the knowledge that the students had different abilities and learning styles. The participant teacher was aware of different learning styles of the students since he mentioned in the post interview that:

"It is very hard for students to understand this topic without showing them some visual aids and doing experiments in the class."

However, the teacher also mentioned the difficulty of showing all the different situations in this topic visually because of the lack of the materials in the school laboratory in the pre-interview.

"… it is hard to find all the materials in the laboratory. It is hard to give everything visually."

The teacher started to teach the liquid pressure topic by showing pictures of a water tank and buildings near the tank, a car that is lifted up on a compressor, a water pump, and a fireman ladder from the science and technology textbook in both classes. He also asked questions like "How does tap water come to our houses? How do you think a fireman ladder work?" When we asked him, why he started teaching the topic with showing these pictures and asking these questions in the post interview,

"I wanted to know what the students knew about this topic and learn if they could make connections between the topic and daily life examples for the topic."

This finding shows that the teacher valued the students' prior knowledge about the topic and that he wanted to build upon the students' prior knowledge. This finding also shows that the teacher wanted to relate the topic to the daily life examples since he mentioned in the post-interview that one of the difficulties that the students have in learning the liquid pressure topic was being unable to relate the topic to the daily life examples.

"The student sees the car brake, the crane but never wonders about how they work. They first become knowledgeable about that in this topic" (Post-interview transcriptions).

Besides the students' needs, the teacher was also considering the student characteristics while he was teaching the topic. Although he covered the same topic and carried out the same experiments in both classes (8A and 8B), he additionally talked about Pascal's life story and solved three more questions of the same type in 8B (Classroom observation notes and audio transcriptions). When we asked him in the post-interview about why he had such differences between the classes although these did not appear in the lesson plan, he explained that this was because of the differences between the student characteristics.

"… students in 8A can easily use the information they receive. However, I cannot say the same thing for the students in 8B. For the students in 8B, the priority should be given to holding the students' attention in the class. Therefore, I talked about the historical background of fluid pressure topic in 8B. . . . The reason for why solving different problems in both classes is to take the attention of the students in 8B. This is not that important in 8A. The students in 8A are already engaged with the class" (Post-interview).

Knowledge about Assessment

Knowledge of assessment component is also divided into two parts; the first one is knowledge about science learning that is crucial to be assessed in a specific unit, the second one is knowledge about assessment methods, furthermore knowledge of advantages and disadvantages of each method. The teacher used teacher-generated tests to assess the students' understanding of fluid pressure topic. It is important that the teachers should be aware of the aspects of scientific literacy to be able to assess students' conceptual understanding, interdisciplinary ideas, and scientific reasoning and investigation in a specific unit.

The participant teacher used teacher-generated tests to assess the students' knowledge about the topic he also tried to make visible students thinking process by initiating classroom discussions. He asks challenging questions and makes students tell their explanations to rest of the classroom. Sometimes he initiates the classroom discussions and makes students to justify their answers. These discussions give an idea to the teacher whether the topic is clear or not.

"I commonly use project based learning in my classes. We do not force students to take project for our courses. They are free to take projects on each course they do want. Some students come and ask taking project for elementary science and technology course. The process is important here. Students are expected to

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ask questions, give necessary information to teacher during the project. I assess the whole process rather than the final project."

Instructional strategies

This section attempts to explore an experienced elementary science teachers knowledge about instructional strategies on liquid pressure topic. Although teacher did not mention about subject specific strategies in during the interviews we observed that he used 5E learning cycle in both classes:

Engagement

He used questions to engage students. Giving daily life examples to facilitate between what students already know and are going to learn.

"Open page 70 in tour textbook, take a look at these pictures (there are four different pictures in the book, picture-1: water tank and buildings near the tank, picture-2: a car is lifted up on a compressor, picture-3: water pump, picture-4: fireman ladder). How does tap water come to our houses?" (Observation notes and transcriptions of lecture voice recordings for 8A).

Exploration

Objects and phenomena are explored.

Teacher introduced U tube to the students. He added some water into one arm of the tube and some oil into the other arm. He asked the students to measure the heights of the liquids with a ruler in both arms and to record the height values. (observation notes for 8A)

Explanation & Elaboration

Explanation: Students use the data collected in the class to solve a problem. They also report their answer to the problem.

Elaboration: Teachers challenge and expand students' understanding and skills.

Teacher: Do we know the density of water?

Students: Yes.

Teacher: Can we find the density of oil by using U tube?

Students:

Teacher: What is the height of water?

Students: It is 8 cm.

Teacher: What about oil?

Students: It is 9 cm.

Teacher: Why do the two liquids have different heights?

Students: They have different densities.

Teacher: We learned that liquids have the same pressure on both arms of u tube.

Teacher asks students to write the mathematical expressions for pressure of each liquid. Students use their data (heights of the liquids, and density of water) and equality between the pressures of the liquid in U tube to calculate the density of oil.

Teacher: We can infer that it is easy to calculate an unknown liquids density by using a liquid whose density is known. What is the important point here? What must be the characteristics of the liquid?

Students: Liquids must be immiscible. (Observation notes and transcriptions of lecture voice recordings for 8A)

Evaluation.

Students assess their knowledge, skills and abilities. Activities permit evaluation of student development and lesson effectiveness. Teacher drew a U tube on the board, including gasoline and water, gave the heights of each liquid and asked the students to calculate the density of gasoline. (8A observation notes). Teacher used the same subject specific strategy in both classes. However, he used some different topic specific strategies in each class. Interview results shows that the teacher knows various topic-specific strategies for elementary science and technology course.

"I use questioning, lecturing, problem solving, drama, illustration, demonstration, examples, reflective discussions, experiential learning, independent study, and cooperative learning as instructional strategies. I use all of these strategies in classes." (Pre- interview).

DISCUSSION & CONCLUSION

The results of this study showed that the participant teacher was knowledgeable about the goals and objectives of the science curriculum, students' prior knowledge, and what the students will learn in future regarding the liquid pressure topic. There was no difference in what is being taught regarding the liquid pressure part of the science curriculum in both classes. The teacher also transmitted some information, which is out of the curriculum but related to the liquid pressure topic because of the questions, which were asked on the SBS exam and required that information in order to be solved by the students. Therefore, the teacher was not strictly dependent on the curriculum formed by the MONE and was also considering the students' needs for the SBS exam since this exam is very important in students' lives. The teacher mentioned that he was absolutely curriculum dependent when he first started teaching. Thus, we believe that it is because of his being an experienced teacher that the teacher does not limit himself with the concepts given in the science curriculum regarding the liquid pressure topic. The participant teacher in this study was found to be knowledgeable about prerequisites of the liquid pressure topic and the parts of the topics that students have difficulty in learning. The teacher mentioned the abstract nature of the liquid pressure as one difficulty that the students have in learning this topic. Although the teacher was also aware of different learning styles of students, one of the biggest problems for the teachers was not being able to find all the materials at the school in order to be able to show all the different situations in science visually and react favorably according to the different learning styles. This, unfortunately, would make the science teachers use the traditional teaching strategies more in teaching. However, science teachers will not be aware of the students' weak comprehensions in the topic. The important points of a topic should be taught by using real objects or situations from the daily life and also arranging activities to make the students practice and enrich their theoretical knowledge (Syh-Jong & Hsiu-Chuan, 2009).

Overall, research has revealed that science teachers lack of crucial PCK, e.g., lack knowledge of students' science conceptions, knowledge of assessment (Abell, 2007). This limitation might possible serve as a limiting factor for improved teaching and learning practices. Furthermore, given the integrated nature of PCK, deficiency in one component of PC knowledge base can have significance outcomes for enactment of science teachers' PCK. For instance, knowledge of assessment strategies forms an important component of science teachers' PCK and provides critical feedback to teachers about the effectiveness of their teaching practices. This respectively allows science teachers to adjust and respond to their students' understanding of phenomena under study.

The participant teacher paid attention to use 5E learning model in both of the classes. As previously mentioned two classes have different academic success level. This forces the teacher to use different instructional strategies. For example, the teacher enhanced the engagement step of learning in 8B. Because these students have concentration problem, most of them did not properly attend the class from the beginning of the semester, they even do not know the what is going on the class, which topic are they going to learn, which topic did they cover in previous lesson etc. Teacher tried to initiate classroom discussion in both of the classes. This is a kind of strategy that he uses in general. He encouraged students to link the fluid pressure topic with their daily life experiences. This might be helpful for students to learn the topic well. Science topics generally are related with daily life, teachers should be aware of this and use this issue as an advantage of the course, if students be able to link the topics that has been covered in the class will be helpful in their life this enhances their motivation to learn, the participant teacher used this strategy in his lessons.

Although professional development programs and workshops, educational courses, professional readings could serve as sources of contribution to PCK, it is in the classroom wherein science teachers' PCK takes form and is shaped. Preparing science teachers with the necessary knowledge of components/knowledge base of PCK to close the feedback loop between teaching and learning can bestow further development of science teachers PCK.

The further development of science teachers' PCK could also be supported as they learn from their practice. Educative curriculum materials can boost science teachers' development of PCK as they teach. Davis and Krajcik (2005) put emphasis on use of educative materials providing support for PCK. Davis and Krajcik stated that, for example, the use of appropriate educative materials can help teachers anticipate common student misconceptions, in addition to understand reasons why students might hold these ideas. Davis and Krajcik, further, asserted that the use of educative curriculum materials would also put forward suggestions to help teachers challenge students' thinking through analogies and alternative ways of representing ideas. According to Davis and Krajcik, in the course of vibrant interactions between teacher and curriculum, both would be transformed.

The focus is to clarify the transformation of knowledge of teacher into the content of instruction. This reaches us to a conclusion as pedagogy and content are parts of inseparable body of understanding (Ong, 1958). Teachers, who have PCK, are expected to know how efficiently to transform the knowledge to pupils, which preconceptions or alternative conceptions do pupils have for current topic, and which strategies are beneficial to overcome these alternative conceptions of pupils etc. Teachers have knowledge of which conceptions are generally misunderstood by pupils and knowledge of which strategies are helpful to overcome these misconceptions. Teachers are not only master of procedure, but also content, and basic grounds. They are also capable of exposing why something is done and reflecting self-knowledge (Shulman, 1986). We would like to finish my review as Shulman did in 1986. He concludes his article by changing Mr. Shaw's calumny "Those who can, do. Those who understand, teach".

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