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# Pre-Service Science Teachers Views of In-Service Science Teachers' Pedagogical Content Knowledge

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**Abstract**

The aim of this study was to determine the pre-service science teachers' views on Pedagogical Content Knowledge (PCK) expected to be possessed by science and technology teachers. With this aim, senior pre-service science teachers' evaluations of the science and technology teachers that they observed at primary schools while they were enrolled in the school experience course. A "Focus Group Interview" was realized with 10 pre-service teachers. The data were analyzed by "descriptive statistics and content analysis methods" and 5 themes were attained. The five themes are: subject matter knowledge, the knowledge of instructional method and strategies, the knowledge of science curriculum, the knowledge of assessment of students and pedagogical knowledge. Generally, the pre-service teachers saw a necessity of the following issues in teaching science and technology: i) sufficient subject matter knowledge and effective communication skills, ii) establishing a balanced authority, iii) following modern innovations, methods and techniques for teaching and training and implementing them successfully in classrooms, iv) effectively usage of the teaching materials, educational technology, and lab facilities.

*Key words*: Pedagogical Content Knowledge; Pre-Service Teachers; Science and Technology

## Introduction

The science and technology courses are important for students to gain a scientific point of view and to learn problem learning skills. One of the most important factors which increase the effectiveness of teaching science and technology is the teacher competencies. Teachers' competencies are pivotal for achieving the targeted level of learning for students. In the literature teacher qualifications are discussed under the title of Pedagogical Content Knowledge (PCK). The concept of PCK was defined for the first time by Shulman (1986; 1987). Shulman (1986) has stated that it had not been questioned before that how the content area is transferred from the teachers' knowledge to the content of the instruction. Therefore, he regarded the PCK as the "missing paradigm" since it was not focused and investigated within the paradigms of teaching. He also stressed that the missing paradigm has consequences for both educational policies and research studies. Shulman (1986) defined the PCK as ways of presenting the subject matter for others to understand better. In other words,

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the PCK is using more powerful analogies, drawings, metaphors, examples, explanations and demonstrations in order to make the subject matter comprehendible. Shulman's ideas has been a framework for several researchers (e.g., Carpenter et al., 1989; Smith & Neale, 1991, Lederman 1992) to study the complexities of teacher knowledge and teaching (Smith & Neale, 1991), and also for discussing and developing the concept of PCK within the field of educational research.

According to Shulman (1987) PCK shows the union of content knowledge and pedagogy. Shulman (1987) divided teachers' knowledge in 7 categories as follows: 1. content knowledge, 2. general pedagogical knowledge, 3. knowledge of the curriculum, 4. pedagogical content knowledge, 5. knowledge of learners and their characteristics, 6. knowledge of educational contents, 7. knowledge of educational aims, goals, values, and philosophical and historical foundations. Shulman (1987) defined PCK as a special amalgam of subject matter and pedagogy. Other researchers who studied PCK (e.g., Tamir, 1988; Grossman, 1990; Cochran, DeRuiter & King 1993; Magnusson, Krajcik & Borko, 1999) investigated PCK in different categories.

Furthermore PCK is discussed in two different points of views as "Transformative Model" and "Integrative Model". Some researchers, classified the subject matter knowledge as a different category from PCK, and presented a transformative model. Gess-Newsome (1999) articulated on and disclosed the differences between the two models. On transformative model the subject matter knowledge is discussed as a different knowledge category from PCK and this subject matter, either its pedagogy and context knowledge improved either together or separately, it is included to PCK. And in integrative model the subject matter knowledge is discussed as one of the knowledge categories of PCK and subject matter, and is integrated into the teaching process by improving the pedagogy and context knowledge separately.

By depending on Shulman's views about the PCK, Grossman (1990) and Magnusson and others (1999) presented a transformative model. They told that the subject matter knowledge is a different knowledge type from PCK. They proposed that a good content knowledge is a precondition and the ingredients which include subject matter knowledge as well may transform to PCK. But it is proposed that PCK doesn't have a different knowledge ingredient, the ingredients improve separately (Marks, 1990) and the experience improves all the teachers' knowledge (Kind, 2009, p. 180). Teachers' education based on more often to experienced teachers' integrative PCKs then the requirements of the pre-service teachers. The researches figure that the subject matter knowledge must integrate with other different knowledge components. And to do that it is required to study more closer on both about the transformation period of subject matter knowledge and how the other knowledge components appears at pre-service teachers (Kind, 2010, p.109).

As it can be understood from the literature, PCK is defined and studied as according to some researchers as it has similar components and according to some others it has different components. And even some researches approach the subject knowledge as a different component from PCK (Shulman, 1987; Grossman, 1990; Magnusson, Krajcik & Borko, 1999). Although PCK provides teaching ways to achieve students' understanding to the successful teachers, the general "indefiniteness" still continues (Loughran, Berry & Mulhall, 2006, p.14). Also there is not a conceptualization accepted as universal of PCK (van Driel, Verloop & Vos, 1998). What teachers should know and how they should teach to their students has become a focus of the researchers and as long as these studies continue, the discussions and the disagreements will continue on the subject.

At the present study, we aimed to investigate pre-service science teachers' views about PCK by assessing science and technology teachers' PCK in during preservice teachers' observations in school experience lessons. For this purpose, PCK is studied under 5 categories. These categories were determined as follows: i) subject matter knowledge, ii) knowledge of instructional methods and strategies, iii) knowledge of science curriculum, iv) knowledge of assessment of students, and v) pedagogical knowledge.

## Method

### *Research Design*

This study was designed as a qualitative case study. Case studies generally focus on phenomena which represent individual groups, individuals, it searches the phenomena by broadening time and space in its natural environment, describes this phenomena as rich because it provides deep knowledge from various sources (Hancock & Algozzine, 2006, 15-16). Case studies are the most common way of qualitative inquiry (Stake, 2005, p. 443) which is trying to find answers to the questions of how and why (Yin, 2003, p. 22). The data at case studies can be provided by observation, interviewing and documents (Yin, 2003). Besides this, the data collection methods can diversify among themselves. Both the individual interviews can be made and also the group interviews can be made with the participants of the study. Group interviewing is a developing form of interviewing that can be implemented in structured, semi-structured, or unstructured format and that is gaining some popularity among social scientists (Denzin & Lincoln, 1998, p.53).

In this study, from the methods of qualitative data collection, "Focus Group Interview" was used. Before the interview, by considering the PCK categories as basic, 5 main questions were prepared to clarify the mentality of pre-service teachers. During the focus group interviews with pre-service science teachers, we wanted to understand every participant's opinions and also tried to get a deeper view by asking new questions according to the answers during discussions or seeking comments on their peer's answers. The focus group interviews are an advantageous method to get efficiency from interviewing time when the participants have similar characteristics (Creswell, 2007, p. 133). Besides, the participants, when they were given an opportunity to speak, did not show reluctance, but rather positively engaged in the discussions by openly were expressing their views either by refusing or accepting the group member's views. We felt that in this way we could obtain a richer and deeper form of data from the participants. Moreover, we felt that, our previous trainings on qualitative research methods knowledge about the PCK issues in the literature have positively contributed to increasing the validity and reliability of this research study. The focus group interviews were conducted according to a semi-structured plan of questions. The interviews were recorded verbatim and were analyzed as a whole.

### *Participants*

A group 10 (2 male, 8 female) senior preservice science teachers enrolled in a large metropolitan university participated in this study. The point here is that sampling for focus groups typically involves bringing people of similar backgrounds and experiences to participate in a group interview about major issues that affect them (Patton, 2002, p. 236). The participants took the "school experience course" for a semester before the focus group interview. By this way they could share their opinions, observations and evaluations that they already observed during the lessons of their in-service teachers' PCK.

### *Data Collection Instrument and Procedures*

A focus group interview is an interview with a small group of people on a specific topic. Groups are typically 6 to 10 people with similar backgrounds who participate in the interview for one to two hours (Patton, 2002: 385). The focus group interview lasted approximately 1.5 hours and was recorded by a voice recorder. The interview questions provided the pre-service teachers' assess the science and technology teachers who are already observed in school experience course under the PCK categories. From 7 semi-structured interview forms of questions which prepared before the interview, 5 questions could directed to the pre-service teachers because of 2 questions answered by in the concept of other questions. Beside this, some other intermediary questions are directed to the pre-service teachers to provide deep opinion. It is tried to get pre-service teachers' opinions for each of the questions in accordance with the focus group interview. In this process the pre-service teachers are attended to each other's opinions, suggested opposite opinions, at the same time they presented different opinions. In this regard, it can be said that the focus group interview was efficient to get rich data.

*Data analysis*

The data provided as voice records from the interview, was transformed into a written form later. The transformed written documents were analyzed by descriptive and content analysis techniques. In content analysis the basic aim is to achieve the relations and concepts which can explain the relation from the collected data. The data collected by this aim, first of all has to be conceptualization, and then organizing mentally according to the apprehended concepts and according to this it needs to determination of the themes which explains the data (Cassel & Symon, 2004). The opinions of the pre-service teachers which transformed into document form are analyzed by HyperRESEARCH 2.8.3 software for qualitative analysis.

According to the analysis results; it is achieved 6 themes as, to know the subject content, to manage the class effective, to use materials in teaching, to know the teaching methods and techniques, to know alternative assessment methods, to know science curriculum. These themes are made re-theme under 5 categories of PCK which selected from the written subject. These themes are determined as; subject matter knowledge, the knowledge of instructional method and strategies, the knowledge of science curriculum, the knowledge of assessment of students and pedagogical knowledge.

## Analysis and Findings

The science and technology teachers' pedagogical content knowledge which is observed within the content of the pre-service science teachers' school experience course is searched the 5 sub-categories of; subject matter knowledge, the knowledge of instructional method and strategies, the knowledge of science curriculum, the knowledge of assessment of students and pedagogical knowledge. In every category, the results, reviews and direct quotations that provided by analysis of pre-service teachers opinions are given. Pre-service teachers' names were coded with PT1, PT2, … , PT10.

*1. The Results of Pre-Service Science Teachers' Views about the Subject Matter Knowledge of In-Service Teachers*

All of the pre-service teachers are frequently mentioned the importance of the science and technology teachers' sufficiency on subject matter knowledge.

> *PT4: "… the content knowledge is very important. While in high school I asked a teacher a question, he did not answer, I asked two questions and he did not answer.*

*Now when I remember him I say that he knew nothing. I mean I don't want to be remembered like that."*

The pre-service teacher PT1 notified that the teacher he observed doesn't have subject matter knowledge. PT1 achieved this result because of his not answering the questions and his suspension.

*PT1: "... when it comes to content knowledge I faced mostly clichéd, non-renewed information ... Because of this reason he was answering students' questions either at a basic level or if he didn't know the answer, he was giving a homework to search for the answer of the question."*

Additionally, *PT6* and *PT9* are highlighted that besides the science and technology teachers' content knowledge, their own content knowledge is also not sufficient.

*PT6: "The content knowledge should be sound… Our content knowledge is weak by this training. We don't know students' knowledge and misconceptions."*

*PT9: "We are lacking a great deal in our field, we will complete within the process of becoming teachers. But the important thing is not only to know the subject matter, it is more important to transfer it to the students."*

The pre-service teachers approach the teachers' subject matter knowledge in terms of answering students' questions related with the subject and to have knowledge about the students' misconceptions. And they notified that teachers' and their content knowledge are insufficient. And they also highlighted that the teacher who has not sufficient knowledge will lose his respectability in the eyes of the students. In this context the pre-service teachers' one of the most highlighted knowledge contents which required to be possessed by a science and technology teacher is the *subject matter knowledge*.

*2. The Results of the Pre-Service Science Teachers' Views about the Knowledge of Instructional Method and Strategies of In-Service Science Teachers*

While 3 of the pre- service teachers find the teacher's teaching methods and techniques efficient and effective, the others find it insufficient. More over some pre-service teachers told about the teacher didn't use any method and didn't create a teaching environment.

*PT2: "... I mean he is not even explaining the subject, he directly says 'open that page, read here, and fill in there', he is not making any entrance to the subject ..."*

While the PT3 find the teacher that she observed as sufficient in terms of his methods and strategies because of using visuals in the course and affording to incorporate the students, but PT6 find the teacher insufficient because of using traditional teaching methods.

*PT3: "... In a subject about Mendel's cross he had two bags made each of 50 pieces of capital "D" and small "d" separately in a fashion a student seeing this subject for the first time could understand it. He made the students draw one from one bag and put in the other ... then he began telling about Mendel then he used this as an entrance to the subject. I liked it very much… He is also showing visuals by using data a projector."*

*PT6: "...we here see a lot of teaching methods and techniques but I was so surprised when I went to school observation none of them was being used. ... only old type*

*presentation but there is only one thing that we observed from our teacher is using only the "portfolios". She tells her students to 'search the subject from internet and put them into your portfolios' ... (PT6 is not satisfied)"*

Beside this, PT1 and PT4 who observed the same teacher give comment by attending each other's opinions about the insufficiency of the teacher on using technology and laboratory implementations. And two of the pre-service teachers were agreed that the teacher wouldn't utilize from the opportunities in science and technology course and it is required to use laboratory efficient.

*PT4: ...when he starts the lesson, he only says hello and last week which subject we learn. I think, at that time any equipment from laboratory can be enough to take attention of the students.*

*PT1: He even doesn't know to prepare Power Point presentation; I mean he is so backward.*

*PT4: (the teacher's) we think even he occupied the lab without a reason! (PT4 and PT1 laughed.)*

The pre-service teachers discussed the sufficiency of the teachers' knowledge of instructional method and strategy by constructivist approach and traditional approach. Therefore, the pre-service teachers are thinking that it is required the use the approaches which takes the students on focus in science and technology courses and most of the pre-service teachers are thinking that the teachers are insufficient about the technology knowledge and they see this as it is a deficiency for a teacher.

*3. The Results of Pre-Service Science Teachers' Views about the Knowledge of Science Curriculum of Teachers*

The pre-service teachers who think about the observed teachers are insufficient in teaching and training, notified that the science and technology teachers are generally following the curriculum from the lesson book and exercises books and they pass the lesson with the homework as given at those books. For example PT4 told his observation about a teacher who follows the lesson from the lesson book.

*PT4: "Only he made the student read the subject from lesson book and says "Ahmet continue to read", he ends the lesson as next week while you are coming solve the problems at your books, do this and turn like this."*

But PT8 told that the teacher solved the questions about the high school entrance examinations and told the subjects about that. In this context, it took the pre-service teacher's attention that the teacher he observed was more following the examination content than Science and Technology Curriculum.

*PT8: "...As how much she is not successful on education I just observed as he more telling the lesson oriented the examinations..."*

From the pre-service teachers' *PT10* mentioned that the curriculum knowledge that the science and technology teachers should have is an important factor which affects the other pedagogical content knowledge components.

*PT10: "...if he doesn't know the curriculum he cannot draw his way, if he doesn't plan what, where and how he will tell, he cannot realize an effective teaching. To know the*

*curriculum manages the teacher to think about which subject, and tell with which method and technique."*

The pre-service teachers generally mentioned that one of the most important components of the PCK is science curriculum knowledge. And the pre-service teachers see curriculum as a guide.

*4. The Results of the Pre-Service Science Teachers' Views about the knowledge of assessment of Teachers*

From the pre-service teachers PT2 doesn't find sufficient the assessment knowledge of the observed teacher. Unlikely the PT8 find his science and technology that he found weak in many components of PCK, he found the teacher sufficient on assessment knowledge because of giving the required feedback to the students and effective solving problems.

*PT2:"Because he doesn't have any activity, there also not any assessment. He is giving the assessment questions as homework. Then solving at the classroom but doesn't give feedback as true or false"*

*PT8:"… She is finding different questions and solving them and at the lesson he examines each question one by one. Even she is hard at the lessons she even response the wrong questions. In fact I think she is a good teacher by this way…"*

*PT5* and *PT10* are in opinion of the observed teachers made effective assessments because of their using alternative methods and techniques to value observations of the students.

*PT5:"She is making performance assessment. Make the students presentation of their studies, asking questions to the other students, she controls whether they are listening or not. She is asking questions to the students who are not listening"*

*PT10:"The teacher is really good … I really surprised, at past there 10 open ended questions were asking, now I looked at to the written paper the teacher asked various questions. I asked the teacher did you prepare these questions. He said yes. I prepared according to the multiple intelligences theory, I mean this attract me so much really..."*

Generally, pre-service teachers gave the examples of assessments of the observed teacher as question answer type. And two pre-service teachers mentioned that observed teacher can make effective process assessments.

*5. The Results of the Pre-Service Science Teachers' Views about Pedagogical Knowledge*

It is discussed that the class management, communication and understanding of students within the concept of pedagogical knowledge. The views of the pre-service teachers on pedagogical knowledge is assessed by considering their examples such as open to the innovation, to follow current events, to make the lesson rich by materials, to be in a good communication with the students and to be at balance on authority.

*PT1 "… to give a harsh reaction is wrong, the reason under his behaviors should be review, he shouldn't be exaggerated about discipline."*

*PT3: "… To be a teacher requires following the innovation."*

*PT4: "He is starting by saying only hello, where we were last week?... He doesn't have ability of using projector and computer… if he uses the tools and equipments at lab, the students' attention will be taken."*

*PT7: "… teacher establishes eye contact equally with everyone and uses his mimics good and even sometimes he laughs. I mean the communication is quite good he is asking one by one… he is a social person, he has information about the current life, and he doesn't leave the questions without response in every way he turns..."*

*PT10: "According to me to establish authority with love is more logical, and first impression is important, in the beginning of the course it can be hard, but then he should provide this authority by endearing himself, the teacher I mean the student should not afraid from the teacher, he has to afraid to lose his love…"*

Furthermore PT9 and PT8 agreed on each other's opinions that especially to be the communication skill first, the teacher who doesn't have sufficient pedagogical knowledge, will not be sufficient even he has enough subject matter knowledge.

*PT9: "I think there needs communication skills besides subject matter knowledge… I as how much I have the subject matter knowledge, if I cannot tell this, if I cannot make it attractive, if I cannot establish the eye touch, I don't think that the things I am telling will not have any efficiency."*

*PT8: "I agree to my friend at this subject certainly. The subject knowledge is really important… but the person has one hundred per cent of content knowledge but if he transfers only fifty percent of it, this has no importance for the students."*

Finally it is asked to the pre-service teachers how a teacher they want to be but in a very surprising way most of the pre-service teachers mentioned that they answered the question with an idealist opinion for now and depending to the further conditions their behaviors and acting can be change. Beside this, they have the opinion of the real teaching environment is not as easy as thought to be, many factors such as the students to be educated and the school conditions will be effective.

*PT9: "Everybody is thinking idealistically but we are talking to newly appointed teachers. They are saying 'no it is not happening, not happening like in the books'."*

*PT3: "...My goals for being a teacher are really idealist… we will be in lack of materials, our environment will be very bad but I believe that if a person wants… then really works for the students. And I believe I will get its reward in return."*

In this context the pre-service science teachers identified their opinions as who will have the teaching skills that means PCK components will be increased by experience and time.

**Conclusion and Discussion**

The results of the study are discussed under the PCK components at this section. The pre-service teachers who observed the same science and technology teacher is parallel to each other on assessment of the teachers' content proficiency. The pre-service teachers pointed out similar subjects and explained their opinions. First of all in the context of subject matter knowledge of science and technology teachers are not sufficient according to pre-service teachers. The pre-service teachers assess the subject matter knowledge of the teachers' proficiency more often according to their response to the students' questions and their

response to students' requirements about the subjects. By this way widely mentioned as a teacher who has enough subject matter knowledge, will establish an effective communication between the students by protecting his dignity he will realize more effective teaching. And it is a widely opinion among the pre-service teachers that a sufficient subject matter knowledge of a science and technology teacher is required and very important. Beside this the pre-service teachers see their own subject matter knowledge as well and they think they will improve during their teaching experience. Mıhladız (2010) at her study mentioned that the pre-service teachers see themselves weak in many of the fields first of all by the subject matter knowledge, in this context their efficacy belief is so weak but they mentioned that they can complete their deficiency by the experience they will get from the teaching period. The pre-service teachers think that they will be sufficient by the experience they will get from the real teaching period not only on the subject matter knowledge but on the other factors of pedagogical content knowledge as well. Related to this result, Uşak (2005) reached the result that there is no relation between pre-service teachers' subject matter knowledge and pedagogical content knowledge. Canbazoğlu (2008) determined to subject matter knowledge is a type of knowledge related to PCK. Also, Özden (2008) stated that the subject matter knowledge has a positive effect on PCK and on teaching the states of matter. Similarly subject matter knowledge is an important type of knowledge for the teachers as revealed by other studies (e.g., Hashweh, 1987; Marks, 1990; van Driel et al., 1998).

In terms of the science and technology teachers should have the knowledge of teaching method, technique and strategy, the pre-service teachers are thinking that must be use to approach by focusing students in science and technology courses. "Constructivist Approach" and "Multiple Intelligence Theory" among the pre-service teachers are taking its place as more highlighted approaches. Half of the pre-service teachers are agreed on the teachers they observed are not sufficient because of their using question-answer method and lecture method. Canbazoğlu (2008) at the result of her researches mentioned as a parallel opinion to the pre-service teachers that the traditional techniques and methods are using at teaching. And highlighted that half of the pre-service teachers are not used the lab and technology by the observed teachers is a deficiency. Beside this, some of the pre-service teachers mentioned that because of the entrance to the high school examinations, during their lessons science and technology teachers always solving problems. For the pre-service teachers the teacher profile who have sufficient knowledge of teaching method technique and strategy; uses various and different activity and also technology in lessons and carry out lab activities in science courses. According to results of their studies, Boz and Boz (2008) stated that pre-service teachers preferred to "tangible objects", "computer animations" and "explaining teaching methods" as a teaching method and strategies. At the study, as general pedagogical knowledge, subject matter knowledge and many other knowledge the selected strategy to teach subject is been main factors of teaching strategy.

Pre-service science teachers are agreed on the knowledge of curriculum is the important proficiency which needs to be in science and technology course. The pre-service teachers are thinking about that teaching curriculum is a main factor which manages teaching. Beside this the common view is the insufficient teachers are following the lessons only by reading the lesson books and the sufficient teachers are implementing different activities under the curriculum subjects. A done of the mentioned view is the teachers are carrying out the lessons according to the high school examinations. As Hasweh (1985) mentioned that he find out the teachers whose subject matter knowledge is sufficient can make differences at the activities at lesson book but the teachers whose subject knowledge is insufficient only follows the lesson book activities. Because of this reason the subject matter knowledge is a very important knowledge type (Koehler & Mishra, 2008, p.13).

The pre-service teachers discussed the observed science and technology teachers' assessment knowledge by based on traditional measuring and assessment methods. The pre-service teachers told that they found sufficient the teachers who uses different type questions, who gives time to the students to attend the assessment activities in classes, who shows ways, who gives a satisfactory responses. The research results are consistent with Uşak (2005) is put forward that the pre-service teachers are using traditional measuring and assessment methods. A small percentage of the pre-service teachers mentioned the alternative methods of assessment. These pre-service teachers are agreed on the portfolio implementations of the alternative assessment methods are not realized appropriately by the teachers.

The pre-service teachers' opinions about pedagogical knowledge are generally insufficient. Less of the pre-service teachers mentioned about the individual characteristics that the teacher should have. Generally, preservice teachers give importance about communication and class management subjects. In this context, they pointed the importance of science and technology teachers' behaviors during their entrance to the classroom and the beginning activities they done. The facts as understanding of the students, motivating to the lesson, taking attention to the lesson, to provide convenience communication environment, to establish a balanced authority, to use rich materials are very often subjected by pre-service teachers. And Mıhladız (2010) at her study reached the conclusion of only very little part of the pre-service teachers' mentioned opinions about pedagogical knowledge can be reflected at the class implementations.

And one of the most important results is the views about the lessons that all pre-service teachers take during their pedagogical training at school will not be very effective in teaching experience period. The pre-service teachers are thinking that depending to the conditions that they will make teaching, will get experience and they will arrange themselves according to those conditions.

## Suggestions

By considering the pre-service teachers have attained partial knowledge about the PCK components concepts, it is taught that to improve their PCK, to review the contents of the courses and to go to the reformation in pre-service teachers' education so it will be efficient for an effective teaching of the future teachers.

During the period of the pre-service teachers training if more teaching implementation courses are provided to pre-service teachers they can find opportunities for composing their pedagogical and subject matter knowledge so their pedagogical content knowledge will improve by practice.

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