

Preservice Science and Technology Teachers' Pedagogical Content Knowledge on Cell Topics

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Abstract

The purpose of this study is to explain preservice science and technology teachers' pedagogical content knowledge (PCK) about the cell. Lesson preparation, laboratory plan, interview with teacher candidates, and concept mapping were used to collect the data for preservice teacher's PCK. The study was conducted with six preservice science and technology teachers in the spring of 2006-2007 in Pamukkale University-Turkey. We aimed to identify the content and structure of the PCK for a topic on cell, describing the PCK in terms of relations between four different aspects: Knowledge about science and technology curriculum, belief about subject matter knowledge, knowledge about students' understanding; knowledge about assessment of students. According to the result of the study, pre-service teacher's knowledge inaccurate special teaching methods, they used a teacher-centered approach, and also they have a high belief of subject matter knowledge. Based on the result of this study, which were discussed in the light of national and international literature, we have suggestions for further researchers, curriculum developers, and science and technological teacher educators.

Key Words

Cell, Pedagogical Content Knowledge, Pre-service Science and Technology Teacher.

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Over the past 25 years, numerous research studies have examined how pre-service teachers develop different knowledge bases. Teacher knowledge bases have been classified as craft-knowledge (Day, & Pennington, 1993), working knowledge (Grossman, 1990), and pedagogical knowledge (Hudson, Usak, & Savran-Gencer, 2009; Shulman, 1986). Additionally, a different knowledge base, called pedagogical content knowledge (PCK), was introduced in the 1980s (Abd-el-Khalick, 2006; Bindernagel, & Eilks, 2009; De Jong, Van Driel, & Verloop, 2005; Grossman, 1990, 1992; Ozden, 2008; Shulman, 1986, Usak, 2005; Van Driel, De Jong, & Verloop, 2002, Sanders, Borko & Lockard, 1993)..

Shulman (1986, p. 9) described PCK as:

"[PCK includes] the most useful forms of representation of [topics], the most powerful analogies, illustrations, examples, explanations, and demonstrations – in a word, the ways of representing and formulating the subject that make it comprehensible to others. Pedagogical content knowledge also includes an understanding of what makes the learning of specific topics easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning of those most frequently taught topics and lessons."

Elaborating on the Shulman's work, other scholars have proposed different conceptualizations of PCK (Grossman, 1990; Marks, 1990). Geddis et al (1993) added that PCK in every curriculum includes special attributes enabling teachers to transfer subject matter knowledge into their knowledge base for teaching. Cochran, Deruiter, and King (1993) proposed an integrative model for teacher preparation helping teachers develop PCK. In addition, Magnusson, Krajcik, and Borko (1999) have presented a strong case for the existence of PCK as a separate and unique domain of knowledge.

Usak (2005) stated that pre-service elementary science teachers' PCK includes information about the student and curriculum, pedagogical knowledge and assessment knowledge, which shows differences from teacher to teacher. Nakiopoglu and Karakoc (2005) contended that there are three categories of knowledge base in Turkey: content knowledge, pedagogical knowledge, and general cultural knowledge. However, in the recent years, a fourth knowledge base, pedagogical content knowledge, as significant as the others, was introduced.

Recently, a new knowledge base was introduced called Technological Pedagogical Content Knowledge (TPACK) referring to the complex in-

terrelationship between a teacher's technology use, instructional methods, and understanding of the subject matter (Mishra, & Koehler, 2006; Arnold, Padilla & Tunhikorn, 2009).

Numerous research studies have been conducted to investigate the PCK of teachers, including science teachers (De Jong et al., 2005; Geddis, Onslow, Beynon, & Oesch, 1993; Hashweh, 1987; Lee, Luft, 2008; Smith, & Neale, 1989; Van Driel et al., 2002; Friedrichsen, 2008). Several researchers also investigated pre-service science teachers' PCK such as De Jong et al. (2005), Van Driel, Verloop and De Vos (1998), Van Driel et al. (2002), Ozden (2008). Different ways to develop PCK in science education have been proposed by Van Driel, Verloop, and De Vos (1998) Van Driel, De Jong, and Verloop (2002) and Henze, Van Driel, and Verloop (2008). It was concluded that research on topic-related PCK should be supported by research on student learning of specific topics. There was a bi-directional process involving better understanding of subject matter knowledge and increasing awareness of pedagogical issues. Similarly, Van Driel et al. (1998) and De Jong et al. (2005) figured out that pre-service teachers developed their PCK through learning from teaching. The relationship between subject matter content and pedagogical content knowledge is also investigated.

Few scholars have studied science teachers' subject matter knowledge and PCK. Usak (2005) found a significant relationship between student teachers' SMK and PCK. Also, pre-service science teachers' content knowledge had positive effect on pedagogical content knowledge and effective teaching (Ozden, 2008). Käpylä, Heikkinen, and Asuntaa (2008) investigated the effect of the amount and quality of content knowledge on pedagogical content knowledge, in which photosynthesis and plant growths were used as an example. They found that primary student-teachers were not aware of students' conceptual difficulties and had problems in choosing the most important content.

Method

Participants of the Study

The participants of this study were six pre-service teachers (4 females and 2 males) from science and technology education department at Pamukkale University, Faculty of Education in the spring semester of 2006-2007. Students were selected with purposive sampling method and

the mean of age was 23 years old. All participants were attending the last year teaching internship program and were selected based on their academic achievement and willingness.

Data Collection

In order to collect the data, pre-service teachers' lesson plans, lab reports and concept maps were used and pre-service were interviewed.

Lesson and Lab Plan: In numerous research studies, lesson and lab plans were used as instruments to gather research data (e.g., Ozden, 2008; Usak, 2005; Van der Valk, & Broekman, 1999). The participants of this study were asked to prepare a lesson and a lab plan on cell concepts for six grade students and follow this plan in the classroom during their practicum teaching.

Concept maps: Concept map is a useful instrument to collect data on pedagogical content knowledge (Gess-Newsome and Lederman, 1999; Reitano, 2004; Usak, 2005). Concept maps were used in this study to evaluate the participants' knowledge of the science and technology curriculum. The participants were told to draw a concept map related to cell concepts which can be used in sixth grade science and technology course. Boud, Dunn, and Hegarty-Hazel (1986) investigated and compared concepts on concept maps and concepts on teaching program and their aims. Prepared concept maps with prospective science and technology teachers and concepts related the science and technology program were compared in this study and compared phrases whether or not related program and objectives also whether or not related the concept map were also investigated.

Semi-structured interview: In numerous research studies related to Pedagogical Content Knowledge in last twenty years, interviews have been used as data collection instrument (Bindernagel, & Eilks, 2009; Ozden, 2008; Usak, 2005; Van Driel et al., 1998). In the present study, after the participants completed their practice lessons, they were interviewed to understand the approached they used to prepare lesson plans, concept maps and lab plans. First section of the interview took between 40 and 60 minutes. They were asked about teaching method, belief for their field knowledge and their understanding related the pedagogical content knowledge in second section of interviews. This section took between 30 and 40 minutes.

Analysis of Data

After collected data, following analysis is made;

1. Researcher and two experts checked lesson plans which were prepared by prospective science and technology teachers. One of the experts have studied biology education and the other studied cell biology. They investigated about how prepared materials teach better and whether concepts are correct in terms of cell biology or not.
2. Researcher and a field expert decided together in order to use paragraph, passage, and sentence in the study.
3. Texts are used in the result section after the researcher and the field expert discussed and come to a consensus.
4. All interviews are listened to many times and transcribed verbatim.
5. Redact data separated into categories according to the sub-components based on the criteria of pedagogical areas.
6. Prepared laboratory plans were evaluated in terms of laboratory approach.
7. Moreover, prepared laboratory plans were evaluated in term of science and technology program.
8. Prospective science teachers' lab applications and whether they used assessment tools were evaluated in terms of student understanding.
9. Prospective science teachers' concept map drawings have been reviewed.
10. Concepts in the concept maps have been matched with acquisitions in the education program.
11. If the concept of the concept map is related acquisitions in the drawn concept map by prospective science teachers, 1 point is given. If the acquisition has not been fulfilled, 0 point is given.
12. All the findings derived from the data collection tools as appropriate to the sub-dimensions of pedagogical field knowledge are given in the results section and the knowledge of prospective science teacher was interpreted.

Results

Pre-service Science & Technology Teacher's Knowledge of Curriculum

Pre-service science and technology teacher's knowledge of science curriculum was examined using the lesson plans and concept maps. In this study, most pre-service teachers' knowledge was not adequate in terms of the time planning compared to the mandatory time requirement in the curriculum. Two teachers have made suitable time planning. It was seen in the concept maps that student teachers had necessary information on the concept of cell in the science curriculum.

Belief about Subject Matter Knowledge

Pre-service teachers' thoughts about SMK were obtained via interviews. Pre-service teachers believe that their SMK is appropriate for teaching the cell. In other words, their self-efficacy is very high to teach this subject.

Knowledge about "Instruction"

Pre-service teachers preferred close-ended laboratory approach and traditional evaluation. Only one prospective teacher preferred open-ended laboratory approach and peers and group evaluation. Consequently, it was observed that pre-service teachers preferred teacher-centered approach rather than various repertory representations. When prospective teachers' lesson plans were reviewed, it was found that four used teaching approach from micro level to macro level (*from cell to organism*) and two used teaching approach from macro level to micro level (*from organism to cell*).

Approach to assess students' understanding

Lesson plans, interview, and laboratory plans were used to examine pre-service teachers' assessment approach about the subject of cell. Findings showed that prospective teachers were using different types of questions (true-false, open-ended, matching, and so on) to assess their students. Traditional and alternative assessment approaches were used to evaluate students' understanding of cell (Table 1). An Interesting result of this study is that all pre-service teachers asked the same question for open-ended exam: "*What is cell, describe it.*"

Table 1.
Pre-service Teachers' Approaches to Assessment

Type of Question	Teacher no					
	PPT1	PPT2	PPT3	PPT4	PPT5	PPT6
Open-end question	X	X	X	X	X	X
Multiple choice	X	X	X	X		X
Gap-filling			X		X	X
Matching	X					
True-false		X		X	X	
Performance evaluation		X			X	
Structured grid	X	X		X		
Concept map		X		X	X	

Results

Prospective science teachers' pedagogical content knowledge about the cell concepts was evaluated in this study. According to the results, prospective science teachers have enough knowledge for specifically teaching the topic of cell and science education program. This result supports the view that pre-service teachers get adequate knowledge and skills during their education program. However, the qualification of prospective science teacher is thought directly related to teaching process, different results will be found in the literature. Ozden (2008) showed that information about the curriculum of prospective science teacher was not enough.

Another finding of this study is that the majority of the prospective science teachers did not have enough information about students' learning difficulties on the topics (Bahar, Johnstone, & Hansell, 1999; Bahar, & Polat, 2007, Childs & Sheehan, 2009). Similar results have also been reported in various studies (Henze, Van Driel, J& Verloop 2008; Federik, Van der Valk, Leite, & Thoren, 1999).

In this study, another important result is also related to the classroom environment. Only some prospective teachers presented student activities as a pedagogical part of the information. They used teacher-centered approach in the classroom even though there are many material and technological tools. These results fit in some previous research findings (e.g., De Jong, Ahtee, Goodwin, Hatzinikita, & Koulaidis, 1999; Lederman, Gess-Newsome, & Latz, 1994)

One of the important results obtained in the study is that concept maps are unique to each prospective science teacher. Even though all prospective science teachers explained the cells according to curriculum; they did not emphasize the same points. These results showed that teachers need to know teaching and curriculum knowledge as well as teaching materials and activities (Magnusson et al., 1999). Regarding the assessment, the prospective science teachers used alternative methods of measurement and evaluation as well as traditional methods. This result is similar to the findings of Staley (2004), Usak (2005), and Ozden (2008). Prospective teachers can use alternative assessment methods for determining students' comprehension levels.

The results of this study show that prospective science teachers' information is not adequate related subject-specific teaching methods, adopting and thinking science and technology literacy. Prospective teachers who feel comfortable about the field knowledge are not adequate in the professional experience and educational theories. These results support that idea that pedagogical work is generally less effective (Adams, & Krockover, 1997).

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Ek 1. Hücre Konusunun Öğretimiyle İlgili Pedagojik Alan Bilgisi Mülakat Soruları

1. Biz öğretmen olarak hücre konusunu neden öğrenir ve neden öğrencilere öğretiriz?
2. Hücre ile ilgili olarak öğrencilere öğretmek istediğiniz en önemli konu nedir?
 - a) Bu konunun neden çok önemli olduğunu düşünüyorsunuz?
 - b) Dersinizde öğretilecek başka önemli konular var mıdır? Varsa onların neden önemli olduğunu düşünüyorsunuz?
3. Hücre konusuna giriş ve onun öğretiminde olması gereken üç önemli özellik nedir?
4. Öğreteceğiniz konunun önemli olduğunu nasıl tespit ediyorsunuz?
5. Size göre hücre konusunu öğretmenin en iyi yolu nedir? Niçin?
6. Öğrencilerin konu anlayıp/anlamdıklarını nasıl değerlendirdiniz? Öğrencilerin hücre konusu ile yanlış anlayışlarını nasıl düzeltirsiniz?
7. Laboratuvarı planlamanızda değiştirebileceğiniz nelerin olduğunu düşünüyor musunuz?
8. Eğer laboratuvar veya öğretiminiz hakkında bir değişiklik yapacak olsanız, bu değişiklikleri neler olurdu?
9. Hücre konusunun öğretimi konusunda kendinizi yeterli buluyor musunuz? Size göre bu konunun öğretimi ile desteğe ihtiyacınız var mı?

Ek 2. Öğretmen Adayının Hazırladığı Laboratuvar Planı

Dengenin Adı: Bitki hücrelerinde neler var?

Dengenin Amacı: Bitki hücrelerinin gözlenebilmesi

Araç ve Gereçler: Kuru soğan, lamin, lamel, mikroskop, iğne, ağzaltıcı, pens ve bisturi

Dengenin Yapılışı: Soğanı bisturi yardımıyla kesiniz. İki yapraklarındaki zardan pens yardımıyla alınır. Lamin üzerine bir damla iğne ağzaltıcı damlatılarak soğan zarını dikatlice yerleştiriniz. Lamin üzerine lameli kapatınız. Hava kurduğunuzda denegi mikroskopla inceleyiniz.

Sonuç: Soğan zarı hücrede; hücre zarı, stoplazma ve çekirdek olmak üzere üç temel yapı vardır. Bitki hücrelerinde hücre zarından başka, hücre vepari (duvar) denilen bir zar daha vardır. Hücre vepari; selülozdan yapılmış i çamır ve tam geçirgendir. Bitki hücresi şekil olarak dikdörtgenlidir.

Ek 3. Öğretmen Adayının Çizmiş Kavram Haritalarından Bir Örnek

