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Review of Studies Related to Pedagogical Content Knowledge in the Context of Science Teacher Education: Turkish Case

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Abstract

As a review study, the present study was carried out in order to introduce PCK construct to researchers and evaluate which aspects of PCK were studied in our country, and, finally, make recommendations in light of the analysis of the studies for further research. For this purpose, ERIC database, YÖK (Higher Education Council) database were searched by using "Pedagogical Content Knowledge" as keyword. Moreover, journals published in Turkey and which are possible to be reached electronically were searched using the same keyword. 28 studies in the science education context were analyzed by means of standards obtained from the related literature. Results showed that large part of the studies were conducted with pre-service teachers as case studies. Moreover, PCK was studied in terms of its components rather than as a whole. In addition to that, participant teachers and pre-service teachers have some shortcomings regarding to PCK, pedagogical knowledge, and subject matter knowledge. Findings will hopefully provide some insight for researchers since shortages of the related literature will be determined by this study.

Key Words

Pedagogical Content Knowledge, Science Teacher Education, Review of Literature.

One of the main purposes of science education in Turkey is to educate scientifically literate people (Milli Eğitim Bakanlığı [MEB], 2006, 2007). Considering this purpose, new science curriculum was developed and implemented. But studies showed that reforms in curriculum were not adequate to fulfill this aim (Cheung & Ng, 2000). Teachers' knowledge, skills, attitudes, and beliefs about new curriculum determine how and to what extent they implement the curriculum (Aydın & Çakıroğlu, 2010; Cheung & Ng; Gözütok, Akgün, & Karacaoğlu, 2005). In other words, teachers are one of the important factors affecting the success of new curriculum. At this point, both pre-service and in-service teacher education programs gain attention.

Different frameworks as PCK (Abell, 2007; Loughran, Mulhall, & Berry, 2004; van Driel, De Jong, & Verloop, 2002), conceptual change (Russell & Martin, 2007), situated learning (Putnam & Borko, 2000), teachers as learners (Loughran, 2007) have been used in teacher education studies. The most common one among them is PCK. Abell, one of the famous researchers in PCK field, attributed it to PCK's strength in guidance researchers and teacher educators in terms of which types of knowledge teachers have (Friedrichsen, 2008).

In the last ten years, number of studies conducted to obtain participants' PCK have been increasing rapidly in our country, even PCK has been studied in the master and doctorate theses (Canbazoğlu, 2008; Karakoç, 2003; Uşak, 2005) At this point, the present study is carried out in order to introduce PCK construct to researchers and evaluate which aspects of PCK were studied and make recommendations for further research.

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Literature Review

Shulman (1986) introduced PCK first to the literature. According to Shulman, it involves "representations and illustrations used to make the topic understandable to the learners during instruction" (1986, p. 9). Shulman (1986) stated that teachers need to have content knowledge, PCK, and curriculum knowledge. Following the study of Shulman, different researchers have put forward different PCK models (Grossman, 1990; Cochran, DeRuiter, & King, 1993, Magnusson, Krajcik, & Borko, 1999). Some of the models are named as transformative models and they accept PCK as a new type of knowledge acquired by means of content and pedagogical knowledge (for example Magnusson et al., 1999), some models are integrative (for example Cochran et al., 1993) and they accept PCK as knowledge formed as the amalgamation of content and pedagogical knowledge (Gess-Newsome, 1999)

In recent years, Magnusson et al.'s (1999) PCK model has been dominantly used (Abell, 2007; Kind, 2009). In this model, teachers have four main knowledge types; content knowledge, pedagogical knowledge, knowledge of educational context and PCK. This is a transformative model accepting PCK as the new knowledge type formed by contribution of the first three types of knowledge. Moreover, there are five sub-dimensions of PCK, orientation to teaching science, knowledge of learners, curriculum, instructional strategies and assessment. Orientation towards teaching science is above the other components hierarchically and has influential role on them.

Theoretical studies about components of PCK and their interplay with each other have been studied continuously (Friedrichsen, van Driel, & Abell, 2011; Park & Oliver, 2008). Moreover, studies about pre-service teachers' (De Jong, van Driel, & Verloop, 2005; van Driel et al., 2002), novice teachers' (Avraamidou & Zembal-Saul, 2010), experienced teachers' (Henze, van Driel, & Verloop, 2008), teaching assistants' and staffs' PCK (Abell, Rogers, Hanuscin, Lee, & Gagnon, 2009; Loughran, Mulhall, & Berry, 2008; Padilla, Ponce-de-León, Rembado, & Garritz, 2008) have been conducted in recent years. Studies regarding pre-service teachers' PCK were carried out in teaching methods courses (Greenwood, 2003), teaching practice courses (Castle, Fox, & Souder, 2006; Bullough et al., 2002) courses or workshops that support the development of PCK (van Driel et al., 2002). In some of the studies, experienced teachers' and pre-service teachers' PCK were compared and contrasted (Geddis, Onslow, Beynon, & Oesch, 1993).

Studies showed that especially pre-service teachers had inadequate content knowledge and PCK and could not use teaching methods effectively (Kagan, 1992; van Driel, Verloop, & de Vos, 1998). Instruction in real classes is the basis for development of PCK; however pre-service teachers do not have much chance to teach in real classrooms. Since studies mainly focused on pre-service teachers' PCK (Abell, 2007; Loughran et al., 2004), there is lack of research that reveal some teaching examples of teachers with rich PCK.

Evaluation of teaching assistant and staff's PCK can be counted as new area in the PCK literature. Lederman et al. (1997) stated that science teacher educators should have content, curriculum, assessment and pedagogical knowledge for science instruction, as well as they should know how learning occurs.

Difficulties Encountered in the Studies Related to PCK

Due to the complex nature of PCK, analysis of participants' PCK is possible by studies that last for a long time (Loughran, Gunstone, Berry, Milroy, & Mulhall, 2000; Loughran et al., 2004). Moreover, various data collecting instruments should be used (Baxter & Lederman, 1999). Different from the interviews, *card sorting activities* (Friedrichsen & Dana, 2005), *lesson preparation method* (Valk & Broekman, 1999), *Content Representation*, CORE, and *Professional and Pedagogical Experience Repertoire*, PaP-eR) (Loughran et al. 2004) have been used as instruments in PCK studies. To understand the nature of PCK, use of different instruments should be useful to capture participants' PCK. For example, Rollnick, Bennett, Rhemtula, Dharsey, and Ndlovu (2008) collected data by means of observation, Pa-peRs, CoRes, reflection, interviews and content knowledge scale.

Different Kinds of PCK Studies

Most studies related to PCK employed qualitative approach but Abell (2008) criticized this situation and suggested the use of mixed design or quantitative approach for the contribution to the related literature. Moreover, Abell stated the need of studies that compare PCK of pre-service and experienced teachers as well as experienced and novice teachers.

In the related literature, some studies were focused on content knowledge (Carlsen, 1999; Rollnick et al., 2008). Abell (2007) stated that Shulman was influenced by Schwab (1964 as cited in Abell, 2007) and

differentiated content knowledge as "*substantive*" and "*syntactic*". Substantive content knowledge involved concepts, hypotheses, laws in a topic, in other words, knowledge related to topic. On the other hand, syntactic content knowledge is process-oriented content knowledge and involves the process of acquisition of scientific knowledge. Abell (2007) stated that most studies explored substantive content knowledge and very few studies in the context of biology focused on the syntactic content knowledge.

Significance of the Study and its Contribution

The purpose of the present study is to analyze the studies that were conducted in Turkey in the context of PCK in science teacher education area. In other words, the present study is carried out in order to introduce evaluate which aspects of PCK were studied and make recommendations for further research. Research questions for this study are:

1. What are the general characteristics of PCK studies conducted in Turkey? (e.g. participants, data collection instruments, design of studies, subjects and topics studied, contexts, etc.)

2. What are the implications of PCK studies conducted in Turkey?

Method

Design of the Study

The present study is qualitative in nature since it gives information about studies of PCK in Turkey in the context of science teacher education. Content analysis was conducted to fulfill this aim (Yıldırım & Şimşek, 2006). Each study was coded in the light of research questions.

Review of Related Literature

First, Similar to Abell (2007) and Kind (2009), ERIC database was searched by using "Pedagogical *Content Knowledge*" as a keyword. Next, YÖK Thesis and Dissertation database was investigated by means of the keyword "*Pedagogical Content Knowledge*" in order to get information about the theses conducted in this area. Moreover, journals published in Turkey and which are possible to be reached electronically were searched using the same keyword. Finally, 28 studies were gathered through the literature review.

Development of the Standards Used in the Data Coding

Standards used in the data coding were decided in the light of related literature review (Abell, 2007, 2008; Baxter & Lederman, 1999; Kind, 2009; Loughran et al., 2000, 2004). Moreover, experiences of authors as both teacher educators and researchers in the context of PCK helped them to reveal the standards.

Coding of Data, Validity, and Reliability of Coding and Data Analysis

After determining the standards which will be used on the coding process, the first author coded all the studies and the second author coded the 25% of the studies that were selected randomly, independently. After independent coding, they came together in order to compare their codes. Inter-rater reliability coefficient was calculated as %94 (Miles & Huberman, 1994) and the discrepancies in the coding were solved by discussing and looking back at the coding process and reaching the consensus.

Results

Results will be given under two main headings. In the first section, data will be summarized descriptively under three subheadings headings: (*i*) Investigation of studies in terms of subject, topic, participants, context studies, instruments used in data collection and design of the study, (*ii*) Information about how PCK is investigated (longitudinal, by considering its components, and comparison), (*iii*) Analysis of studies investigating content knowledge by using the PCK framework. In the second main heading, how these results contribute to the literature regarding PCK, content knowledge and pedagogical knowledge will be summarized.

Analysis of the Studies Descriptively

Subjects and Topics Studied: Among the twenty eight studies, nine of them were conducted regarding the chemistry topics whereas six of them dealt with biology topics. Only two studies were about the physics context, however, there were not any specific topics mentioned in these studies. On the other hand, no subject or topic of the science was studied by eleven studies two of which focused on technological PCK (TPCK) (Savaş, Öztürk, & Tüzün-Yılmaz, 2010; Sungur, Kaya, & Kaya, 2010).

Profile of the Participants: Among the twenty eight studies, pre-service teachers were selected as participants in the 23 of the studies whereas only three studies focused on determining in-service teachers' PCK and only one study was conducted with teaching staff at the university. Moreover, in terms of school level, 16 studies were conducted with elementary pre and in-service teachers, which indicates the scarcity of research with high school physics, chemistry, and biology teachers.

Context of the Studies: No special context was used in most of the studies related to PCK. However, five of the studies were conducted in the context of teaching practice course and there was one study for each teaching methods course, elective pedagogical course and in-service training program.

Investigation of Data Collection Instruments: Most studies used multiple data collection instruments to reveal participants' PCK. 19 of the studies employed interview, observation and lesson plans as instruments. Only one type of instrument was used in eight of the studies. Another finding related to instruments was that the most preferred data collection instrument used in studies was the interviews. Tests measuring content knowledge, scales and lesson plans were the ones that were used most frequently following interviews. It was found that researchers did not prefer using observations much in their studies.

Investigation of the Studies in terms of Design: Most of the studies preferred the qualitative approach and case study was counted as the most preferred design among the qualitative approaches. Survey design was used in four of the studies, that quantitative approach was employed.

Information about How PCK is investigated (longitudinal, by considering its components, comparison of its components)

Components of PCK: Only one component of PCK was studies in six studies whereas seven studies investigated more than one component of PCK. However, no study examined all the components of PCK. Knowledge of learners, curriculum and instructional strategies were amongst the PCK components that were studies much. Three of the studies researchers studied PCK in general without focusing on any PCK components (Demirdöğen, Aydın, & Tarkın, 2010; Fizan et al., 2010; Tekin, 2006). Moreover, in three of the studies, researchers asserted that their study investigated PCK though it was not, instead it examined pedagogical knowledge.

Investigation of the relationship between components of PCK: 18 of the studies did not look for the relationship between PCK components. On the other hand, in only eight studies, this relationship was examined. One study was review of literature so it was not coded here (Nakiboğlu & Karakoç, 2005).

Studies that investigate the development of PCK: Only six studies examined development of participants' PCK in a certain time period like one semester whereas 21 studies did not aim to examine development of PCK.

Studies Comparing Participants' PCK: In only two studies, PCK of participants were compared. For example, one study involved comparison of PCK of teachers working at public school and private school.

Analysis of Studies Investigating Content Knowledge by Using the PCK Framework

None of the studies were focused on the syntactic nature of content knowledge; instead all of the eleven studies investigated the substantive content knowledge.

Findings Obtained from the Investigation of Studies in the PCK Literature:

1) *Both pre-service and in-service teachers do not have adequate content knowledge.* Some of the participants had similar misconceptions like their students as reported in the literature (Aydın, Boz, & Boz, 2010; Aydın, Demirdöğen, Tarkın, & Uzuntiryaki, 2009; Canbazoğlu, Demirelli, & Kavak, 2010; Gödek, 2004; Karakulak & Tekkaya, 2010; Kaya, 2009; Kılınç & Salman, 2009; Özdemir, 2006; Özden, 2008; Özden, Uşak, & Eilks, in press). Moreover, pre-service teachers lack conceptual understanding of the content and they tried to answer the questions by textbook definitions, but they told that they had forgotten since they memorized (Aydın et al., 2010; Çekbaş, 2008; Canbazoğlu et al., 2010; Özdemir, 2006; Özden et al., (in press)).
2) *Pedagogical knowledge of pre-service teachers is not sufficient* (Kılınç & Salman, 2009; Oskay, Erdem, & Yılmaz, 2009). Studies showed that pre-service teachers have problems especially in classroom management, motivating students, communicating students and tracing students' development.
3) *Participants had lack of PCK and its components.*
   - *Participants had difficulties in applying different instructional methods and strategies.*

Participants preferred traditional instruction most of the time (Aydın et al., 2010; Canbazoğlu et al., 2010; Özden, et al., (in press)). They did not prefer using methods based on conceptual change model, learning cycle and inquiry in their instruction (Aydın et al. 2009; Aydın et al. 2010; Canbazoğlu et al., 2010; Oskay et al., 2009; Uşak, 2009). Moreover, most of the participants reported that they need help about how to implement teaching methods in class (Özden, 2008; Tuzcu & Yakar, 2010).

- *Pre-service teachers and novice teachers were not aware of the possible alternative conceptions that their students might have* (Aydın et al., 2010; Karakulak & Tekkaya, 2011; Kutucu, Ekiz, Boz, & Akkuş, 2010; Nakiboğlu, Karakoç, & De Jong, 2010; Özden, 2008; Özden et al., (in press); Uşak, 2005).
- *Pre-service teachers do not have sufficient knowledge about curriculum* (Canbazoğlu et al., 2010; Uşak, 2005).
- *Pre-service teachers do not have adequate knowledge about assessment and evaluation techniques.*

4) *Mentors at the placement schools restrict pre-service teachers from using different teaching methods and activities.* Even experienced mentors use traditional method of teaching most of the time. This affects pre-service teachers in a way that they also apply tradional instruction during their teaching at school placements. (Aydın et al., 2010; Mıhladız & Timur, 2011; Nakiboğlu et al ., 2010)

5) *Factors affecting pre-service teachers' choice of teaching methods are;* preparation time, class time, facilities of the placement schools, concerns about classroom management (Aydın et al., 2010), beliefs about use of activities and personal experiences while they learnt that topic previously (Boz & Boz, 2008).

6) *In-service training sessions may be helpful for teachers in order to enhance their knowledge.* Çoruhlu and Çepni (2010) stated that teachers attending in-service training sessions had an idea of alternative assessment and evaluation techniques, especially learnt how to prepare rubric.

7) *Courses that emphasize pedagogical content knowledge and instruct content knowledge conceptually are influential for pre-service teachers in order to develop their PCK and content knowledge* (Aydın et al., 2009).

8) *In the PCK literature, it was reported that there was a strong relationship between content knowledge, pedagogical knowledge and PCK and its components.* For example, content knowledge of teachers affect their choice of instructional strategies. Aydın et al. (2010) found that some of the pre-service teachers did not prefer to use discussion as a teaching method due to their lack of content knowledge. Kaya (2009) reported a statistically significant positive relationship between PCK and content knowledge meaning that participants with sufficient content knowledge also had adequate PCK.

9) *Teachers need in-service training sessions in order to get information about the new curriculum and the application of it* (Balta & Eryılmaz, 2011).

10) *"Orientation towards science teaching" was the least studied PCK component compared to the others.*

Discussion

After reviewing studies about PCK conducted in Turkey, it was found that studies generally explored participants' PCK in the chemistry and biology topics whereas no study about physics topics were encountered. However, in the international related literature, participants' PCK about different topics of physics, chemistry, biology and "Earth and Space" science were examined (Abell, 2007). Considering topic-specific nature of PCK (Loughran et al., 2004; van Driel et al., 1998), this is a gap of the research studies in Turkey.

Participants were mostly pre-service teachers in the studies about PCK in Turkey, which is also parallel to the international literature (Abell, 2007; Loughran et al., 2004). However, pre-service teachers do not have adequate PCK. Therefore, studies should be conducted with experienced teachers as well.

In the international literature, PCK was studied in the context of teaching methods, teaching practice courses and some courses or workshops designed to develop PCK (Greenwood, 2003; Bullough et al., 2002; van Driel et al., 2002). However, most studies were not conducted in these contexts in Turkey. Considering the importance of teaching methods and teaching practice courses on the development of pre-service teachers' PCK (Grossman, 1990) and influence of workshops on enhancement of participants' PCK (van Driel et al., 2002), it is important to trace participants' PCK in these contexts in our country as well. In addition to that only one study focused on instructors' TPCK (Atila, Yıldırım, & Sanalan, 2010).

As suggested by the literature, data were collected by using various data collection instruments in most of the studies in Turkey. However, international literature reported studies collecting data with different instruments as card sorting activities, content representation, and professional and pedagogical experience repertoire (Friedrichsen & Dana, 2005; Loughran et al., 2008). We suggest the use of these instruments as well in the studies in our country.

Parallel to the findings in the international literature, most studies about PCK in Turkey were qualitative in nature. However, Abell (2008) suggested the use of mixed design in PCK studies.

In terms of components of PCK, no study in Turkey investigated all the components altogether. In the international literature, Abell (S. K. Abel, personal communication, February, 2010), Friedrichsen and Dana (2005) and Loughran et al. (2000) indicated the difficulty of coding and interpretation of data in studies where one or few components of PCK are investigated due to the blurriness of the border of the components. The PCK component that is investigated the least in Turkey is orientation towards science teaching, which is consistent with the international literature (Abell, 2007). However, Abell (2008) emphasized the necessity of PCK studies investigating this component as well.

Only five studies in Turkey investigated the development of PCK. However, it is recommended to trace the development of participants' PCK for a long time (Loughran et al., 2000, 2004). Moreover, Abell (2008) suggested studies that compare inexperienced and experienced teachers' PCK would be valuable to give information about development of PCK as well as its sources. Moreover, no study exploring the syntactic nature of content knowledge was encountered in Turkey. In the international area, very few studies were about syntactic content knowledge (Abell, 2007).

Recommendations

- Courses, workshops and in-service training programs to enhance both pre- and in-service teachers' PCK would be beneficial for the development of PCK (Aydın et al., 2009; Çoruhlu & Çepni, 2010; van Driel et al., 1998).
- Teaching staff at the university should employ different teaching methods in both content and pedagogical courses in teacher education programs (Kaya, 2009).
- Experienced mentors who would be role models for pre-service teachers in terms of using instructional strategies and other components of PCK effectively should be selected for teaching practice courses (Aydın et al., 2010; Mıhladız & Timur, 2011; Nakiboğlu et al., 2010).
- Content of the courses in teacher education programs is important (Nakiboğlu &Karakoç, 2005; Tekin, 2006). Teaching methods courses are important since pre-service teachers will have the chance to learn about different teaching methods. Kaya (2009) recommended the integration of courses, which emphasize content knowledge, PCK, and teaching experiences at schools. These courses take place in teacher education programs of other countries, e.g. United States of America (Veal, Tippins, & Bell, 1999).

Studies Analyzed in this Review and their Codes/Çalışmada Analiz Edilen Araştırmalar ve Kodları

Code/Kod	Studies/Çalışmalar
1	Aydın, S., Boz, N., & Boz, Y. (2010). Factors that are influential in pre-service chemistry teachers' choices of instructional strategies in the context of methods of separation of mixtures: A Case study. *The Asia-Pacific Education Researcher*, *19* (2), 251-270.
2	Boz, N., & Boz, Y. (2008). A qualitative case study of prospective chemistry teachers' knowledge about instructional strategies: Introducing particulate theory. *Journal of Science Teacher Education, 19,* 135–156.
3	Canbazoğlu, S., Demirelli, H. ve Kavak, N. (2010). Fen bilgisi öğretmen adaylarının maddenin tanecikli yapısı ünitesine ait konu alan bilgileri ile pedagojik alan bilgileri arasındaki ilişkinin incelenmesi, *İlköğretim Online, 9* (1), 275-291.
4	Nakiboğlu, C., Karakoç, Ö., & De Jong, O. (2010). Examining pre-service chemistry teachers' pedagogical content knowledge and influences of Teacher course and practice school. *Journal of Science Education, 11* (2), 76-79.
5	Özden, M. (2008). Konu alan bilgisinin pedagojik alan bilgisi üzerine etkisi: Maddenin fiziksel hâllerinin öğretilmesi durumu. *Kuram ve Uygulamada Eğitim Bilimleri, 8*, 611-645.
6	Nakiboğlu, C. ve Karakoç, Ö. (2005). Öğretmenin sahip olması gereken dördüncü bilgi: Alan öğretimi. *Kuram ve Uygulamada Eğitim Bilimleri, 5*, 181-206.
7	Kaya, O. N. (2009). The nature of relationships among the components of pedagogical content knowledge of pre-service science teachers: 'Ozone layer depletion' as an example. *International Journal of Science Education, 31* (7), 961–988.
8	Kılınç, A. ve Salman S. (2009). Biyoloji eğitiminde 1998-2007 yılları arasında uygulanan programın alan ve öğretmenlik bilgisi yönünden incelenmesi. *Gazi Eğitim Fakültesi Dergisi, 29* (1), 93-108.
9	Mıhladız, G., & Timur B. (2011). Pre-service science teacher's views of in-service science teachers' Pedagogical content knowledge. *Eurasian Journal of Physics and Chemistry Education, January* [Special Issue], 89-100.
10	Uşak, M. (2009). Preservice science and technology teachers' pedagogical content knowledge on cell topics. *Educational Sciences: Theory & Practice, 9,* 2033-2046.
11	Oskay, Ö. Ö., Erdem, E., & Yılmaz, A. (2009). Pre-service chemistry teachers' beliefs about teaching and their pedagogical content knowledge. *Hacettepe University Journal of Education, 36,* 203-212.
12	Çoruhlu, T. Ş. & Çepni, S. (2010). Reflection of an in-service education course program: Pedagogical content knowledge about alternative measurement and assessment techniques and attitude development. *Elementary Education Online, 9* (3), 1106-1121.
13	Uşak, M. (2005). *Fen bilgisi öğretmen adaylarının çiçekli bitkiler konusundaki pedagojik alan bilgileri.* Yayımlanmamış yüksek lisans tezi, Gazi Üniversitesi, Ankara.
14	Aydın, S., Demirdöğen, B., Tarkın, A., & Uzuntiryaki, E. (2009). Effectiveness of a course on pre-service chemistry teachers' Pedagogical content knowledge and subject matter knowledge. In M.F. Taşar & G. Çakmakçı (Eds.), *Contemporary science education research: pre-service and in-service teachers Education* (pp. 59-69). Ankara, Turkey: Pegem Akademi.
15	Balta, N., & Eryılmaz, A. (2011). Turkish new high school physics curriculum: Teachers' views and needs. *Eurasian Journal of Physics and Chemistry Education, January* [Special Issue], 72-88.
16	Özdemir, Z. (2006). *Fen bilgisi öğretmen adaylarının bazı biyoloji konularındaki alan bilgilerinin değerlendirilmesi.* Yayımlanmamış yüksek lisans tezi, Gazi Üniversitesi, Ankara.
17	Çekbaş, Y. (2008). Fen *bilgisi öğretmen adaylarının temel fizik alan bilgilerinin değerlendirilmesi.* Yayımlanmamış yüksek lisans tezi, Pamukkale Üniversitesi, Denizli.
18	Tekin, S. (2006, Eylül). *Özel Öğretim Yöntemleri Derslerinin öğrencilerin pedagojik içerik bilgilerine katkılarının irdelenmesi*. 7. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi'nde sunulan poster bildiri, Ankara.
19	Gödek, Y. (2004). *Fen bilgisi öğretmen adaylarının çözünme kavramı hakkındaki düşünceleri.* VI. Ulusal fen Bilimleri ve Matematik Eğitimi Kongresi'nde sunulan bildiri (UFBMEK-6), Marmara Üniversitesi, İstanbul.
20	Özden, M., Uşak, M., & Eilks, I. (in press). Teaching chemical reactions: A case study on subject matter knowledge and pedagogical content knowledge of beginning science teachers in Turkey. *European Journal of Teacher Education*.
21	Tuzcu, D. ve Yakar Z. (2010). *Öğretmen adaylarının pedagojik alan bilgilerinin öğretim stratejileri alt boyutunda incelenmesi.* XI. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi'nde sunulan bildiri (UFBMEK-9), Dokuz Eylül Üniversitesi, İzmir.
22	Kutucu, E. S., Ekiz, B., Boz, Y. ve Akkuş, H. (2010). *Kimya Öğretmen adaylarının galvanik hücreler konusuna ilişkin öğrenciyi anlamabilgilerinin değerlendirilmesi*. XI. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi'nde sunulan bildiri (UFBMEK-9), Dokuz Eylül Üniversitesi, İzmir.
23	Karakulak, Ö. ve Tekkaya C. (2010). *Göreve yeni başlamış Fen bilgisi öğretmenlerinin Ekoloji Öğretimi konusunda pedagojik alan bilgilerinin incelenmesi*. XI. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi'nde sunulan bildiri (UFBMEK-9), Dokuz Eylül Üniversitesi, İzmir.
24	Sungur, S., Kaya, Z. ve Kaya, O. N. (2010). *Fen bilgisi ve sınıf öğretmeni adaylarının teknolojik alan bilgisinin (TPAB) belirlemede ders planı hazırlama yönteminin etkinliği*, XI. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi'nde sunulan bildiri (UFBMEK-9), Dokuz Eylül Üniversitesi, İzmir.
25	Savaş, M., Öztürk, N. ve Tüzün-Yılmaz, Ö. (2010). *Fen Bilgisi öğretmen adaylarının fen eğitiminde teknoloji kullanımı ile ilgili görüşleri ile ilişkili olan faktörlerin belirlenmesi*. XI. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi'nde sunulan bildiri (UFBMEK-9), Dokuz Eylül Üniversitesi, İzmir.
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