The Eurasia Proceedings of
Educational & Social Sciences (EPESS)
ISSN: 2587-1730

The Eurasia Proceedings of Educational & Social Sciences (EPESS), 2016

Volume 4, Pages 303-308

ICEMST 2016: International Conference on Education in Mathematics, Science & Technology

EXAMINATION OF PROSPECTIVE CHEMISTRY TEACHERS' PEDAGOGIC CONTENT KNOWLEDGE CONCERNING GRAPHS ABOUT SOLUTIONS, SOLUBILITY, AND CHANGE OF STATES TOPICS

Cem GÜLTEKİN
Emet Vocational School, Dep. of Chemistry and Chemical Processing Technologies, Dumlupinar University

Canan NAKİBOĞLU
Necatibey Education Faculty, Chemistry Education Division, Balıkesir University

ABSTRACT: This study explored the nature of the integration of the three components of pedagogical content knowledge (PCK): 1) Knowledge of the Chemistry Curriculum, 2) Knowledge of the Instructional Strategies and Representations, 3) Knowledge of the Assessment. This study was conducted in the context of the teaching graphs about *solubility*, and *change of states* topics of eight prospective chemistry teachers who were attending to chemistry teacher training program of Faculty of Education. The study was designed as a case study and data were collected by means of lesson plans and it was performed with 8 prospective chemistry teachers. Five prospective teachers were asked to prepare a lesson plan concerning *solubility topic* and others prepared a lesson plan concerning *the change of states topic*.

Key words: Pedagogic content knowledge, graphs, solutions, solubility, and change of states.

INTRODUCTION

In recent years, there has been a growing interest in the knowledge base of both experienced and prospective teachers. Shulman (1986) presented pedagogical content knowledge (PCK) as central to the knowledge base of teachers and described PCK as "that special amalgam of the content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding". The view of PCK generally encompasses ' a teachers' understanding of how to help students understand specific subject matter' (Magnusson, Krajcik,& Borko, 1999). The components of PCK have been defined in various ways by different authors. Magnusson et al. (1999) have conceptualised PCK for science teaching as consisting of five components: 1) orientations toward science teaching, 2) knowledge and beliefs about science curriculum, 3) knowledge and beliefs about students' understanding of specific science topics, 4) knowledge and beliefs about assessment in science, and 5) knowledge and beliefs about instructional strategies for teaching science.

The orientation toward science teaching component of PCK refers to teachers' knowledge and beliefs about the purposes and goals for teaching science at a particular level. The knowledge and beliefs about science curriculum consist of two categories: mandated goals and objectives, and specific curricular programs and materials. The third component of PCK refers to the knowledge teachers must have about students in order to help them develop specific scientific knowledge. It includes two categories of knowledge: requirements for learning specific science concepts, and areas of science that students find difficult. Magnusson et al. (1999) have conceptualized the fourth component of PCK, which was originally proposed by Tamir (1988), as consisting of two categories: knowledge of the dimensions of science learning that are important to assess, and knowledge of the methods by which learning can be assessed. The component of instructional strategies comprises of two categories: knowledge of subject-specific strategies, and knowledge of topic- specific strategies. Strategies in these categories differ with respect to their scope. Subject-specific strategies are broadly applicable; they are specific to teaching science as opposed to other subjects. Topic- specific strategies are much narrower in scope; they apply to teaching particular topics within a domain of science.

- Selection and peer-review under responsibility of the Organizing Committee of the conference

*Corresponding author: Cem GÜLTEKİN-icemstoffice@gmail.com

De Jong (2000) advocated that science teacher preparation courses aim at promoting the development of an appropriate pedagogical content knowledge for preservice teachers and according to a constructivist perspective, the acquisition of pedagogical content knowledge is considered a dynamic process in which the preservice teachers actively construct meaning from their actual experiences in connection with their prior understanding. It can be said that that inviting pre-service teachers to prepare lesson plans is very effective because these plans appeared to elicit many important aspects of pre-service teachers' PCK. The lesson plan method has also limitations. For example, this tool does not capture what actually happens in the classroom and does not provide information about pre-service teachers' PCK in action or practice. However, the lesson plan method is a simple and adequate tool for university supervisors and school mentors. It provides them with useful information about the development of pre-service teachers' PCK and influences of course work and practice school activities on this development.

Based on these explanations, the following main problem and sub-problems were developed for this study:
What is the status of pedagogical content knowledge of prospective chemistry teachers about graphs in the topics of solubility and change of states?
Sub-problems:
1. What is the status of knowledge of the chemistry curriculum of prospective chemistry teachers about graphs in the topics of solubility and change of states?
2. What is the status of knowledge of the instructional strategies and representations of prospective chemistry teachers about graphs in the topics of solubility and change of states?
3. Prospective teachers' knowledge of students' learning
4. What is the status of knowledge of the assessment of prospective chemistry teachers about graphs in the topics of solubility and change of states?

METHODS

Context of Study

The present study was situated in the context of the ten semester of a five-year pre-service chemistry teacher education program, qualifying for the teaching of chemistry at upper secondary school level, at Balikesir. The prospective chemistry teachers took courses on general education issues, for instance, development and learning, instructional planning and evaluation, and guiding students, and they take courses on chemistry teaching issues, for instance, misconceptions in chemistry, chemistry textbook analysis, and methods of teaching chemistry topics. The issue of lesson preparation was taught in both general education courses and chemistry education courses to the prospective chemistry teachers.

Research Design

In this study, the case study method which is one of the qualitative research patterns and which facilitates in-depth examination and analysis of one or more special cases was adopted. McMillan (2000) defines case studies as a method for examining one or more events, media, programs, social group or other interconnected systems in depth (op. cit. Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz and Demirel, 2014).

Participants

The subjects in the study were eight prospective chemistry teachers (5 females and 3 males; average age 22 and (referred to below as PCT 1-8)). Participants were selected using the case sampling technique, which is one of easily accessible purposive sampling methods. In this sampling method, a close and easily accessible case is selected (Yıldırım and Şimşek, 2005, p. 113).

Data Collection

The data were collected through lesson plans. In the preparation of lesson plans, prospective teachers weren't given liberty but were guided by 6 questions. With the first two questions, they were asked to write down the acquisitions for the lesson in question as well as prior knowledge about the topic. The next question wanted them to pick up a strategy to teach this lesson and explain why they chose that strategy. Then, they were requested to design an activity for the topic in question and prepare questions for assessment purposes. Five prospective teachers were asked to prepare a lesson plan concerning solubility topic and others prepared a lesson plan concerning the change of states topic. This topic is a regular part of the Turkish high school chemistry curriculum

Data Analysis

The data were analyzed through *enumerative approach*. Before proceeding with the analysis, content analysis was performed on the lesson plans to identify the themes. Then, themes and sub-themes were established to combine the codes. To ensure reliability, prospective teachers' answers to the questions were analyzed by the researcher and a field specialist according to identity the number of agreements and disagreements. The formula, proposed by Miles and Huberman (1994), i.e., reliability = number of agreements / (number of agreements + number of disagreements) x 100, the reliability of the study was used to calculate the reliability of the study. The reliability was found to be 92% and the analysis of the data from interviews with prospective chemistry teachers was deemed reliable. Thus, the findings obtained through the analysis of the data were readied for description.

RESULTS and FINDINGS

1. Prospective teachers' knowledge concerning the curriculum

The findings regarding the knowledge of the prospective teachers about the curriculum were provided in two parts below:

Prospective teachers' knowledge of instructional acquisitions: In this component of PCK, first it was discussed whether PCTs wrote the acquisitions meeting the content of the curriculum topics of solubility and the change of states and to find out the level of the Bloom taxonomy this corresponds to. Categories of Instructional acquisitions PCTs determined were examined. Five prospective teachers (PCT2, PCT4, PCT5, PCT6, PCT7) wrote the acquisitions that are in compliance with the topic to be taught while three (PCT1, PCT3, PCT8) failed to wrote any acquisition. The Bloom taxonomy levels of instructional acquisitions were given in Table 1.

Table 1: Bloom Taxonomy Levels of Instructional Acquisitions PCTs determined

Instructional Acquisitions	Number of PCTs
Knowledge	---
Comprehension	PCT2, PCT5, PCT6, PCT7
Application	PCT2, PCT4, PCT5
Analysis	---
Synthesis	---
Evaluation	---
No acquisitions	PCT1, PCT3, PCT8

An examination of Table 1 for the instructional acquisitions about graphs reveals that 4 prospective teachers (PCT2, PCT5, PCT6, PCT7) came up with the acquisitions that correspond to the "Understanding" level of the cognitive domain of the Bloom taxonomy while three teachers (PCT2, PCT4, PCT5) wrote down acquisitions that are related to the "Applying" level of the same taxonomy. PCT2's statement, "Explains the factors influencing the solubility on the graph" can be given as an example for an acquisition on the "Understanding" level while the same teacher's statement, "Reads the solubility graph and draws solubility graphs for substances" exemplifies an acquisition on the "Applying" level.

Prospective teachers' knowledge of representations of subject matter: The results of the analysis conducted to find out to what extent the prospective teachers' topic presentations in their lesson plans overlap with the curriculum or textbook were given in Table 2.

Table 2: Representations of Subject Matter of Pts In Terms Of Sequence

Representation of topic	Number of PCTs
Meeting the sequence existing in the curriculum or textbooks	PCT2, PCT4, PCT6, PCT7, PCT8
Partly the sequence existing in the curriculum or textbooks	PCT1, PCT3, PCT5
Confused the sequence existing in the curriculum or textbooks	---

Looking at Table 2, it is clear that 5 prospective teachers (PCT2, PCT4, PCT6, PCT7, PCT8) came up with topic presentations in their lesson plans that overlapped with the curriculum or textbook while the topic presentations of 3 prospective teachers (PCT1, PCT3, PCT5) overlapped with the curriculum or textbook only partially.

2. Prospective teachers' knowledge of instructional strategies

The findings regarding the knowledge of the prospective teachers about the instructional strategies were provided in two parts below:

Prospective teachers' knowledge of subject-specific strategies: The subject-specific strategies in the lesson plans were analysed in terms of expository teaching (ET), problem-based teaching (PBT), discovery teaching (DT), and inquiry teaching (IT). The subject-specific strategies followed and reasons are given in Table 3.

Table 3. Strategies Adopted by Prospective Teachers and Reason of Choice

Lesson Plan Topic	Number of PCTs	Strategy Adopted	Reason of Choice
Solubility	PCT1, PCT4,	ET	"Because students know nothing about it and it is hard for them to figure out with their own efforts" (PCT1) "Because the implementation of other strategies would take more time" (PCT4)
	PCT2,	PBT	"Because it is possible to see many examples of it in daily life" (PCT2)
	PCT3, PCT5	DT	"Because it will whet the students' appetite for learning through their desire for exploration, making the process fun and learning a lasting experience" (PCT3) "To ensure that every student can clearly speak their mind" (PCT5)
	PCT6	IT	"Because student can decide on what they will do and be free in their work"
Change of states	PCT7, PCT8	DT	"Because learning by doing and through individual efforts will be more lasting" (PCT7) "Because it is appropriate for giving examples for the topic and asking students to provide examples about it" (PCT8)

Given the data in Table 3, it is clear that 4 prospective teachers adopted the discovery strategy and 2 prospective teachers went for the expository strategy while the problem-based and inquiry strategies were used by 1 prospective teacher each.

Prospective teachers' knowledge of topic-specific strategies: The topic-specific strategies in the lesson plans were analysed in terms of use of representations and use of teacher demonstrations and student experiments.
It was found that 5 prospective teachers (PCT2, PCT3, PCT5, PCT6, PCT7) made room for student experiments in their lesson plans.

3. Prospective teachers' knowledge of students' learning of solubility and change of states topics

This knowledge is can be related to teachers' knowledge of students' difficulties and teachers' knowledge of prerequisite knowledge for learning topics. Here only the findings related to the knowledge of prerequisite for student learning topics were presented. These findings were divided into two sub-themes as prerequisite knowledge for drawing graphs and prerequisite knowledge for reading and interpreting graphs.

Prospective teachers' knowledge of prerequisite knowledge for drawing graphs

The prerequisite knowledge for drawing graphs, as provided by prospective teachers, was analyzed to determine the level of their usage of the sub-skills of graph drawing --namely, axis selection, axis tagging, axis scaling, data entry, creating points and joining points. As a result of this analysis, it was observed that during the graph drawing phase, none of the prospective teachers provided any prerequisite knowledge for axis selection while prerequisite knowledge was provided by 3 prospective teachers (PCT1, PCT4, PCT5) for axis tagging, 2 prospective teachers (PCT1, PCT4,) for axis scaling, 2 prospective teachers (PCT1, PCT4) for data entry and 1 prospective teacher (PCT4) for creating points and 1 prospective teacher (PCT4) for joining points.

Prospective teachers' knowledge of prerequisite knowledge for reading and interpreting of graphs

The prerequisite knowledge for reading and interpreting graphs, as provided by prospective teachers, was analyzed to determine the level of their usage of the sub-skills of reading and interpreting graphs --namely, identifying the dependent and independent variables, focusing on a single point, focusing on interpolation, focusing on extrapolation and focusing on the holistic relationship. As a result of the analysis, it was found that during the phase of reading and interpreting graphs, only 1 prospective teacher (PCT1) provided prerequisite knowledge for identifying the dependent and independent variables while prerequisite knowledge was provided by 5 prospective teachers (PCT1, PCT2, PCT4, PCT5 and PCT8) for focusing on a single point, 1 prospective teacher (PCT2) for extrapolation, 4 prospective teachers (PCT1, PCT2, PCT3 and PCT7) for focusing on the holistic relationship (between variables) and none of them gave any prerequisite knowledge for interpolation.

4. Pre-service teachers' knowledge of the Assessment

The answers the prospective teachers asked in their lesson plans for the assessment and evaluation of the skills for drawing, reading and interpreting graphs were given in Table 4.

Table 4. Prospective Teachers' Preferences for Assessment and Evaluation of Graphing Skills

Lesson Plan Topic	Prospective Teacher	Drawing Graphs	Reading and Interpreting Graphs
Solubility Change of states	PCT1	Open-ended	Open-ended
	PCT2	Open-ended	Open-ended
	PCT3	Open-ended	Open-ended
	PCT4	Open-ended	Multiple-choice
	PCT5	Open-ended	Open-ended + Multiple-choice
Solubility	PCT6	Open-ended	Open-ended
	PCT7	Open-ended	Open-ended
	PCT8	Open-ended	Open-ended

An examination of the data in Table indicates that all of the prospective teachers employed open-ended questions regarding graph drawing in the assessment and evaluation process. For reading and interpreting graphs, 6 prospective teachers used solely open-ended questions and 1 prospective teacher employed solely multiple-choice questions while 1 prospective teacher resorted both to open-ended and multiple-choice questions.

It was further observed that the open-ended questions the prospective teachers prepared in connection with graph drawing entailed the use of the data in a table or in a text for graph drawing purposes while the questions they prepared in connection with reading and interpreting graphs were related to the focusing on a single point or finding of the holistic relationship between variables.

CONCLUSION

In this study, it was found that more than half of the prospective teachers were able to write down proper acquisitions for the subject matter at hand, but these hardly made above the Bloom taxonomy's "Applying" level. Many prospective teachers came up with topic presentations in their lesson plans that complied with the curriculum or textbook. Özden (2008) had studied the effect of the quantity and quality of content knowledge on the pedagogical content knowledge (PCK) and, in contrast with the findings of this study, indicated that the prospective science teachers didn't have sufficient knowledge concerning the curriculum. It was observed that the prospective teachers usually preferred student-centered teaching strategies and student experiments. All of the prospective teachers used graphs as visuals in their lesson plans. In literature, there are studies that reported prospective teachers who preferred teacher-centered teaching strategies in contrast to this study (Usak, 2005; Van Driel, De Jong and Verloop, 2002).

It was concluded that most of the prospective teachers (except PCT1 and PCT4) didn't provide any prerequisite knowledge for the sub-skills of graph drawing, namely, "axis selection, axis tagging, axis scaling, data entry, creating points and joining points" while most of the prospective teachers (except PCT1 and PCT2) didn't present any prerequisite knowledge for the sub-skills of graph reading and interpreting, namely identifying the dependent and independent variables, focusing on a single point, focusing on interpolation, focusing on extrapolation and focusing on the holistic relationship." This finding implies that most of the prospective teachers didn't have the knowledge about potential learning difficulties students may encounter regarding graphs in the topic of solubility and change of states.

It was determined that all of the prospective teachers adopted the traditional assessment and evaluation tools and they didn't use alternative assessment and evaluation approaches. However, considering the importance of the joint use of diverse tools and methods for assessing student achievements, it is recommended that the chemistry teachers should resort to all sorts of tools and methods for assessing the knowledge, skills and attitudes of students in the chemistry class (Ministry of Education, 2013).

Based on the findings of this study, it can be argued that the prospective teachers lacked sufficient pedagogical content knowledge for teaching graphs in the topics of solubility and change of states. This finding was supported by the results of other studies that reported insufficient pedagogical content knowledge (Adams and Krockover, 1997; Van Driel et al., 2002; Van Driel, Verloop and De Vos, 1998).

RECOMMENDATIONS

We believe that the assumption that the prerequisite knowledge for graphs is provided at mathematics or geometry classes will be an obstacle to finding solutions to the problems students may face with regarding graphs. Therefore, it is recommended that prospective teachers should provide students with prerequisite knowledge for drawing as well as reading and interpreting graphs when they will make use of graphs in teaching particular topics.

If the pedagogical content knowledge (PCK) of prospective teachers is improved through lessons like "Chemistry Special Teaching Methods" and "Instructional Principles and Methods," we believe that the difficulties students encounter regarding graphs will largely be eliminated.

With a view to addressing the shortcomings of prospective teachers regarding the use of alternative assessment and evaluation tools, it may be suggested that chemistry teacher trainers should give courses on assessment and evaluation. The development of the PCK of the prospective teachers in other chemistry topics where graphs are used extensively may be monitored starting from the first grade. We also believe that more in-depth information may be gathered about the PCK of prospective teachers by integrating interviews along lesson plans, lesson observations, PCK tests and teacher diaries with the data collection process.

REFERENCES

Adams, P. E., & Krockover, G. H. (1997) Concerns and perceptions of beginning secondary science and mathematics teachers. Science Education, 81(1), 29-50.

Büyüköztürk, Ş., Çakmak, E., Akgün, Ö., Karadeniz, Ş. ve Demirel, F. (2014). *Bilimsel Araştırma Yöntemleri* (16.Baskı). Ankara: Pegem A Yayıncılık.

de Jong, O. (2000). How to teach the concept of heat of reaction: a study of prospective teachers' initial idea. chemistry education. *Research and Practice in Europe, 1*(1), 91-96.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources, and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. Lederman (Eds.), *Examining pedagogical content knowledge* (pp. 95- 132). Dordrecht: Kluwer.

Miles, M. B., and Huberman, A. M. (1994). *Qualitative data analysis.* Thousand Oaks, CA: Sage.

Özden, M. (2008). The effect of content knowledge on pedagogical content knowledge: The case of teaching phases of matters. *Kuram ve Uygulamada Eğitim Bilimleri, 8*(2), 611-645.

Shulman, L. S. (1986). Those who understand: knowledge growth in teaching. *Educational Researcher, 15*(2), 4-15.

Tamir, P. (1988). Subject matter and related pedagogical knowledge in teacher education. *Teaching and Teacher Education, 4*(2), 99-110.

T.C. Milli Eğitim Bakanlığı, (2013). Ortaöğretim Kimya Dersi (9, 10, 11 ve 12. sınıflar) Öğretim Programı [online]. (19 Aralık 2013), http://ttkb.meb.gov.tr/www/ogretim-programlari/icerik/72

Usak, M. (2005). Prospective elementary science teachers' pedagogical content knowledge about fl owering plants. Unpublished doctoral dissertation, Gazi University, Insitute of Educational Science Ankara.

Van Driel, J. H., Verloop, N., & De Vos, W. (1998). Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching, 35*, 673-695.

Van Driel, J. H., De Jong, O., & Verloop, N. (2002). T e development of pre-service chemistry teachers' PCK. Science Education, 86(4), 572-590.

Yıldırım, A., ve Şimşek, H. (2011). *Sosyal bilimlerde nitel araştırma yöntemleri* 8. Baskı, Ankara: Seçkin Yayıncılık.