Investigation of Chemistry Teachers’ Pedagogical Content Knowledge in Iranian High School

Zohreh Abedi Kargiban
Ministry of Education Iran

Submitted: May 21, 2013; Accepted: Jul 1, 2013; Published: Sep 11, 2013

Abstract: The purpose of this study is to investigating chemistry teacher pedagogical content knowledge (PCK) in Iranian high school. A group sample of 376 teachers was selected through simple random sampling method. The research was based on a naturalistic qualitative study. To study the goals of research, questionnaire, observation and test were administered. The results showed that out of 376 respondents, the relationship between educational level and type of computer (PC) and PCs linked to a network (P-value = 0.994) was not significant. Observation and test also showed chemistry teacher PCK were low.

Key words: Pedagogical content knowledge • Chemistry teacher • High school

INTRODUCTION

What teachers know and what they do is the most an important influence on what students learn [1]. If we are to challenge students to deeper understanding and high order thinking, teachers need to have a thorough conceptual and pedagogical understanding of content [2]. This has become to be known as Pedagogical Content Knowledge (PCK). PCK has long been an attractive construct for educational researchers since its conception over twenty-five years ago [3]. PCK includes what teachers know about learners, curriculum, instruction and assessment that help them transform content knowledge into effective teaching and learning [4].

As stated, the teacher needs to know what curriculum materials and instructional strategies are particularly effective in engaging students in learning [5]. For example, a science teacher who decides to engage students in learning about the moon needs to be aware of the misconceptions that students may bring to class [6]. The teacher needs to understand how to effectively assess student learning about moon [7]. However, science teachers often have problems to transform their content knowledge into a form which is appropriate for the specific target group they teach [8].

Moreover, when we are teaching unfamiliar topics, teachers express more misconceptions [9] and they talk longer and more, moreover they mainly pose questions of low cognitive level [10]. In only one of these studies [11], these results are interpreted in terms of PCK. It is stated that experienced science teachers, when they are teaching a topic out of their area of certification, they seem to be sustained by their wealth of general pedagogical knowledge, while their PCK is limited.

PCK is a hierarchy that encompasses General PCK, Domain specific PCK and Topic-specific PCK [12]. General PCK refers to the different content disciplines (math, science, history, etc.). Domain-specific PCK is a branch of these disciplines. For example science domains are: chemistry, physics, biology, etc. Finally, Topic-specific PCK refers to the specific topics within each domain. More studies have shown science teachers limited knowledge of the history and philosophy of science [13] and as a consequence, hold inadequate or naive conceptions of the nature of science [14]. From the above-described settings, there is a literature gap on science teacher PCK in international level. As there is a lack of literature on science education reform in general [15]. Inadequate information and lack of research based on literature constitute the present study in Iran.

The purpose of the present study was to investigate Chemistry Teacher PCK in Iranian High School. In the meanings described above, deriving authentic findings based on real classrooms is important to overcome the problem chemistry teachers PCK in Iranian high school. It can also help policy makers understand the need to chemistry teachers PCK in classroom practice. The objectives of this research are as follow:

Corresponding Author: Zohreh Abedi Kargiban, Ministry of Education Iran.

1199
To determine technology of knowledge, skill and attitude of chemistry teachers (information application and classification).

To identify the PCK chemistry teacher.

Theoretical Framework: The theoretical framework is adapted from the Bruce and Shulman [16]. Content knowledge (CK) is knowledge about the actual subject matter that is to be learned or taught. Therefore, teachers must know and understand the subjects that they teach. Pedagogical knowledge (PK) is deep knowledge about the processes and practices or methods of teaching and learning and how it encompasses, among other things, overall educational purposes, values and aims. A teacher with deep pedagogical knowledge understands how students construct knowledge, acquire skills and develop habits of mind and positive dispositions toward learning. As such, pedagogical knowledge requires an understanding of cognitive, social and developmental theories of learning and how they apply to students in their classroom.

The pedagogical content knowledge is a kind of knowledge that includes knowing what teaching approaches fit the content and likewise, knowing how elements of the content can be arranged for better teaching. PCK is concerned with the representation and formulation of concepts, pedagogical techniques and knowledge of what makes concepts difficult or easy to learn, knowledge of students’ prior knowledge and theories of epistemology. It also involves knowledge of teaching strategies that incorporate appropriate conceptual representations in order to address learner difficulties and misconceptions and foster meaningful understanding, the complete as:

- General pedagogical knowledge, with special reference to those broad principles and strategies of classroom management and organization that appear to transcend subject matter.
- Knowledge of learners and their characteristics.
- Knowledge of educational contexts, ranging from workings of the group or classroom, the governance and financing of school districts, to the character of communities and cultures.
- Knowledge of educational ends, purposes and values and their philosophical and historical grounds
- Content knowledge
- Curriculum knowledge, with particular grasp of the materials and programs that serve as “tools of the trade” for teachers.
- Pedagogical content knowledge, that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding.

Although Shulman did not discuss technology, but teaching and learning with technology exist in a dynamic transactional relationship. We believe that these issues are important. The technology supported pedagogical practice in classroom. The recently most technologies used in classrooms [17], thus, knowledge of technology become an important aspect of overall teacher knowledge. However, the relationships between content (the actual subject matter that is to be learned and taught), pedagogy (the process and practice or methods of teaching and learning) and technology (both commonplace, like chalkboards and advanced, such as digital computers) are complex and nuanced. It is illustrated in more details in Figure 1.

Our framework emphasizes the connections, interactions, affordances and constraints between and among content, pedagogy and technology. In this model, knowledge about content (C), pedagogy (P) and technology (T) is central for developing good teaching.

The reasons of using this theory are: 1) this model examines pedagogy that should be understood within a broader framework of educational practice and 2) teaching-learning process requires research teacher PCK and the thinking that leads to observable elements in practice. Therefore, this framework should be observed at the classroom.

Conceptual Framework: Conceptual framework of this study, as developed from the literature, shows the relation between the conceptual framework and the factors which identified for investigation in this study as:

- Technology Knowledge Skill and Attitude (TKSA) chemistry teacher
- PCK chemistry teacher

Factors that are evaluated in this study are expressed in the conceptual framework in Fig. 2. However, this five category of concern are important benchmarks for assessing the overall progress and achievement of chemistry teacher in Iranian schools.
MATERIALS AND METHODS

The researcher has adopted the naturalistic qualitative method for the investigation of the problem. This helps to find real conditions in the classroom. Random sampling technique is used for selecting the sample. The sample consists of 376 chemistry teachers from 5 urban schools in Tehran, Iran. Their teaching experience ranged from less than five years to above 10 years and they were trained at different schools. With the approval and help of the principals from these selected schools, arrangements were made with the heads of the chemistry teachers sections to distribute the questionnaires to the chemistry teacher's concerned. This study is organized into two phase first phase to determine technology Knowledge, skill and attitude (TKSA) of chemistry teachers and the second phase to identify PCK chemistry teachers.

Phase 1: The data survey consisting of a 76-items questionnaire. The instrument includes:

- Questionnaire given to the chemistry teachers to gauge their technology knowledge, skill and attitudes.

The survey instrument for the data collection was divided into three parts: the first part of the survey consisted of 12 items regarding chemistry teacher's demographic information, the second part consisted of 44 items about ICT knowledge and skill in practice classroom, the purpose of this part was to find out the knowledge and skill level of chemistry teachers. This part consisted of 12 factors that encourage teachers’ usage of technology.

The third part of the survey consisted of 20 items related to ICT attitude of chemistry teachers and closed-ended questions. This study used the data collected from these 376 participants to conduct statistical analyses. The average age of the participants was 25. These participants were undergraduates from universities. The age group from 25 to 30 comprised 11.1% of the total participants. About 48.5% of them were in the range of 31-35, 28.3% were 36-40 and 12.1% of the participants were above 41 years old. They were female (100%). The questionnaire consisted of 76 items on a 5-point Likert scale to collect the data: a) Knowledge (Rarely: 1, Sometimes: 2, Never: 3, Often: 4 and Very often: 5), b) Skill (Average Important: 1, Little Important: 2, Not Important at All: 3, Important: 4 and Very Important: 5), c) Attitude (Not Sure: 1, Disagree: 2, Very Disagree: 3, Agree: 4 and Very Agree: 5).

Tools Used: Knowledge, skill and attitude towards ICT scale has been developed by the investigators. The dimensions of the scale are tasks, ability to do task, anxiety in classroom learning and positive impact on society.

Statistics Used: For analyzing the data Mean score, t-test and chi-square test were used. Data were analyzed and run thorough these tests using the Statistical Package (SPSS).

Data Analysis: In this study, the data collected from these 376 participants were used to conduct the statistical analyses. The alpha reliabilities range of skill was 0.963, knowledge 0.984 and attitude 0.977, that was fairly reliable. The possible explanations for certain knowledge, skill and attitude might be apparent by identifying factors that seem to be related to the certain responses [18].

Phase 2: The aimed was to identify chemistry teacher PCK, the instrument includes:

- We selected the 60% from 376 participants for test.
- We designed class for observation. This research study is a case study [19] were understanding PCK at classroom three teachers related to teaching chemistry.
Setting and Participants: The researcher selected three schools in an urban the Tehran, Iran. The participants in this study were Zahra, Sima, Parvin, who had 20, 5 and 12 years of teaching experience been observed and observation checklist 4 categories. Observations were not consistent due to the fact that participation in this study was voluntary and teachers individually decided how often they wanted to work with the researcher. Zahra lessons usually 1 hour, Sima were between 45-60 minutes and Parvin were in the range of 45-70 minutes.

Data Analysis: we for the data analysis using the four categories: a) instructional strategies; b) ways to asses students; c) student understanding; and d) goals-objectives in the curriculum.

RESULTS AND DISCUSSION

TKSA and PCK chemistry teachers were investigated. Data were collected from different sources and analyzed. Qualitative methodology was used to validate to obtained data.

Phase 1: Questioner was selected to determine TKSA chemistry teacher. The descriptive statistic of the sample is illustrated in Table 1.

Table 1 depicts the factors which contribute to the use of computers among teachers. The mean score values of 2.39 for use of Word processing, 2.37 for communication, 2.42 for presentation, 2.35 for manage files and records, 2.52 for monitor activities and events in education, 2.57 for perform financial function, 2.74 for internet research, 2.60 for repaired, 2.61 for publish and 2.63 for develop were obtained which contribute to the negative skill of the chemistry teachers in the use of computer to teach due to the weak obtained factors.

The analysis of ICT attitude, skill and knowledge of chemistry teachers is illustrated in Table 2.

Table 2 shows the t-test results for mean score ICT of chemistry teachers. According to this Table, mean score value of 2.49 was obtained for ICT skill of chemistry teacher and the hypothesis that the "ICT skill of teacher is in low level" was accepted (p-value <0.01). ICT attitude and skill of chemistry teachers was not equal.

Phase 2: a) The instrument test includes: 3 questions given to the chemistry teachers to gauge their PCK.

Q1: As for the meaning of solution temperature writes a context which can fully define this content. If this text includes a section of a book, write your proposal maximally in two pages.

The 75% of teachers couldn’t write their proposal based on given time in two pages. This shows chemistry teachers are not familiar with the content of their lessons as a specialist.

Q2: Now that you could produce some parts of the tutorial book with the proposition that you want to teach this lesson personally and make it applicable in a class, what answers do you have for the below questions? The descriptive statistic is illustrated in Table 3.

The Mean score 1.200, 1.866 in Table 3 shows that chemistry teacher in systemic approach and pedagogical knowledge is low level.

Q3: If you be counsellor writer chemistry text book what content do you suggest?

The mean score 2.375 in Table 4 shows that most chemistry teachers are familiar with quantitative aspects of chemistry.

Observation: Triangulation was use through observation checklist, videotape and transcript [20]. The teacher PCK is divided into above mentioned four elements Instructional strategy. Zahra, Sima, Parvin were observed the PCK at classroom. Zahra, for example wanted students to discover science on their own, but she focused on connecting the content to students’ lives through lectures and teacher-led discussions. She use of strategy that observation played not important role and students has problem in understanding content.

Student Understanding The students answer question without discussion. There isn’t any creativity and innovative at classroom. The used of tools is very limit.

Ways to Assess Student: The students have many difficult in to understand, because class is base on lessening. The students take note and exam was question to assess student skill.
Table 1: Factors contributing to the use of computers among teachers.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Mean score(Skill)</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word processing</td>
<td>2.39</td>
<td>1.13</td>
</tr>
<tr>
<td>Communication</td>
<td>2.37</td>
<td>1.07</td>
</tr>
<tr>
<td>Presentation</td>
<td>2.42</td>
<td>1.13</td>
</tr>
<tr>
<td>Manage files and records</td>
<td>2.35</td>
<td>0.99</td>
</tr>
<tr>
<td>Monitor activities and events</td>
<td>2.52</td>
<td>0.95</td>
</tr>
<tr>
<td>Perform financial function</td>
<td>2.57</td>
<td>1.01</td>
</tr>
<tr>
<td>Internet research</td>
<td>2.74</td>
<td>1.09</td>
</tr>
<tr>
<td>Repaired</td>
<td>2.6</td>
<td>1.48</td>
</tr>
<tr>
<td>Publish</td>
<td>2.61</td>
<td>1.49</td>
</tr>
<tr>
<td>Develop</td>
<td>2.63</td>
<td>1.03</td>
</tr>
</tbody>
</table>

Table 2: T-test results for mean score ICT (attitude, skill and knowledge) of chemistry

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>t-value</th>
<th>df</th>
<th>p-value</th>
<th>Mean difference</th>
<th>Mean score</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT attitude of teacher</td>
<td>4.246</td>
<td>375</td>
<td>0</td>
<td>3.196</td>
<td>0.196</td>
<td>105</td>
<td>287</td>
</tr>
<tr>
<td>ICT skill of teacher</td>
<td>11.981.-</td>
<td>375</td>
<td>0</td>
<td>2.497</td>
<td>502.-</td>
<td>58.-</td>
<td>42.7</td>
</tr>
<tr>
<td>ICT Knowledge of teacher</td>
<td>6.646</td>
<td>375</td>
<td>0</td>
<td>3.414</td>
<td>414</td>
<td>29</td>
<td>531</td>
</tr>
</tbody>
</table>

Table 3: Mean score q2.

<table>
<thead>
<tr>
<th>Item</th>
<th>M</th>
<th>Me</th>
<th>Mo</th>
<th>Std.deviation</th>
<th>V</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Knowledge</td>
<td>2.896</td>
<td>3.000</td>
<td>3.00</td>
<td>0.922</td>
<td>0.851</td>
<td>4</td>
</tr>
<tr>
<td>Scientific knowledge</td>
<td>2.946</td>
<td>3.000</td>
<td>3.00</td>
<td>0.898</td>
<td>0.807</td>
<td>4</td>
</tr>
<tr>
<td>Systemic Approach</td>
<td>1.866</td>
<td>1.000</td>
<td>1.00</td>
<td>1.106</td>
<td>1.225</td>
<td>3</td>
</tr>
<tr>
<td>Pedagogical knowledge</td>
<td>1.200</td>
<td>1.000</td>
<td>1.00</td>
<td>0.545</td>
<td>0.297</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 4: Mean score test q3.

<table>
<thead>
<tr>
<th>Item</th>
<th>M</th>
<th>Me</th>
<th>Mo</th>
<th>Std</th>
<th>V</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of subject</td>
<td>2.800</td>
<td>3.000</td>
<td>1.00</td>
<td>1.470</td>
<td>2.189</td>
<td>4</td>
</tr>
<tr>
<td>Basic concepts</td>
<td>2.120</td>
<td>1.000</td>
<td>1.00</td>
<td>1.384</td>
<td>1.917</td>
<td>4</td>
</tr>
<tr>
<td>Knowledge structure</td>
<td>1.066</td>
<td>2.000</td>
<td>1.00</td>
<td>1.177</td>
<td>1.387</td>
<td>4</td>
</tr>
<tr>
<td>Aspects of applied</td>
<td>2.786</td>
<td>3.000</td>
<td>3.00</td>
<td>1.276</td>
<td>1.629</td>
<td>4</td>
</tr>
<tr>
<td>Relationship between science</td>
<td>2.466</td>
<td>3.000</td>
<td>1.00</td>
<td>1.244</td>
<td>1.549</td>
<td>4</td>
</tr>
<tr>
<td>Understanding the language of chemistry</td>
<td>2.720</td>
<td>2.000</td>
<td>2.00</td>
<td>1.236</td>
<td>1.528</td>
<td>4</td>
</tr>
<tr>
<td>Familiar with quantitative of chemistry</td>
<td>2.375</td>
<td>2.000</td>
<td>1.00</td>
<td>1.238</td>
<td>1.534</td>
<td>4</td>
</tr>
</tbody>
</table>

**Goals and Objective in the Curriculum:** Model is a way to teach at classroom. We don’t observed teacher use of models at classroom.

There was little evidence in our data to suggest that the participants knew about PCK. This finding is similar to [21] who found that secondary chemistry teachers became aware of student difficulties and changed their instruction accordingly. However, these three teachers need more instruction. We believe this could be a catalyst for the conception of views and policies that contribute to shaping the future. This study can start a process, which is a process of joint thinking about the strategy for the policy today.

**CONCLUSION**

The purpose of this study was to investigate TKSA and PCK chemistry teacher. It was concluded that there was a significant difference in ICT knowledge, skill and attitude among chemistry teachers. However, they were unable to integrate the technology into practice classroom. The results showed that the use of ICT was sufficient in enhancing teachers’ thoughts towards technology integration, but it was not sufficient in helping them to actually integrate ICT in teaching. The actual experience of teaching itself may have a powerful influence on a teacher’s teaching [22]. Teachers that use
ICT during training become more confident in integrating technology in their teaching [23]. However, our findings indicate that TKSA and PCK chemistry teachers were low. Their views of instruction were active learning approached but we recognizing the teachers’ gaps in PCK are critical for improving teacher education [24]. Therefore, the results suggested that:

- Teachers should be trained for use of ICT as well as multimedia (including movie, animation, sound, etc.) in practice classroom.
- Internet facilities and tools should be extended in all schools so that the teacher trainees use the best material resources and interact with their schools or educational experts.
- The subject curriculum should be revised by including use of various educational software's in the practice classroom.
- Chemistry teachers need to instruction PCK.

**Limitations and Delimitations:** A threatening limitation of the current research was the fact that only a few chemistry teachers had participated in this research. Furthermore, the method of data collection was qualitative methodology. Moreover, this study was based on data analysis and transcript. The researcher had also faced some delimitation in their research such as the time factor which was extended over two months by participants who answered the questions quickly. The additional opportunity for test and observation was important to clarify the categories that participants were asked and observed. Unfortunately this study lacks such opportunities. Finally, there was some overlap in the categories that may have caused confusion in this research.

**REFERENCES**