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A New Perspective on Pedagogical Content Knowledge: Intellectual and Emotional Characteristics of Science Teachers

Muharrem DURAN¹, Muhammet USAK², Ming-Yuan HSIEH³,
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Abstract

The purpose of this study was to analyze the development of pedagogical content knowledge (PCK) of science teachers with different teaching experience on acids and bases and offer new domains of PCK which describe the relationship between PCK and emotional characteristics of teachers and their intellectual knowledge in science teaching. The research was carried out with the participation of six science teachers with different teaching experience. In the selection of participants, teaching the subject of acids and bases at least once, three and ten times, and being willing to participate in the study were the required criteria. Face to face interviews, videos and classroom observation forms, a pedagogical content knowledge form and academic follow-up forms are the assessment tools that were used in the study. It was found out that the teachers' intellectual knowledge and positive emotional characteristics contributed to their pedagogical content knowledge. Teachers who were able to create effective learning environments with sufficient level of intellectual knowledge and positive emotional characteristics had more qualified pedagogical content knowledge. These properties had a significant role in students' understanding.

Keywords: emotional characteristics, intellectual knowledge, pedagogical content knowledge, teaching experience.

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Introduction

As it is all over the world, science teaching is not conducted successfully in our country too. Both the international evaluations and analyses made on the results of our countrywide exams show that we fall behind the needed level in science teaching (Ilanlou, & Zand, 2011). As the required success in science teaching cannot be achieved, teaching processes and the qualification of science teachers are criticized by various sections of the country and teachers are the focal point of this criticism. The general impression is that teachers cannot perform science teaching in an adequate way. However, a teacher's professional qualification is essential for effective science teaching. In order to perform effective science teaching, teachers should have the ability to design and guide learning experiences under specific and adverse circumstances (Magnusson, Krajcik & Borko, 1999).

Literature review

Recently, studies have been conducted all over the world on teachers' professional development and qualifications. As the question "what a teacher should know in order to teach?" has been discussed for a long time, Shulman suggested in the first half of the 1980s that a teacher should have a special combination of content knowledge and pedagogical knowledge and he termed this new kind of knowledge as "Pedagogical Content Knowledge (PCK)" (Shulman, 1986). Shulman proposed PCK as a special form and type of content knowledge and stated that it could be "described as different types of knowledge to be used for teaching". While pedagogical knowledge, which can be obtained through education practices and experiences, is related to the "how" of teaching, content knowledge which means the "what" of teaching. PCK is different from the knowledge of a disciplinary expert and from general pedagogical knowledge. It is generally explained as a special part and type of the knowledge that differentiates subject matter experts (basic sciences experts) from expert teachers in the field (Berliner, 1986).

Characteristics of a qualified teacher in terms of PCK components have been studied by many researchers. For instance, areas that have been studied include, teaching experience (Van Driel, De Jong & Verloop, 2002); knowledge of understanding students Hashweh (2005), Abell (2008); professional development programs Park and Oliver (2008a), Luft (2009); content knowledge Van Driel, Verloop & De Vos (1998), etc. On the other hand, such questions as "How would the emotional characteristics of a teacher as a human affect the optimum level of using knowledge PCK domains?" or "Does he/she have adequate intellectual ability to organize this knowledge?" should also be answered. There is a lack of studies in the literature on teachers' knowledge towards questions we frequently hear such as "Is the science teacher affectionate?", "Is he/she angry or lovable?", "Does he/she love his/her profession?", "Does he/she create an emotional learning

environment and a cozy atmosphere for students?”, “Can he/she give excitement to students for learning?”, “Can he/she lift their spirits and set new goals for them and open up horizons?”. Some of the studies express the importance of teachers’ knowledge towards students’ feelings together with the fact that this lack of knowledge would not allow teachers to comprehend the content, curricular and pedagogical knowledge and thus teachers could not plan the teaching process well. It is also emphasized that “the knowledge of recognizing students’ emotions” is a significant component of PCK (Hargreaves, 1998; McCaughtry, 2004; Rosiek, 2000).

This study aims to explain the effect of teachers’ emotional characteristics and intellectual knowledge on students’ learning and its effect on teachers’ plans and practices in science teaching. Several studies have been conducted on teachers’ emotions and their effect on teachers’ pedagogical content knowledge (McCaughtry, 2004; Zembylas, 2007). However, theory and research on PCK have tended to ignore the emotional characteristics of teachers and their intellectual knowledge. Nevertheless, both emotional characteristics and intellectual backgrounds of science teachers are highly related with domains of PCK such as knowledge of students’ difficulties.

For effective science learning, the most widespread idea among curriculum writers, educational researchers and teachers is the engagement of students. Fundamental studies on education emphasize that students’ engagement and participation within the courses is highly significant for an efficient teaching and learning (Ainley, Hidi & Berndorff, 2002). On the other hand, many researchers regard individual or collective success in science teaching as an unconventional, nascent experience arising from new necessities. This experience is a co-generative dialogue between teacher and student in which all participants learn from each other (Fraser, Tobin, & McRobbie, 2011). Individual or collective success of students and the co-generative dialogue within the class can only be obtained through teachers’ adequate intellectual knowledge. Teachers who lack intellectual knowledge cannot perform the needed instruction and productivity in case of unconventional and astonishing situations. The positive emotional energy to be created by the teacher together with his/her students will enable the whole class to have a common spirit and contribute to receptivity within the learning process and thus students will increase their reception. Through this study; such issues as the impacts of intellectual knowledge and positive emotional characteristics of science teachers, who have different teaching experience, on their PCK and to what extent these features are associated with the other PCK components (knowledge of students’ understanding in science, curriculum, instructional strategies and representations, assessment of science learning on students, strategy, evaluation and assessment, etc.) will be elucidated.

Intellectual Knowledge of Teachers: An intellectual is described as someone who uses his/her intelligence and analytical thinking ability duly in order to achieve personal aims (Deng, 2007; Blevins, Salinas, & Blevins, 2013; Heyder, Bergold,

& Steinmayr, 2018). He/she is also described as someone who is responsible for producing and disseminating ideas and knowledge (like academicians, scientists, etc.) unlike other occupational groups that provide goods and services (Sowell, 1980). In terms of teaching, the features of an intellectual teacher are described as a one having high intellectual capacity, substantial content knowledge, well academically equipped, adequate development and teaching knowledge, and positive personal characteristics (Deng, 2007).

As teachers have a guiding role in terms of moral and material values in the society, they should have an intellectual knowledge such as comprehensive knowledge of the necessities of the time, should be at peace with themselves, be open to change and improvement, manage processes well enough, adapt themselves to social, technologic, scientific and environmental developments as well as possess affective and cognitive qualifications that are different than the others.

A teacher who has an adequate intellectual knowledge and the capability of intellectual teaching is expected to raise individuals who think analytically, synthesize, have the capability of problem solving, communicate effectively, know how to obtain knowledge and have the capability of critical thinking. According to Seatter (2003), intellectual teaching in science should include all activities and preparations around the subject to be taught. These activities are the acts and preparations that can give answers to the question “How a subject should be taught in the best way to enable elementary students to understand a science course?”. Such preparations are the activities that are centerpieces of the teaching activity and supported by appropriate teaching strategies.

Intellectual teaching primarily supports content knowledge and “awareness” or “comprehension” of ideas that are by definition driving forces to this kind of knowledge. Introducing the course, presenting, explaining, describing, justifying, comparing, questioning, proving, assigning and substantiating can be given as examples for intellectual teaching activities (Komisar, 1968; Green, 1971).

Tyler (1964) describes intellectuality as “applying the thinking process to the solution of problems”. He emphasizes that teaching is an intellectual act because of certain properties required for an effective learning such as formulating appropriating objectives, selecting and arranging learning opportunities and selecting and constructing evaluation devices. Science teaching differs from other fields because of the nature of science. As science has plenty of abstract concepts and it is an applied field that is based on experiments, etc. As well as pedagogical content knowledge that is regarded as success criterion for science teachers, whether they have adequate intellectual knowledge and positive emotional characteristics in order for an effective teaching and permanent learning, should be questioned. This research study mainly focuses on this idea.

Some researchers determined special field qualifications for science teachers by conducting a scientific study. These are some capabilities such as planning

the teaching process in accordance with the curriculum, preparing learning environments, using supportive materials and sources, arousing curiosity among students towards learning and observing the environment they live in, giving insight to the students in terms of the interaction between scientific and technological developments and society and the environment and benefiting scientific and technological developments in order for professional development and communication (Duran, & Usak, 2015).

Within the scope of this study, the intellectual knowledge of science teachers is tried to be identified with some questions like reading and writing articles on the related subject area, preparing materials for lessons and specific questions on the field, conducting qualified projects in cooperation with students, following curriculum changes, attending to group studies conducted by subject teachers and being active in these studies, preparing original lecture notes related to science field, using smart boards effectively and preparing presentations, preparing questions for periodic exams, preparing animations or videos about the course content, using body language effectively, adopting a student-oriented education, using technology and taking personal differences into account, etc. (Ozden *et al.*, 2013).

Emotional Characteristics of the Teacher: Having both affective and cognitive abilities such as pedagogical knowledge, love and loyalty for his/her profession, philanthropy (humanity), etc. will contribute to the management of the teaching process that is regarded as complicated and abstruse as well.

Some characteristics as a teachers' level of commitment for his/her profession, blessing and loving his/her profession, loving students, establishing a sincere relation with them, behaving inclusively and kindheartedly, keeping his/her teaching enthusiasm alive, not reflecting the negative impacts of daily life onto the class, are all factors that show the teachers' efforts for students' success and development and they are regarded as positive emotional characteristics of a teacher within the scope of this study.

Psychologists generally categorize an emotion as positive (such as happiness and satisfaction) if one enjoys his/her goal-oriented job and makes progress in this direction. Love for the profession and compassion are discussed as positive emotions for teachers within the body of the literature (Sutton, & Wheatley, 2003). The emotional interaction in class between the teacher and the student underlies education and learning. If these relations that are based upon utterances and acts are well, a positive learning atmosphere will develop within the class; otherwise, the learning atmosphere of the class will deteriorate gradually, and the education will not achieve its aim. Thus, it can be said that the educational atmosphere of the class is highly based upon the teacher's attitudes (Alhebaishi, 2019) and naturally on positive emotional characteristics.

It is due to the scantiness of studies conducted in this field that the knowledge of teachers' way of adjusting emotions, the interaction between their emotions

and motivation and the impact of emotional experience on their development is insufficient. Within this context, although researchers have conducted many studies on teachers' emotions since the early 1980s, there is still too little knowledge on the role of emotions in learning to be used in teaching, the relation between the teachers' emotional experience and teaching practices, sociocultural content of teaching and its relation with teachers' emotions (Sutton & Wheatley, 2003). Collins (2004) states that the emotional energy created through the interaction in a class would be a significant component of class participation and support of students' learning and attendance. A positive emotional energy in a class could be created with successful interactions and it would support cognitive and behavioral aspects of class participation. Such energy would surround all students having got lost in the collective and emotional atmosphere of the class.

Teachers' positive emotional features and creating a positive learning atmosphere are highly significant in order to be able to provide a comprehension of such concepts as sharing, cooperation, solidarity, justice and being a good citizen that are all among the fundamental goals of science teaching. Nonverbal messages could be more significant than verbal ones within the preparation of a positive learning environment. Students could be impressionable towards teachers' nonverbal messages. For instance, students could learn muscle contractions, marginal stretched facial lines on the lips and how to understand body signals. If these nonverbal messages contravene verbal messages, students would be confused or believe nonverbal messages and regard contradictory verbal messages as deceitful (Karunaratne *et al.*, 2019; Vykhreshch *et al.*, 2020).

Students are mostly aware of teachers' negative emotions and are affected by these. When a group of primary school students is asked "What would you like to set as a rule for your teachers?" they answered "Do not shout at us" (Thomas & Montgomery, 1998). According to the researchers, in students' mindsets, teachers' yelling and shouting make students feel disrespected, sorrowful, embarrassed, offended, guilty and dissocial. And most of the students stated in the same study that they felt teachers' shouting at others as if it was done against them.

Sutton and Wheatley (2003) explained multi-component aspects of emotions in their study on teachers' emotions and teaching activities and stated within the body of the literature that teachers' positive and negative emotions could affect both their own and their students' cognition, motivation and behavior. Emotional characteristics of the science teachers included in this study were learnt partially and the impact of these characteristics on their PCK development. Answers of teachers given to questions on aforementioned issues are given in *Table 3* in detail. Due to the scantiness in terms of scientific studies on PCK development of teachers in teaching a specific subject in the science field and the fact that two new different domains other than PCK will be examined, it is thought that the findings to be obtained through this study would give a different point of view to the body of literature.

This study seeks answers for the following questions: (1) What are PCK levels of science teachers who have different teaching experience about acids and bases? (2) How do intellectual knowledge and emotional characteristics of science teachers affect their PCK? In addition, the answers of following questions will be tried to be elucidated: (1) What are the PCK levels of science teachers about the acids and bases subject? (2) What are the levels of science teachers in intellectual knowledge? (3) What is the impact of intellectual knowledge on PCK and how is their relationship? (4) What is the impact of positive emotional characteristics on PCK?

Methodology

Selection of Participants

This study was conducted in cooperation with 6 teachers working as science teachers for 8th grade classes in boarding schools within the Ministry of National Education in the Yenimahalle district of Ankara. As it was aimed to analyze how pedagogical content knowledge in teaching acids and bases subject of science teachers with different experience changes, teaching experience was regarded as a significant criterion in this study. For this reason, three experience categories as having an experience of five years and ten years at most and more than ten years were determined as criteria for the selection of participants.

During the selection process for the teachers to be included in work groups, the maximum variation method was used in order for significance richness. As a result, it was aimed to obtain common or different aspects from different situations and describe the current situation from a broader perspective by not generalizing people with heterogeneous features but finding significant clues about population values (Lodico, Spaulding, & Voegtle, 2010).

Features of Participants

Some information about the participants is given in Table 1. Four of the participants graduated from science teaching while the other two from chemistry teaching and biology teaching respectively. Two of the participants are in 2nd and 5th year of their career and they have already taught acids and bases subject at least once. The other two teachers are in their 7th and 9th year and have already taught acids and bases subject at least three times. Two teachers in the last group have an experience of more than ten years in their profession and have taught acids and bases subject at least ten times. Participants were designated as T1, T2, T3, T4, T5 and T6.

Table 1. Background information of participants

Name	Science Background	Gender	Teaching years	Teaching subject when observer is in class	Other activities that he/she does in extra time
T1	Science education	Male	1	Properties of Acids & B.	Social activities
T2	Science education	Male	5	Properties of Acids & B.	Social activities
T3	Science education	Male	7	Strength of Acids & B.	Science trips
T4	Science education	Male	9	Properties of Acids & B.	Extracurricular activities
T5	Chemistry education	Male	18	Properties of Acids & B.	Problem solving
T6	Biology education	Male	20	Acids & base reactions	Show experiments

Data Collection Tools

Basic data collection tools used in this study consisted of a PCK evaluation form, a class observation form, a semi-structured interview form developed by the researcher and video recordings of classes. Data collection tools and information to be obtained are given in *Table 2*.

Table 2. Data Collection Tools

Data Collection Tool	Features to be evaluated
Academic development follow-up form	To determine intellectual knowledge and emotional characteristics
Class observation form	To determine class management, ability to create positive learning environments, body language and oral communication
Video recordings	To consider class management, pedagogical knowledge, cognizant individual differences
Interview	Teacher's intellectual knowledge, emotional characteristics, emotional ties with students, loving his/her profession and students

Pedagogical Content Knowledge Questionnaire Form

A PCK evaluation form composed of open-ended questions was prepared in order to determine the teachers' pedagogical content knowledge. It consisted of questions to measure such sub-dimensions as science teachers' pedagogical content knowledge in acids and bases subject, assessment and evaluation knowledge, levels in cognition of learning and teaching difficulties, knowledge of concepts, levels in cognition of mistakes and reasons for mistakes, ability of determining conceptual misapprehension and knowledge of experiment-observation.

In order to measure the PCK of participant teachers, 40 open-ended questions were prepared based upon remarks of scientists such as Shulman (1987), Cochran, De Ruiter, & King (1993), Magnusson *et al.* (1999) and Hashweh (2005) on PCK components. These questions were about content knowledge (20), levels in cognition of learning and teaching disabilities (10), knowledge of assessment and evaluation (5) and knowledge of teaching strategies (5). These questions were broached to three domain experts studying in physics, biology and science respectively and two other expert chemistry teachers. The necessary editing was made in accordance with the suggestions of experts; some questions were eliminated and a final PCK evaluation form was created.

Class Observation Form

A class observation form was prepared considering Class of Teaching Practice Class Observation form and resources of the Council of Higher Education related to class observation such as, Sawada *et al.* (2002) and Genc, & Buyukkarci (2013). First of all, an observation form consisting 25 items was broached to subject matter experts. Considering the remarks of these experts, the number of questions was determined as 20 and the final interview form was obtained. Within the evaluation of the items included in the class observation form, teachers' best practice and adequate explanations and unpracticed acts were graded with 5 and 0 points respectively.

Video Recordings

Video recordings are highly significant data sources for the analysis of in-class relationships between the teacher and students. Results of live class observations are limited with the notes of the observer. Likewise, although control lists are beneficial for class observations, mostly observers are not quick enough to record all details. It's because of the fact that many developments emerge in class within a short while and a short winded development may have a potency of being a new data. However, using video recordings changes the situation. Video recordings can be stopped, moved forward, moved back and replayed (Stigler, Gallimore & Hiebert, 2000). Within this study, participant teachers were recorded in classes

with 20 students while they were teaching the acids and bases subject in 40-minute lessons.

Interviews

According to Merriam (1998) and Yin (2003), interview is one of the most basic data sources to be used for a better understanding of the study in qualitative researches. Interview is a significant data source in PCK studies because of the fact that the best way of collecting data about the thoughts of teachers related to the components of PCK is face-to-face interviews. Teachers' thoughts and knowledge on teaching can only be obtained through this way. All interviews were recorded; certain details that could not be obtained through other data collection tools and could not be clarified were acquired through a semi-structured interview form.

Academic development follow-up form

A questionnaire form was prepared in order to determine participant teachers' intellectual knowledge and emotional characteristics. The most important criteria for preparing these questions was specified as determining the academic development and intellectual knowledge that a teacher should have in order to educate his/her students in scientific literacy and his/her positive emotional characteristics in terms of reflecting this knowledge onto students.

Moreover, competence and performance indicators were prepared based on certain factors such as "personal and professional values – professional development", "acknowledgement of students", "teaching and learning processes", "program and content knowledge" that are stated in the general competence of the teaching profession (Duran, & Usak, 2015). These factors show similarity with universal consents on PCK and its sub-dimensions. From this point of view, 30 yes-no questions were prepared in order to evaluate teachers' academic development and intellectual knowledge. Of these 20 questions were chosen according to the remarks of experts and education leaders and a final questionnaire was created. These questions were graded with (1) point for "yes" and (0) point for "no". Besides, 7 questions were prepared in a questionnaire for learning emotional characteristics of participant teachers towards the teaching profession in accordance with the ideas of experts and education leaders.

Data Collection

The data was mostly collected from schools during the year of study. The survey was conducted in teachers' free times. Video recordings were taken during ordinary course hours taking care not to denaturalize the class environment. The data collection process was extended over a period of time and more than one evaluation was conducted. The data was broached to different experts with different points of views and the similarity of results was tested.

Validity and Reliability of the Study

Multiple data sources such as observations, interviews and document analyses were used in this study in order to ensure validity. The case study report was prepared after consulting one of the participants. Therefore, subjective judgments of the researcher (Clarke, 2002; Lichtman, 2013). could be minimized. Class observation forms were filled in during video recordings and significant details were noted. Accuracy of information was controlled by interviews with teachers, sharing the notes with other teachers and interviews with group leaders and students as well. The validity of data was proved by watching the video recordings concurrently together with the advisor in order to make inquiries on teachers' knowledge of basic and sub-dimensions of PCK components. In this way, internal validity of the research was proved by a joint evaluation of data sources such as interviews and video recordings.

Reliability, which cannot be regarded as independent from validity, is a significant concept and related to whether a similar study would give same or similar results when it is conducted by another researcher in the same way (Yin, 2003). It is generally seen that reliability increasing principles proposed by different researchers are mostly identical with the ones suggested for reliability. Triangulation, control of data by the staff, long observation periods, and analysis of the study by other researchers can be listed as certain measures to be taken in order to increase reliability in qualitative researches (Denzin & Lincoln, 1994; Lodico, Spaulding, & Voegtler, 2010). Reliability of this research was proved by a data triangulation together with different data collection methods, extended studies and approvals of different experts.

Analysis of Qualitative Data

Basic data sources of this research study consist of evaluation forms, questionnaire forms, video recordings, interviews and observations. The data obtained from video recordings, interviews and observations were computerized through word and excel software. Interview and observation videos prepared with six different teachers with different teaching experience were written out in a computer environment through the transcription method. These transcripts prepared as a data set were crosschecked with video and tape recordings again and deficient or incorrect parts were edited.

The Cronbach's alpha internal consistency coefficient of the questions in the PCK evaluation form was measured as .802. It means that the PCK evaluation form is a reliable data collection tool. During the transcription and analysis of data obtained through interviews, observations and video recordings utterances of participants were left as they were and they were not changed in any way. Completing transferring and editing, the data were analyzed through descriptive analysis and content analysis methods.

Findings

Each science teacher was analyzed one by one in this section. First of all, teachers' responses to the emotional form will be given and then teachers' PCK levels and the relationship between emotional characteristics and intellectual knowledge on PCK levels will be analyzed separately and thereafter crosschecked with each other. PCK and the relation between two novel dimensions were analyzed and evaluated by the data obtained through evaluation tools.

Answers given to the questionnaire prepared in order to determine participants' emotional characteristics are given in *Table 3*.

Table 3. Responses of participants to academic development follow-up form relating to their emotions

Questions	T1	T2	T3	T4	T5	T6
Would you prefer being a teacher now if you have a chance to choose your profession again?	Yes	Yes	Yes	Yes	No	Yes
If you answered the first question with "No", why?	-	-	-	-	The public view on the teaching profession	-
How much time do you spend with the teaching profession and your own field of study?	Long enough	Long enough	Half of my time out of the one I spend with my family	Half of my time out of the one I spend with my family	All of my time	All of my time out of the one
Based on the idea that "Teaching is a profession that requires conscientious responsibility", to what extent you feel responsible for the profession you profess conscientiously?	I'm conscious of my responsibility.	I sleep with a clear conscience on this point.	I'm conscious of my responsibility.	I'm conscious of my responsibility.	I'm conscious of my responsibility.	I'm conscious of my responsibility.

Do you agree with the idea that "Teaching is a blessed profession"?	Yes	Yes	Yes	Yes	Yes	Yes
Do you think success in "content knowledge" is enough to be a qualified teacher?	No	No	No	No	No	No

It can be said that all participants have favorable emotions for the teaching profession according to *Table 3*. All participant teachers except for T5 expressed that they would like to choose the teaching profession again. Out of the time they spend with their families, participants allocate their time for their professional development and they stated that they believed that the teaching profession required conscientious responsibility and is a blessed one. All of the participants expressed that having content knowledge was not enough for being a qualified teacher.

PCK levels, intellectual knowledge and emotional characteristics of science teachers were analyzed separately and findings obtained for each research question were explained.

Analysis of T1: Relationship between PCK-Intellectual knowledge and emotional characteristics

T1 is the most inexperienced participant. He practices expository teaching with a teacher oriented perspective. He has a weak relationship with students but a strong control over the class. It was identified about T1 that he does not have a sufficient intellectual knowledge due to being a novice teacher but loves the teaching profession and makes an effort to establish an emotional bond with students. T1, who loves his profession, allocates sufficient time for his professional development, emotionally commits to his students and believes the blessedness of the teaching profession is an inexperienced and less improved teacher in terms of PCK but is successful in communication with students and preparing a positive learning atmosphere within the class due to his positive emotional characteristics. T1 expressed his commitment to the teaching profession as follows:

"I can say that I'm in love with my profession, I chose this profession consciously, willingly and to be beneficial to students and I love my profession".

Table 4. Intellectual knowledge and Emotional Characteristics of T1

Intellectual knowledge and reflecting on the class	Emotional characteristics and reflecting on the class
Very low level of intellectual knowledge, Limited role in cooperation and leadership, Low level of reflecting practices that improve learning quality. Very less developed PCK.	Emotional, Loves the profession, Has a medium level in verbal-nonverbal communication, Excited. Has a normal level in preparing a positive learning environment.

Analysis of T2: Relationship between PCK-Intellectual knowledge and emotional characteristics

T2 practices both student and teacher oriented teachings. The fact that he can make students participate in the course in an active way, treats equally in giving the floor and corrects the mistakes with feedbacks, strengthens the idea that T2 is good at in-class management and communication with students. In the light of findings obtained through the evaluation instrument it was identified that T2, who has a low level of teaching experience and does not have a sufficient level of PCK, has a warm and strong bond with his students and prepares a positive learning environment for in-class communication due to his sufficient intellectual knowledge, love for the teaching profession and commitment. T2’s expressions about students are as follows:

“I try to be in their lives, I’m an emotional person, I can be affected easily from things through my own observations, I ask myself about my expectation when I was a student and behave with my students remembering those expectations. I’m closely acquainted with some of my students, they are interested in mathematics and talented too but they can abandon mathematics because of any problem with their teacher”.

Table 5. Intellectual knowledge and Emotional Characteristics of T2

Intellectual knowledge and reflecting on the class	Emotional characteristics and reflecting on the class
Sufficient level of intellectual knowledge. Good role in cooperation and leadership. Good level of reflecting practices that improves learning quality. Less developed PCK.	Emotional. Loves the profession, Good at verbal-nonverbal communication, Calm. Good at preparing positive learning environments.

Analysis of T3: Relationship between PCK-Intellectual knowledge and emotional characteristics

T3 practices as a teacher oriented depending on the book. It can be said that he cannot use teaching technologies efficiently during classes. He has a less developed in-class planning and management ability. His PCK level was identified as medium using the data obtained through evaluation forms. Having a low level of teaching experience and less developed PCK, T3, who has a medium level of intellectual knowledge, loves his students and profession, became successful in preparing in-class communication and learning environment due to his positive emotional characteristics. Words of T3 about a teacher’s compassion are as follows:

“The more a student likes you, the more he/she will be successful, I behave towards my students as a compassionate father, I always call them for sharing their happiness and sorrow They also call me and share their feelings whenever they want. Remembering their birthdays, giving moral support when they lose one of their relatives, playing football together, etc. may change students’ perspectives towards the lesson”.

Table 6. Intellectual knowledge and Emotional Characteristics of T3

Intellectual knowledge and reflecting on the class	Emotional characteristics and reflecting on the class
A normal level of intellectual knowledge. Good role in cooperation and leadership. Good level of reflecting practices that improves learning quality. Developing PCK.	Emotional. Loves the profession, Good at verbal-nonverbal communication. Sympathetic. Good at preparing positive learning environments.

Analysis of T4: Relationship between PCK-Intellectual knowledge and emotional characteristics

T4 is teacher who practices with a teacher oriented approach, has a strong in-class communication, can use body language effectively. His content knowledge is sufficient but cannot give satisfactory answers to students’ questions about detailed subjects. It was determined during class observations that T4, who is a science graduate, has difficulty in answering detailed questions about the acids and bases subject. This teacher, who has a medium level of intellectual knowledge, practiced a successful teaching by preparing positive in-class teaching environments and establishing warm relationship with students. A similar feature was observed for this teacher too as the others; the teacher’s commitment to the profession, positive emotional characteristics and developing PCK helped the teacher to practice a successful science teaching process. Words of T4 about the emotional bond with the students are as follows:

“Emotional bonds are so important, you should really like your students, even if they are the naughtiest or laziest, if we do not like the student, we cannot appeal to him/her. Sometimes, some of the students are mentioned many times during teachers’ meetings but you think that you have never had a problem with that student. Because you will see that the student really likes you, you’ve established a bond and he/she does not want to break that bond. You also do not force him/her. When you do not offend the student in front of others, he/she also likes you and when you explain the student’s faults in a face to face conversation kindly, he/she does not repeat the same thing. It means as long as you become patient towards the student, he/she can put up with your occasional reprehensions”.

Table 7. Intellectual knowledge and Emotional Characteristics of T4

Intellectual knowledge and reflecting on the class	Emotional characteristics and reflecting on the class
A normal level of intellectual knowledge. Good role in cooperation and leadership. Good level of reflecting practices that improves learning quality. Developing PCK.	Emotional. Loves the profession. Good at verbal-nonverbal communication. Sympathetic. Good at preparing positive learning environments.

Analysis of T5: Relationship between PCK-Intellectual knowledge and emotional characteristics

T5 adopts a teaching style that uses teaching strategies appropriately and properly, takes prior knowledge of students into account, conducts an inquiry based teaching method in accordance with principles of life-long learning approach. T5 has the most developed PCK according to the data obtained through data collection tools. Having a high level of intellectual knowledge, T5 is quite good at in-class communication and successful in preparing positive learning environments. Despite his professional commitment, T5 states that he chose teaching as a profession at the recommendation of one of his favorite teachers and would not prefer teaching if he had to choose a profession again. He states that the negative perception of the community he lives in had an impact on this decision. Statements of T5 about teaching profession and the relationship with students are given below in brief:

“I liked my students so much although I had some difficulties. I thought of the importance of my profession and continued. Do I regret being a teacher today? No. But I think teaching is not something valuable in Turkey. I see many students coming to me and saying ‘teacher, I study science because I like you so much’ although they were not successful students.”

Table 8. Intellectual knowledge and Emotional Characteristics of T5

Intellectual knowledge and reflecting on the class	Emotional characteristics and reflecting on the class
A high level of intellectual knowledge. Highly good role in cooperation and leadership. Very good level of reflecting practices that improves learning quality. Very developed PCK.	Logical. Loves the profession. Very good at verbal-nonverbal communication, Calm. Very good at preparing positive learning environments.

Analysis of T6: Relationship between PCK-Intellectual knowledge and emotional characteristics

T6, who practices with a teacher oriented approach, is good at in-class interaction with students although he does not pay regard to individual differences sufficiently. As the most experienced participant, T6 is a teacher who loves his profession and has a professional commitment in addition to a developed PCK according to evaluation forms but not in a perfect level. His intellectual knowledge has not developed in proportion to his teaching experience. T6’s professional commitment and love for the students contribute to his PCK level. Statements of T6 about a teacher’s love for the students and school success are given below:

“If a student likes the teacher, he/she loves the lesson and becomes more successful too. If a teacher can make students like him/her, others will come naturally. For example, this year I attended the first class and one of my students said that he never liked science lessons. I dealt with this student personally and after three weeks the same student told that ‘teacher, I like this lesson so much’.”

Table 9. Intellectual knowledge and Emotional Characteristics of T6

Intellectual knowledge and reflecting on the class	Emotional characteristics and reflecting on the class
A medium level of intellectual knowledge. A good role in cooperation and leadership. Level of reflecting practices that improves learning quality. Developed PCK.	Emotional. Loves the profession. Good at verbal-nonverbal communication, Sympathetic, Good at preparing positive learning environments.

Pedagogical content knowledge is described as the integration of five different components; a) Orientations toward teaching science b) knowledge of students' understanding in science, c) knowledge of science curriculum, d) knowledge of instructional strategies and representations, and e) knowledge of assessment of science learning (Park & Oliver, 2008a). As well as the importance of the harmony among those five components, Magnusson *et al.* (1999) emphasized on the linear relationship among dimensions and the relationship between these dimensions and the tendency toward science teaching while they ignored the dynamic and cyclical relationship among themselves (Friedrichsen, Van Driel, & Abell, 2011). On the other hand, according to the pentagon model, PCK is central and other five components are in a relationship with each other equally (Park & Oliver, 2008b).

Two new components were examined in our study; it was determined that the intellectual knowledge of the teacher and the intellectual teaching practices conducted through this knowledge and positive emotional characteristics of the teacher and the emotional intra-class energy created by reflecting these emotions onto class have a direct interaction with the other components of PCK. The pentagon model formed by Park and Oliver (2008b) became the framework for the hexagon structure of this study.

Findings obtained through detailed multiple case study and the data variation method conducted on science teachers' PCK indicate that there is a dynamic relation between dimensions, teaching experience and PCK development which are directly proportional, components developed in different ways for each teacher and teachers' positive emotional characteristics. Adequate intellectual knowledge contributes to pedagogical content knowledge as well as to other dimensions.

A teacher should have an adequate level of intellectual knowledge in order to perform an effective teaching. In addition to this, having positive emotions and establishing warm relationships with students are in a close relation with knowledge about students. Students of a teacher with such characteristics become more enthusiastic and eager to participate in classes and to address questions to teacher.

Conclusion

With their gains obtained through intellectual knowledge, teachers' "giving appropriate examples associating to daily life" while lecturing on a subject coincides with the "good exempling" feature of pedagogical content knowledge concept. When considered from this point of view, intellectual development of a teacher actually means the development of PCK features and should be regarded as a significant and novel part of PCK.

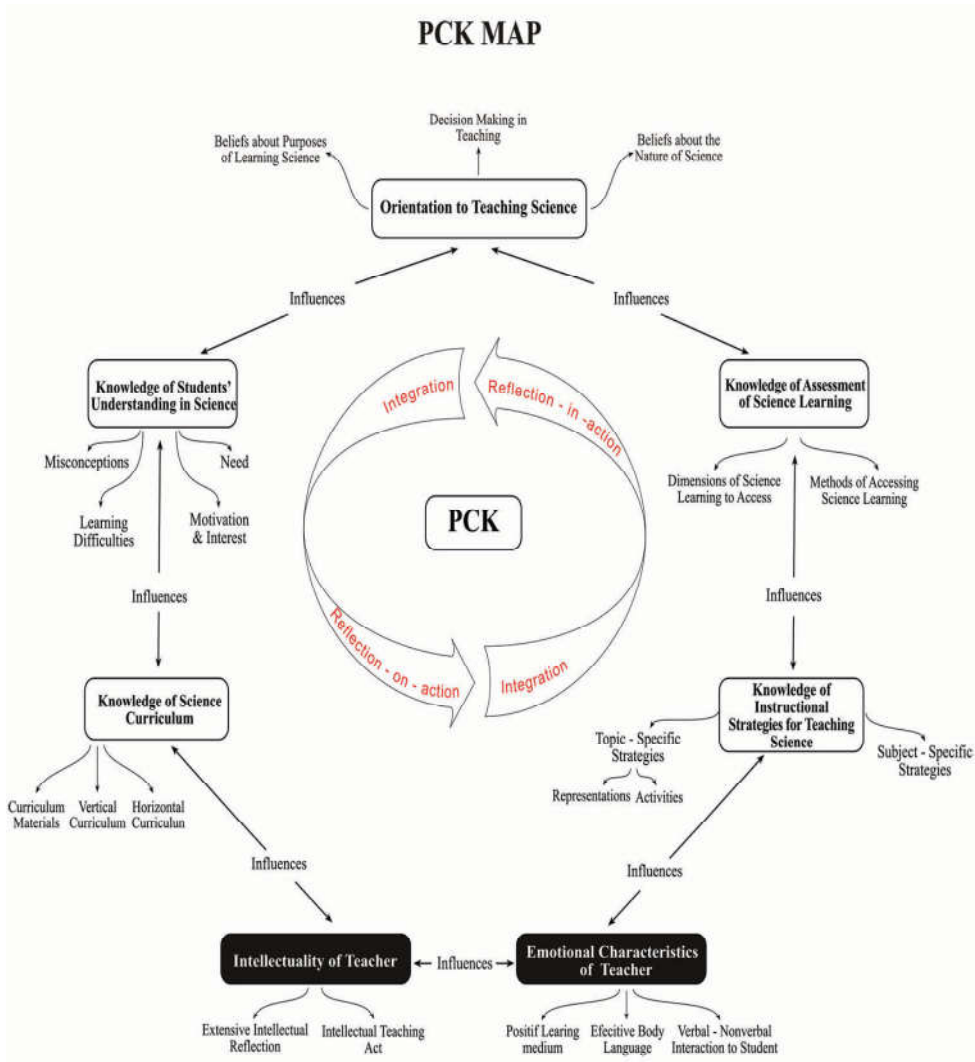


Figure 1. Proposed hexagon model of PCK for teaching science (modified from Park & Oliver, 2008b by rearranging the components).

Teachers with positive emotions treat students with love and compassion. Teachers in our study showed that having positive emotional characteristics is significant for in-class interaction, motivation and encouragement for the students. All participants of this study are teachers who love the teaching profession, have chosen this profession willingly and believe that they would choose teaching again if they have to make a decision. They also believe that teaching is a sacred profession and requires patience and self-sacrifice and state as a common ground that a teacher should behave as a teacher not only in class but also in every phase

of life. This situation has been found compatible with the findings of the study. Only T5 expressed his/her discomfort stemming from certain negative attitudes of society towards the teaching profession and that he/she would choose another profession. It was concluded that teachers with lower teaching experience and insufficient intellectual knowledge love their students and profession, sacrifice their own interests by spending more time with students, establish strong emotional bonds with them and this situation leads students to take interest in learning science and spend more time in studying contrary to terms of other teachers whom they dislike and most importantly the fact that these teachers may substantially fill the gap in their PCK knowledge. Rosiek (2003) states that although western societies regard emotional reactions as feminine and think that emphasizing the emotional side of teaching would lead to a decrease in professional status, our society and culture highlights the sacred (Borman, & Kimball, 2005; Rothstein, 2010) status of the teaching profession by pointing out the status of teachers and teaching as well as the emotional side of instruction.

Positive emotional characteristics of a teacher can be regarded as a significant factor in having a developed PCK and improving pedagogical content knowledge as well as eliminating deficiencies in PCK. According to this fact, teachers should love students, have commitment toward the teaching profession and have appropriate disposition and characteristics. Studies like Hargreaves, (1998), Rosiek, (2000), Zembylas (2007) suggested that it is another dimension of a teacher's knowledge to understand students' feelings and design the course content accordingly. They also state that emotional knowledge of the teacher is an important aspect of PCK. It is stated in these studies that in order to teach well, teachers must be able to connect their emotional understanding with what they know about the subject matter, pedagogy, school discourses, personal histories, and curriculum. This statement corresponds to the findings of this study except for our suggestion that not only teachers' knowledge of emotion but also the positive emotional characteristics and intellectual knowledge of teachers that were determined with certain questions mentioned above play a crucial role in the formation of PCK.

Recommendations

It was determined in this study that emotional characteristics of science teachers also contribute to development of PCK depending on teaching experience. Particularly the fact that teachers who love their students and make sacrifices for the sake of the profession have more developed PCK levels brings critical responsibilities for the authorities in educating prospective teachers. It is recommended that teacher candidates and active teachers who do not like children, do not or cannot take individual differences into account and do not have the capability of being a counselor should be directed to another profession.

Educational policy makers should take certain measures against the negative perception of our community toward the teaching profession. One of the teachers

with the most developed PCK, T5 stated that he was disheartened with the profession because of this negative perception of the community.

As we cannot generalize the situation by looking at emotional characteristics of the limited number of participants, longitudinal studies should be conducted on teachers' PCK development and emotional characteristics. For this reason, there is still a need for large-scale ethnographic studies in order to identify teachers' emotions and emotional characteristics and their relation with teaching practices in a detailed manner.

Questions such as "How is the relationship between peculiar emotions and content knowledge, pedagogical knowledge or subject-specific pedagogical knowledge of teachers within their first year of teaching" and "How is the relationship between teachers' emotions and their in-class management?" should be studied with different questionnaires and groups of teachers. Comparing these studies with the ones conducted in other cultures would answer the question on the effect of emotional characteristics of teachers who own the values of their cultures on teaching and learning.

It is inevitable for school principals to take the proper steps in order for the intellectual knowledge a novice teacher should have for an effective teaching. Teachers can be encouraged in terms of staying up to date, following scientific studies, carrying out scientific studies with their students and participating in professional development seminars. In addition, teachers can also be encouraged to conduct academic studies on the profession or their specific subject and the ones who conduct such studies should be rewarded.

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