LOOK ACADEMIC PUBLISHERS
OPEN ACCESS

INTERNATIONAL JOURNAL OF ENVIRONMENTAL & SCIENCE EDUCATION
2016, VOL. 11, NO.15, 8040-8054

A Multiple Case Study of Preservice Science Teachers' TPACK: Embedded in a Comprehensive Belief System

Erhan Güneş[a], and Eralp Bahçivan[b]

[a]Ahi Evran University, Kırşehir, TURKEY; [b]Abant İzzet Baysal University, Bolu, TURKEY

ABSTRACT

Integrating technology into science education provides opportunities to foster students' meaningful learning. This study focused on technological pedagogical content knowledge (TPACK) and its connections to belief system in a science teaching context. The purpose of this study was to investigate the effects of preservice science teachers' (PST) beliefs on their TPACK level. Multiple case study method was implemented. Multiple cases of the study were: low, medium and high confidence of TPACK. Purposive sampling was adapted to select cases. Data was collected through individual semi-structured interviews and lesson plans of PSTs. Content analysis was used in order to analyze the data. Holistic and embedded analyses were implemented to grasp each case entirely and comparing specific aspects and relations of the cases. According to findings there was a positive relationship between PST's TPACK confidence and TPACK level. The PSTs' belief systems consistently related to their TPACK levels in terms of several respects. When epistemological beliefs were not taken into consideration, relationships among other variables of the study showed consistency with previous research findings related to relationship between self and conceptions of teaching and learning. Implicational suggestions for future research and science teacher education programs were presented.

KEYWORDS
TPACK, belief system, science teachers, technology, confidence

ARTICLE HISTORY
Received 06 May 2016
Revised 11 May 2016
Accepted 11 May 2016

Introduction

Technology integration empowers teachers' instructions since it contributes positively to students' meaningful learning (Byrom & Bingham, 2001; Mitchem, Wells & Wells, 2003; West, 2012) and creates chances to present extraordinary (difficult to find) realities in a learning environment (Lai, 2006; Wang, 2005; Butzin, 2001). Today, a plethora of countries attempt to integrate instructional

CORRESPONDENCE Erhan Güneş ✉ guneserhan@gmail.com

technologies into schools and classrooms (Keengwe, Schnellert & Mills, 2012). Turkey has also started a thorough transformation to adapt instructional technologies by FATIH (Movement of Enhancing Opportunities and Improving Technology) Project since 2010.

FATIH Project has two follow up steps (Ministry of National Education, 2015). The first is distribution of LCD interactive boards to all classrooms together with internet network and necessary software packages. This step relates to what Ertmer (1999; 2005) define as first-order barriers that inservice or preservice science teachers (PSTs) may have. In today's world, second-order barriers, which involve inservice or preservice teachers' intrinsic motivators such as beliefs and attitudes toward utilizing instructional technologies (Ertmer, 1999; 2005) seem more important than the first-order barriers. Because, obtaining instructional technologies is cheaper than tomorrow in a developing and well-developed country by means of economic and technological developments. Considering this reality, FATIH Project has involved a second step to provide inservice teacher trainings for informing them about the new instructional technologies and making a positive change in their intrinsic motivators.

FATIH Project has not any plan for PSTs. And also, effectiveness of its inservice teacher trainings seem quite suspicious (Çiftçi, Taşkaya & Alemdar, 2013; Pamuk, Çakır, Ergun, Yılmaz & Ayas, 2013). This is most probably encountered due to ignoring the complexity of relationships among intrinsic motivators. Considering that technological pedagogical content knowledge (TPACK) is an important predictor of how a PST adapt instructional technologies into her own possible teaching practices, this study was conducted to investigate possible relationships among certain intrinsic motivators by three different cases selected in accordance to their TPACK confidence.

Background

Belief Systems

A belief involves an individual's subjective judgments about herself and her environment (Fishbein & Ajzen, 1975). This definition actually reveals why preservice and inservice teachers' beliefs have been examined by a plethora of scientist for years. For example, Pajares (1992) states that teachers' beliefs filter their knowledge; therefore, they provide direction for teaching practices. Fives and Buehl (2012) also have a similar view about the effectiveness of teachers' beliefs on their practices, but there is not any systematic approach how and why these beliefs are effective.

At this point, belief system approach proposed by Rokeach (1968) widen the horizon. According to him, people have countless of beliefs effective on their daily activities but their effectiveness are determined by amount of their connectedness. In other words, Rokeach (1968) states that beliefs are connected to each other on a central-peripheral continuum. If a type of belief is more central, then it has more number of connections to others, so it has the potential to be more effective on behavior in comparison to a more peripheral belief. From this point of view, he concludes that to make a change in central beliefs is more difficult than a change in peripheral beliefs. Because, when a central belief is changed, the peripheral beliefs connected to that central belief should also transform in that manner.

Rokeach (1968), based on his theoretical and empirical evidences, offers five types of beliefs. Among them, Types A and B beliefs are the ones about an individual's own self. Type C beliefs involve the authority beliefs assisting an individual to hold a rational picture of life. Type D beliefs are the ideological beliefs derived from authorities. Finally, Type E beliefs are the ones about matters of taste and personal pleasures. Rokeach (1968) states that Types A and B beliefs are the more central than other types of beliefs because they involve the beliefs about nature of self. Type C beliefs are more central than Type D beliefs because the latter is derived from the former. Finally, Type E beliefs are the most peripheral among all of these beliefs, because these beliefs have no direct or relatively weak relations to other beliefs.

Self-Construal

Self-construal is a social construct comprising an individual's beliefs about who s/he is (Kağıtçıbaşı, 2007). As a social construct self-construal is affected by cultural values such as collectivism and individualism (Kitayama, Duffy & Uchida, 2007). Social psychologists studying on relational collectivism-individualism focus mainly on independency and interdependency of self-construal (Kağıtçıbaşı, 2007). According to the most of researchers in this area, if a society has weighted on individualistic values more than collectivist values, then, the probability of observing autonomous self individuals in that society is expected as higher than the probability of observing related self people. Kağıtçıbaşı (2007) criticizes this dualistic view of self-construal and defense the idea that relatedness and autonomy are not opposite to each other, in fact, an individual may hold both of them in a unique self-construal. She defines (Kağıtçıbaşı, 1996; 2007) three types of self-construal: autonomous, related and autonomous-related. Autonomous people feel a real independency and self-sufficiency in their activities where as people holding a related self-construal feel themselves dependent to others (such as family members, authorities) and consider others' ideas in their own decision making processes. In addition, people holding autonomous-related self-construal can make their decisions independently but they have also close relations with other people.

Self-construal is effective on people's behaviors, decisions and emotions because they involve central beliefs (Rokeach, 1968). For example, autonomous people have more tendency to self-enhancement. In addition, certain research studies provide evidence that autonomous people have a more personal achievement motivation than people holding a related self-construal (Kağıtçıbaşı, 2007).

Personal Epistemology

Personal epistemology covers individuals' beliefs about structure of knowledge (i.e. certainty and simplicity) and how they come to know (i.e. source and justification) (Hofer & Pintrich, 1997). There are three different approaches to personal epistemology: developmental view, multidimensionality and domain specificity. According to developmentalists, whose studies date back to seminal work of Perry (1970), individuals, at the beginning, have an absolutist position about everything. To an absolutist position, knowledge is certain and labeled as either right or wrong. Then, through biological developments (as proposed by Piaget) they step up to multiplist (i.e. certainty is not possible) and evaluativist (i.e. certainty may be possible with justification and interpretations) positions

(Kuhn, Iordanou, Pease & Wirkala, 2008). When it comes to second approach, Schommer (1994) envisions personal epistemology as a system of epistemological beliefs which are more or less independent. According to Schommer (1994) an individual may have a more sophisticated epistemological position about any dimension of this system whereas the same individual may hold a naïve position regarding other dimensions. For example, a student may believe that knowledge comes from authorities (naïve position about source) but involve interrelated bits (sophisticated position about simplicity). Schommer actually has provided partial evidences related to validity of her interpretations; however, quantitative measurement tool that she developed highly criticized by developmentalists (Hofer & Pintrich, 1997). In the third approach, certain researchers (e.g. Buehl, Alexander & Murphy, 2002; Hammer & Elby, 2002; Hofer, 2006) believe that individuals' epistemological beliefs are sensitive to different contexts and domains. For example, individuals may believe that knowledge in science is more certain than knowledge in humanities (Palmer and Marra, 2008).

Why certain researchers attempt to further investigations in this area can be explained by the view that personal epistemology is a framework for teaching and learning beliefs. Hofer and Pintrich (1997) and also Brownlee, Boulton-Lewis and Purdie (2002) point out epistemological beliefs in a relatively central position in comparison to teaching and learning beliefs. Following researchers have supported this expectation by empirical evidences. For example, Chan and Elliott (2004) have evidenced that inservice and preservice teachers' epistemological beliefs affect their conceptions of teaching and learning.

Conceptions of Teaching and Learning

Conceptions of teaching and learning cover preservice or inservice teachers' personal definitions about what teaching and learning mean and beliefs about how they should be processed (Chan & Elliott, 2004). A plethora of researchers, mostly by phenomenographic studies, have been investigating those conceptions for approximately 30 years. Memorizing, increase of knowledge, making science, etc… are examples of certain conceptions of learning (science) (Author, 2014; Saljö, 1979). In addition to these, transfer of knowledge, interacting with pupils, process, etc… may be presented as conceptions of teaching evidenced in certain studies (Koballa, Graber, Coleman & Kemp, 2000; Tsai, 2002). Koballa et al. (2000) and Tsai (2002) have also evidenced that (preservice) science teachers generally hold similar conceptions of teaching and learning so these conceptions cannot be separated from the other. In other words, if a PST holds a traditional conception of teaching, s/he is also expected to hold a traditional conception of learning. Based on these previous observations, Chan and Elliott (2004) offer just two types of conceptions of teaching and learning: constructivist vs. traditional. To constructivist conception, learners are accepted as active in the learning processes, so teachers should give importance to learners' existing knowledge and feelings in order to support them in this meaning making process. Reasoning and justification are also encouraged in learning and teaching processes. Traditional conceptions, on the other hand, accept students as passive learners; therefore, teachers are viewed as knowledge transmitters.

Researchers have evidenced that these conceptions are effective on science teachers' classroom practices (Koballa, Glynn, Upson & Coleman, 2005), so these conceptions should be investigated as a critical part of teaching belief systems. Research studies have also empirically evidenced that (preservice) teachers

holding constructivist conceptions have a tendency to utilize instructional technologies in their actual practices (Molebash, 2002; Sang, Valcke, van Braak & Tondeur, 2010; Mumtaz, 2000; Bai & Ertmer, 2008).

Technological Pedagogical Content Knowledge (TPACK)

TPACK is an important theoretical framework that has emerged recently to guide research in teachers' use of ICT (Chai, Koh & Tsai, 2013). This concept was actually built on Shulman's (1986) conception of pedagogical content knowledge. In according to teacher educators, there are three main components of teachers' knowledge: content, pedagogy, and technology (Koehler & Mishra, 2009). The TPACK Framework (See Figure 1) illustrates interactions among content knowledge, pedagogical knowledge and technological knowledge. Also this framework shows where TPACK is formed.

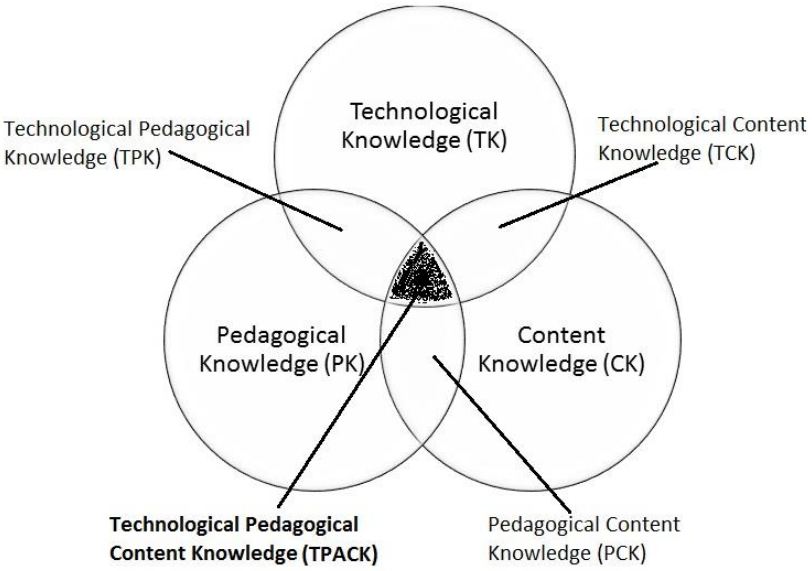

Figure 1. The TPACK Framework (Koehler & Mishra, 2009)

TPK is related to understanding the impact of technology on general pedagogical practices that are not content-specific. TCK represents knowledge of technology tools and representations within a content discipline. TK represents the technical skills of a teacher. Therefore, measuring TPACK level of a teacher involves TPK, TCK and TK levels (Graham, Burgoyne, Cantrell, Smith, St Clair & Harris, 2009).

According to educational technologists, teachers' required knowledge of technology integration for effective teaching is strongly related with the course content (Graham et al. , 2009). TPACK is the basis of effective teaching with technology. *"By simultaneously integrating knowledge of technology, pedagogy and content, expert teachers bring TPACK into play any time they teach."* (Koehler & Mishra, 2009). For this reason ICT integration and TPACK are strongly related concepts.

Grandgenett and Hofer (2010) state that there are different types of data that can be used for assessing TPACK. These are self-report (via interviews, surveys

etc.), observed behavior, and teaching artifacts (such as lesson plans). In this research, answers of the participants to TPACK questions in their interviews and lesson plans of them were used to define their TPACK levels. By this way, we classified TPACK levels as (1) qualified (participant(s) with high score), (2) support (participant(s) with medium score and needed support) and (3) *missing* (participant(s) with low score).

Significance of the Study

Today, it is a fact that there is an increasing investment on improving technological opportunities in education around the world. In Turkey FATIH Project, with a huge budget, has been being conducted. The goal has been declared as *"ICT will be one of the main instruments of the education process and it will also make teachers and students use these technologies effectively"* (Ministry of National Education, 2015). However researchers and practitioners must find out in what level these investments serve the purpose. As Ertmer (2005) mentions, second-order barriers, which involve inservice or preservice teachers' intrinsic motivators such as beliefs and attitudes toward utilizing instructional technologies should be taken into consideration for effective ICT integration. There is a huge amount of research related to ICT integration in the literature. However, the literature still lacks empirical findings evidencing relationships among certain critical variables such as belief systems covering PSTs' self-construal, epistemological beliefs, conceptions of teaching and learning science and TPACK level. Some of these variables have already been proven to be effective on teachers' technology usage behaviors as presented above and others are expected to be effective. Policy makers will be able to shape their decisions according to recommendations of this kind of empirical research findings regarding which variables predict teacher behaviors toward use of technology in the classroom and which interventions should be done in order to educate PSTs for this purpose. Also, science teacher education programs may probably be in/directly affected by such empirical recommendations for encouraging teacher candidates in terms of being equipped and ready to integrate ICT in science teaching-learning activities. Finally, considering that scientific concepts has intangible nature; therefore, utilizing instructional technologies provides a broad practice opportunities to foster students' meaningful learning. This study focused on TPACK and its connections to comprehensive teaching belief system in a science teaching context.

Purpose and Research Questions

The purpose of this study is to investigate the effects of PSTs' beliefs on their TPACK level. For this purpose, three different cases of PSTs who hold different levels of TPACK confidence were selected. Then, following research questions were prepared to answer for each case:

1) What are the possible relationships among PSTs' self-construal, epistemological beliefs and conceptions of teaching and learning?

2) What are effects of these beliefs on PSTs' TPACK level?

Method

Multiple case study (Creswell, 2007) was implemented as one of the qualitative research designs. Creswell (2007) points out that in a multiple case

study one issue is selected and then different cases are chosen to investigate or illustrate this issue. In this study, the issue was PSTs' TPACK level which was investigated by three multiple cases: low, medium and high confidence. In selecting the cases, TPACK confidence survey developed by Graham et al. (2009) was utilized. This survey was previously adapted into Turkish by Timur and Taşar (2011) who presented the construct related evidence by a confirmatory factor analysis (χ^2/df=2.86, NFI=.87, and RMSEA=.069) and reported high internal Cronbach alpha reliability scores in a range of .86-.89 for different factors. The survey has 31 items distributed to four factors: TPACK (8 items), TPK (7 items), TCK (5 items) and TK (11 items). Items has a 5-point Likert structure (from not confident=1 point to completely confident=5 point) except for TCK items which have 6-point Likert structure (from I don't know about this kind of technology=0 point, to completely confident=5 point). Therefore, the maximum available score that a PST may get is 155 while the minimum is 26. This survey has not any negative items and so there is no need for recoding process. The higher scores pointed to higher TPACK confidence.

Sample

The purpose of the study was slightly described to third year PSTs in Ahi Evran University, and the TPACK confidence survey was distributed to 55 PSTs during their regular course time, almost at the end of spring semester. Third year PSTs were selected to study since they got almost all the technology and pedagogy related courses, so they most probably provide more reliable data in comparison to prior year PSTs. Purposive sampling was adapted to select cases based on their TPACK confidence scores. Participants were requested to write their full name or a nick name. One participant for each case were selected among the participants. Low confidence participant got 86 point (observed minimum score) from the TPACK confidence survey, the medium confidence participant had a score of 112 (observed medium score), and the high confidence PST's score was observed as 149 (observed maximum score).

Data Collection

Data was collected through individual semi-structured interviews and lesson plans. Each participant was requested to choose a course objective from national elementary science teaching program to fill their first lesson plan form, prepared by the researchers. The objectives were especially requested to be related to physics since one of the researchers is expert in physics education. While the participants were giving the filled forms (first lesson plan), the researchers gave another lesson plan form (second lesson plan) to them. In the second form, PSTs were requested to fill the same lesson plan form for the same objective(s) but by adapting instructional technologies as much as they could this time. Each PST participated in four different semi-structured interview sessions. A brief session plan is given in Table 1.

Each session took 20 minutes in average and focused on different aspects of their TPACK levels and teaching belief systems, which comprised of personal epistemology, self-construal and conceptions about teaching and learning science. Interviews were audio-recorded and transcribed verbatim.

Table 1. Interview Sessions

Session	Session Content
1	• Informing the participant about the aim of the research and expectations, • Delivering first lesson plan form, • Interviewing about epistemological beliefs.
2	• Detailed questions related to first lesson plan, • Interviewing about self-construal, • Delivering second lesson plan form.
3	• Interviewing about conceptions of teaching and learning, • Detailed questions related to second lesson plan.
4	• Interviewing about content knowledge (limited with objective(s) in the lesson plan), • Interviewing about technology and TPACK.

Data Analysis

The data was analyzed by content analysis which is a technique, producing valid and reliable interpretations from texts in which language is used such as the documents about individuals' beliefs (Krippendorff, 2004). Transcripts of each case were carefully read at the beginning by taking notes. Coding units were constructed considering the variables of the study. These coding units together with interview question samples corresponding to each units were presented in Table 1. Each coding units covered categorical distinctions (Krippendorff, 2004) observed on the participants' interview transcripts or lesson plans (see Table 2). Beginning from the second reading categorical distinctions were coded by comparing participants' responses with existing literature presented above. Based on these categorical distinctions, both of holistic and embedded analyses were implemented to grasp each case entirely and comparing specific aspects and relations, the cases hold (Creswell, 2007).

Table 2. Transcription Details

Interview question samples	Coding Units	Categorical Distinctions	Intercoder Reliability
Does knowledge develop? Clarify your answer. How can you be sure that a piece knowledge is true?	Personal epistemology	• Absolutist • Multiplist • Evaluativist	.83
Can you please describe yourself by ten sentence such as 'I am a ……person'? How are your daily relations with other people?	Self-construal	• Autonomous self • Related self • Autonomous-related self	.89
What does teaching science mean? What does learning science mean?	Conceptions of teaching and learning science	• Constructivist • Traditional	.91
Why do you need to utilize this type of technology in teaching this content? What are the advantages of this type of technology in terms of students' learning?	TPACK level	• Qualified • Support • Missing	.84

When it comes to validity of interpretations, Cresswell (2007) offers utilizing multiple data sources and member checking for evidencing. In this study, not only interview transcripts but also lesson plans were provided data for our interpretations. And also, each participant was invited to check their categorical distinctions. In addition to these validation processes, Krippendorff (2004) defines three types of reliability for content analysis which are stability, reproducibility (intercoder reliability) and accuracy. Intercoder reliability was adapted in this study since two different researchers were coded the whole dataset. To examine agreement between two researchers Krippendorf's α was calculated for each coding units (see Table 1). Considering that α values were calculated as above .80 it can be said that the results of this study were reliable.

Results

Results of Holistic Analyses

Case 1 (Low TPACK Confidence)

In this case, the PST had a view of knowledge and knowing which was developing and changing considering justifications. She believed that people were the main source of knowing and that knowledge is not certain. To her, in some situations certainty of knowledge may be supported by different types of justifications. Therefore this participant mostly had an "evaluativist" position in terms of her personal epistemology.

This participant described herself as a patient, persistent and respectful person. Even though, she mentioned the importance of making own decisions independently, her descriptions mostly pointed to relatedness, so she was coded as "related self".

She defined learning science as "memorizing the scientific facts and remembering them when they are necessary". In the same direction, she defined teaching science as "adding a new scientific knowledge to students' existed body of facts in their minds". These descriptions were matched to "traditional conception" among categorical distinctions presented above (See Table 2).

When it comes to her lesson plans, her learning objective was related to "charging by friction". In the first plan she made an entrance to the lesson by a video demonstration about the topic of lesson plan including real life examples. Then she intended to learn about students' pre-conceptions by questioning them. Next, she planned to continue with some hands on experiments in order to show charging by using a plastic comb, rubber and some pieces of paper and hair. In the second plan, she intended to start the lesson by a detailed Power Point presentation about flash and lightning. Additionally she intended to present some animated real life stories about charging. Considering lesson plans and interview results about TPACK, it can be said that this participant had too many misconceptions. In addition she did not know what the charging is and the source of charges are. She could not give any in-depth examples to technology which she had been using in her daily life, except for computers. She believed that integrating technology into science teaching is not critically important because it could transform students into passive learners. She also believed that technology had the potential to visualize concepts. However, her interpretations were not, in fact, content related. Therefore, this participant was codded as "missing" in terms of TPACK level.

Case 2 (Medium TPACK Confidence)

In this case, the PST deducted knowledge to experience. According to her, knowledge was not certain and it could change based on sources of knowing. She mentioned that "the main source of knowledge is human intelligence…"; therefore, knowledge could change in accordance to who want to know. Considering that her statements about rejecting simplicity and looking for justifications with a relativistic view of knowledge, she was coded as "multiplist" in terms of personal epistemology.

Impatient, ambitious and empiric are the self-related keywords that become prominent in her interview. She also stated that "when I am undecided about anything, I consult to my kith and kin…". Considering that her self-descriptions involved both relatedness and autonomy intimately, she was coded as "autonomous-related self".

She defined learning science as remembering scientific facts and being curious about daily events in terms of this body of scientific facts. According to her, teaching science "… presenting scientific solutions in a learning environment…". These explanations were recorded as "traditional conception" of learning and teaching science.

She started the first lesson plan with by asking students "what do you know about buoyancy?". Following this simple questioning she directly presented course content by involving some pictures in her plan. Then she planned a demonstration related to buoyancy using a cup of water and some physical materials having different volumes and weights such as plastic ball and metallic keys. When it comes to her second lesson plan, she started with a Power Point presentation in order to make a beginning to course content. Instead of the demonstration in the first plan this time she intended to present a video including real-life examples related to buoyancy. She also said that she would use the smart board in order to present exercise questions for students. She could not be able to give right answers to certain simple questions about the reasons of buoyancy. She was not aware of scientific history of this concept, so she did not have any plan towards taking advantages of history of science. Moreover, main drivers for why she planned to utilize instructional technologies in her lesson were gaining students' attention and saving time. The nature of the content was not observed as a reason to adapt these instructional technologies. In this case the participant intimately tended to benefit from advantages of instructional technologies but could not related her technological preferences to the nature of the content. Therefore, she was codded as "support" in terms of TPACK level.

Case 3 (High TPACK Confidence)

In this case, the PST defined knowledge as a certain and distinct phenomena. She rejected relativistic nature of knowledge and ways of knowing. In addition, she stated that "… all the scientists say the same things…". Her answers were recorded as "absolutist" in terms of personal epistemology.

She introduced herself as impatient, nervous, well-disciplined and well-scheduled. In addition she stated that "… I am affected by my close relationships if they have similar ideas and views with me…". She defined herself as a self-ordained person. Her answers corresponded to "autonomous self".

She defined learning science as a transformation process of pre-existing body of scientific knowledge, views and thoughts by considering different dimensions. "Gaining a new perspective" is also another descriptor for her conception of science learning. To her, "...a student should listen a science teacher only if s/he is an active participant…". She also defined teaching science as being sensitive and adaptive to students' learning styles. She was labeled as "constructivist".

She started her first lesson plan presenting real pictures about refraction of light and questioning. Then she planned to make a demonstration using real materials such as a glass of water and a pen in it. She intended to use this activity as a part of brainstorming with active participation of students. In her second plan she utilized animations instead of real pictures. She also added a lab experiment to show refraction in a dark environment. In addition, she was willing to use interactive board for presenting the key concepts. She gave true answers to most of the questions related to refraction of light course content. She was found to be willing to use technology as much as she can for different purposes in her daily life. She thought that instructional technologies would enhance visualization of the concepts. In TPACK interview, she planned to use instructional technologies considering the nature of content. For example she stated that "… adapting animations instead of pictures will help students realize third dimension of the path of refracted light…". Therefore, she was codded as "qualified" in terms of TPACK level.

Results of Embedded Analyses

Results of holistic analyses were achieved considering the literature based coding units in Table 2. In order to make comprehensive embedded analyses it was necessary to make comparisons among cases. For this purpose categorical distinctions, attained in holistic analyses, were utilized. All of these observed coding categories were presented in Table 3.

Table 3. Overall Coding Categorizations Utilized for Embedded Analyses

Case	Self-construal	Personal epistemology	Conceptions of teaching and learning science	TPACK level
Case 1 (Low TPACK Confidence)	Related	Evaluativist	Traditional	Missing
Case 2 (Medium TPACK Confidence)	Autonomous-related	Multiplist	Traditional	Support
Case 3 (High TPACK Confidence)	Autonomous	Absolutist	Constructivist	Qualified

According to Table 3, it was observed that there was a positive relationship between PST's TPACK confidence and TPACK level. In other words when a PST had higher TPACK confidence then s/he also had a more qualified TPACK level. In addition to this, the PSTs' belief systems consistently related to their TPACK levels in terms of several respects which were:

1. Sophisticated epistemological beliefs negatively related to TPACK level. In other words, when a PST hold a sophisticated epistemological position, s/he presented lower TPACK level.

2. When self-construal went from related to autonomous self, TPACK level stepped up from missing to qualified.

3. Traditional conceptions provoked lower level of TPACK whereas constructivist conceptions seemed to shape TPACK into a qualified level.

Discussion

Results of this study showed that PSTs may have teaching belief systems presenting a hierarchical relationship among their parts. This result is consistent with what Rokeach (1968) states. When epistemological beliefs are not taken into consideration, relationships among other variables of the study show consistency with previous research findings related to relationship between self and conceptions of teaching and learning, as we already have expected. In other words, if a PST is autonomous in terms of self-construal, which involve central beliefs (Rokeach, 1968), s/he holds a constructivist view, as indirectly provoked by certain researchers (e.g. Kağıtçıbaşı; 2007).

What about if we consider self-construal, epistemological belief and conceptions of teaching and learning of a PST together? According to literature, briefed above, PST with autonomous self is expected to be evaluativist and an evaluativist PST is expected to have a constructivist view. On the other hand, PST with related self is expected to be absolutists and is expected to have a traditional view. However, results of the study were contradictory. Epistemological beliefs do not seem to be core beliefs in the belief system approach proposed by Rokeach (1968). In addition, results related to epistemological beliefs are ill-matched. For this reason, epistemological beliefs should not be assumed as Type C beliefs in the belief system approach. In this regard, results conflict with research findings related to epistemology (Hofer & Pintrich, 1997; Brownlee et al., 2002). This conflict points out that epistemological beliefs itself may not have direct effect or as much effect as supposed on PSTs' teaching and learning conceptions. Epistemological beliefs seem not to find an exact position in the belief system as expectedly when compared with self-construal which covers a unit of core beliefs.

Results regarding TPACK can be discussed in three different points of view. Firstly, in this research, TPACK confidence was used as a predictor for TPACK level in order to form 3 different cases. Results showed that there is a positive relationship between TPACK confidence and TPACK level. Existing research already stated this relationship (Finger, Jamieson-Proctor & Albion, 2010; Jamieson-Proctor & Finger, 2006; Koh & Chai, 2014). For this reason findings of the study met our expectations in this context.

Secondly, TPACK level directly linked to CK in the results, but we did not presented details about this finding in the study because we did not have such a different category. This close relationship between TPACK and CK can easily be seen in the literature (e.g. Graham et al., 2009). CK was found to have a direct effect on TPCK. For this reason the intersection area of CK and TPACK in the TPACK framework schema of Koehler & Mishra (2009) should be enlarged.

Thirdly, excluding epistemological beliefs, the results related to relationship belief system and TPACK showed consistency with the literature. Because;

a. Beliefs of a PST predicts her knowledge and behavior (Pajares,1992; Fives & Buehl, 2012)

b. When self-construal goes from related to autonomous self, possibly personal achievement motivation will increase (Kağıtçıbaşı, 2007) and it will make a PST think in a constructivist perspective. A constructivist teacher wants to arrange the learning environment considering course content and students' needs, by integrating technology (Sang et al., 2010; Ertmer, 2005; Molebash, 2002).

Implications

Considering the results and discussions, we presented four implicational suggestions for the following researchers. The first two were about research suggestions, and the last two were about science teacher education programs:

- Future research should attempt to define the relationship between self and epistemological belief in different ways.
- This research can be repeated and supported by including different data types in similar cases in order to make a more comprehensive data triangulation.
- In terms of teacher education, results show that if teacher candidates are provided with self-construal education, it seems possible to change their teaching and learning conceptions and to increase TPACK levels by this way. We recommend that self-construal education should be integrated in science teacher education programs. For this purpose program developers can collaborate with social psychologists.
- Results underlined the positive and close relationship between CK and TPACK. In that case, PSTs should be supported for better CK levels. If the aim is enhancing TPACK level, then number of courses related to CK, PCK and TK in the science teacher education program should be increased instead of courses related to general pedagogy.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributors

Erhan Güneş holds a PhD in Educational Technology and now is an assistant professor at Ahi Evran University, Kırşehir, Turkey.

Eralp Bahçivan holds a PhD in science education and now is an assistant professor at Abant İzzet Baysal University, Bolu, Turkey.

References

Bahçivan, E. (2014). Investigating coherence between preservice science teachers' conceptions of learning and teaching science: a phenomenographic study. Ahi Evran Üniversitesi Kırşehir Eğitim Fakültesi Dergisi, 15(3), 147-166.

Bai, H., & Ertmer, P. (2008). Teacher educators' beliefs and technology uses as predictors of preservice teachers' beliefs and technology attitudes. *Journal of Technology and Teacher Education, 16*(1), 93-112.

Brownlee, J., Boulton-Lewis, G., & Purdie, N. (2002). Core beliefs about knowing and peripheral beliefs about learning: developing a holistic conceptualisation of epistemological beliefs. *Australian Journal of Educational & Developmental Psychology, 2*, 1-16.

Buehl, M.M., Alexander, P.A., & Murphy, P.K. (2002). Beliefs about schooled knowledge: domain specific or domain general? *Contemporary Educational Psychology, 27,* 415–449.

Butzin, S.M. 2001. Using instructional technology in transforming learning environments: An evaluation of project CHILD. *Journal of Research on Computing in Education 33*(4): 367–373.

Byrom, E., & Bingham, M. (2001). Factors influencing the effective use of technology for teaching and learning: Lessons learned from the SEIR-TEC intensive site schools. AEL, Inc.

Chai, C.-S., Koh, J. H.-L., & Tsai, C.-C. (2013). A Review of Technological Pedagogical Content Knowledge. *Educational Technology & Society, 16* (2), 31–51.

Chan, K.W., & Elliott, R.G. (2004). Relational analysis of personal epistemology and conceptions about teaching and learning. *Teaching and Teacher Education, 20*(8), 817-831.

Çiftçi, S., Taşkaya, S. M., & Alemdar, M. (2013). The opinions of classroom teachers about FATIH project. *Elementary Education Online, 12*(1), 227-240.

Creswell, J.W. (2007). *Qualitative inquiry and research design: choosing among five approaches* (2nd ed.). Thousand Oaks,CA: Sage.

Ertmer, P.A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *ETR&D, 53*(4), 25-39.

Ertmer, P.A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology Research and Development, 47*(4), 47-61.

Finger, G., Jamieson-Proctor, R., & Albion, P. (2010). Beyond pedagogical content knowledge: The importance of TPACK for informing preservice teacher education in Australia. In *Key competencies in the knowledge society* (pp. 114-125). Springer Berlin Heidelberg.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behaviour: An introduction to theory and research.* Reading, MA: Addison-Wesley.

Fives, H., & Buehl, M.M. (2012). Spring cleaning for the "messy" construct of teachers' beliefs: What are they? Which have been examined? What can they tell us? In K.R. Harris, S. Graham, T. Urdan, S. Graham, J.M. Royer, & M. Zeidner (Ed.), *APA Educational Psychology Handbook: Individual Differences and Cultural and Contextual factors* (pp. 471-499). Washington, DC: American Psychological Association.

Graham, R. C., Burgoyne, N., Cantrell, P., Smith, L., St Clair, L., & Harris, R. (2009). Measuring the TPACK confidence of inservice science teachers. *TechTrends*, *53*(5), 70-79.

Hammer, D., & Elby, A. (2002). On the form of a personal epistemology. In Hofer, B.K., & Pintrich, P.R., (Ed.), *Personal Epistemology: The Psychology of Beliefs* (pp. 169-190). London: Lawrence Erlbaum Associates Publishers.

Hofer, B.K. (2006). Domain specificity of personal epistemology: resolved questions, persistent issues, new models. *International Journal of Educational Research, 45*, 85-95.

Hofer, B.K., & Pintrich, P. R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67*, 88–140.

Jamieson-Proctor, R., & Finger, G. (2006). Relationship between pre-service and practising teachers' confidence and beliefs about using ICT. *Australian Educational Computing, v. 21* (2), 21(2), 25-33.

Kağıtçıbaşı, Ç. (2007). *Family, Self, and Human Development Across Cultures, Theory and Applications* (2nd ed.). London: Lawrence Erlbaum Associates.

Kağıtçıbaşı, Ç. (1996). Özerk-ilişkisel benlik: Yeni bir sentez. *Türk Psikoloji Dergisi, 11*, 36-44.

Keengwe, J., Schnellert, G., & Mills, C. (2012). Laptop initiative: Impact on instructional technology integration and student learning. *Education and Information Technologies*, *17*(2), 137-146.

Kitayama, S., Duffy, S., & Uchida, Y. (2007). Self as cultural mode of being. In Kitayama, S., & Cohen, D., (Eds.), *Handbook of cultural psychology* (pp. 136-174). New York: The Guilford Press.

Koballa, T.R, Graber, W., Coleman, D.C., & Kemp, A.C. (2000). Prospective gymnasium teachers' conceptions of chemistry learning and teaching. *International Journal of Science Education, 22*(2), 209-224.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70.

Koh, J. H. L., & Chai, C. S. (2014). Teacher clusters and their perceptions of technological pedagogical content knowledge (TPACK) development through ICT lesson design. *Computers & Education, 70*, 222-232.

Krippendorff, K. (2004). *Content analysis: an introduction to its methodology* (2nd ed.). Thousand Oaks, CA: Sage.

Kuhn, D., Iordanou, K., Pease, M., & Wirkala, C. (2008). Beyond control of variables: What needs to develop to achieve skilled scientific thinking? *Cognitive Development, 23*, 435-451.

Lai, C. (2006). The advantages and disadvantages of computer technology in second language acquisition. *National Journal for Publishing and Mentoring Doctoral Student Research, 3*(1), 1-6.

Ministry of National Education (2015). FATIH Project. Retrieved in August 07, 2015 from http://fatihprojesi.meb.gov.tr/tr/english.php

Mitchem, K., Wells, D.L., & Wells, J.G. (2003). Effective Integration of Instructional Technologies (IT): Evaluating Professional Development and Instructional Change. *Journal of Technology and Teacher Education, 11*(3), 397-414. Norfolk, VA: Society for Information Technology & Teacher Education. Retrieved in May 15, 2015 from http://www.editlib.org/p/14612.

Molebash, P. E. (2002). Constructivism meets technology integration: The CUFA technology guidelines in an elementary social studies methods course. *Theory & Research in Social Education, 30*(3), 429-455.

Mumtaz, S. (2000). Factors affecting teachers' use of information and communications technology: a review of the literature. *Journal of Information Technology for Teacher Education, 9*(3), 319-342.

Pajares, M.F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

Palmer, B., & Marra, R.M. (2008). Individual domain-specific epistemologies: ımplications for educational practice. In Khine, M.S., (Ed.), *Knowing, Knowledge and Beliefs. Epistemological Studies across Diverse Cultures* (pp. 325-350). Springer Science + Business Media B.V.

Pamuk, S., Çakır, R., Ergun, M., Yılmaz, B. & Ayas, C. (2013). The use of tablet PC and interactive board from the perspectives of teachers and students: Evaluation of the FATİH Project. *Educational Sciences: Theory & Practice, 13* (3), 1799-1822.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme.* New York: Holt, Rinehart and Winston.

Rokeach, M. (1968). *Beliefs, attitudes and values*. San Francisco: Jossey-Bass Inc.

Saljö, R. (1979). Learning in the learner's perspective: Some commonsense conceptions. Gothenburg, Sweden: Institute of Education, University of Gothenburg.

Sang, G., Valcke, M., van Braak, J., & Tondeur, J. (2010). Student teachers' thinking processes and ICT integration: Predictors of prospective teaching behaviors with educational technology. *Computers & Education, 54*(1), 103-112.

Schommer, M. (1994). An emerging conceptualization of epistemological beliefs and their role in learning. In Garner, R. and Alexander, P., (Ed.), *Beliefs about text and about text instruction* (pp. 25–39). Hillsdale, NJ: Erlbaum.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Timur, B., & Taşar, M.F. (2011). Teknolojik pedagojik alan bilgisi öz güven ölçeğinin (TPABÖGÖ) Türkçe'ye uyarlanması. *Gaziantep Üniversitesi Sosyal Bilimler Dergisi, 10*(2), 839-856.

Tsai, C.-C. (2002). Nested epistemologies: science teachers' beliefs of teaching, learning and science. *International Journal of Science Education, 24*(8), 771-783.

Wang, L. (2005). The advantages of using technology in second language education: Technology integration in foreign language teaching demonstrates the shift from a behavioral to a constructivist learning approach. *T.H.E. Journal, 32*(10), 38-42.

West, D. M. (2012). *Digital schools: How technology can transform education*. Brookings Institution Press.