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SCIENCE TEACHING SELF-EFFICACY BELIEFS OF PRE-SERVICE TEACHERS: CONTEXT OF TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE AND VISUAL METAPHORS

Zeynep Yıldız

Abstract. *It is of great importance to examine the level of science teaching self-efficacy (SE), which is related to technological developments in primary school teacher education. It is seen that this subject is not addressed in the context of technological pedagogical content knowledge (TPCK) and visual metaphors. The purpose of this research was to examine the pre-service primary school teachers' SE beliefs related to science teaching in terms of the TPCK levels and visual metaphors they created related to science teaching. For this purpose, qualitative and quantitative methods were used in the research. The research sample consisted of 75 pre-service primary school teachers. A metaphorical perception form, a science SE scale, and a TPCK scale were applied as data collection tools. It was found that the majority of pre-service teachers in science teaching had moderate and high SE and technological pedagogical content. It was also found that pre-service teachers' science teaching SE levels were related to the sub-dimension levels of the TPCK. When the visual metaphors created by the pre-service teachers were associated with quantitative data, it was seen that as the SE level of the pre-service teachers increased, visual metaphors gained a quality from general to specific. It was also concluded that the metaphors of the pre-service teachers with high SE levels were formed in more detail and accurately, and the conceptual errors were reduced.*

Keywords: *pre-service teachers, primary school, science teaching, self-efficacy, visual metaphors*

Zeynep Yıldız
Yildiz Technical University, Turkey

Introduction

The SE belief is one of Albert Bandura's main concepts in social learning theory and the center of this theory. Bandura has defined SE beliefs as individuals' judgments about their capacities to fulfill the actions necessary to perform performance and to organize those actions (Bandura, 1986, 1995; Zimmerman, 1995). SE concerns judgments about how well individuals can perform the actions needed to cope with possible situations. These judgments affect the choice of right or wrong events and environmental regulations. According to Bandura, success does not only depend on having the skills necessary to do a job but also requires the effective use of skills with confidence.

An individual's SE belief affects his perception, motivation, and performance in many ways. People's motivation levels, emotional states, and behaviors are objectively based on what they believe rather than the situation or event (Bandura, 1995). From this point of view, perceived SE belief being firm can affect individuals' cognitive processes and their motivation by causing them to have higher goals and to be consistent in their decisions (Locke & Latham, 1990). SE belief can affect their sensory states by influencing how much stress and depression they may experience in a threatening situation or a difficult situation by raising their beliefs on coping skills. It also influences the process of making functional choices by allowing individuals to enter different circles with different beliefs to be successful and be in different activities. In addition, in cases where individuals do not believe that certain behaviors produce certain results, they can only do the necessary activities. Still, they will not do other behaviors that are related to this behavior, or they will not insist on it even if they do (Bandura, 1977, 1997).

One of the most important concepts related to SE belief is the concept of the teacher SE. In this context, it is thought that a teacher who thinks that learning is affected by effective teaching and believes that he can do it with his own abilities, is more persistent about teaching than a teacher who does not believe it and spends most of his time in the classroom, and uses different feedback types (Berkant & Ekici, 2007). In research by Gibson

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and Dembo (1984), it was found that teachers with firm and low SE beliefs differed in their academic studies and feedback behaviors in the classroom, and teachers with low SE beliefs preferred large group teaching. In failure, they used negative criticism and showed less determination. SE believes in science teaching judgments about teachers' beliefs about science teaching and activities, about their ability to make science teaching effective and productive and to increase the student's success (Akbas & Celikkaleli, 2006; Bıkmaz, 2002). Teachers with high SE beliefs have some differences. These teachers tend to use student-centered approaches. Also, they spend more time teaching science. They prefer to conduct research-based instruction. After all, they are quite successful in doing so. On the other hand, teachers with low SE beliefs prefer to use teacher-centered approaches such as reading and verbal explanations of information (Schriver & Czerniak, 1999). Moreover, according to Chan (2003), teachers with higher SE reported offering more effective instruction and less intensive stress during teaching. For this reason, special attention should be paid to the development of SE perception in teacher education (Altuncekic et al., 2005).

Coşkun (2019) stated that a moderately positive relationship exists between teachers' SE perceptions and their technological pedagogical content knowledge (TPCK). In the context of this result, he deduced that content knowledge (CK) would increase depending on the increase in SE belief. Similarly, Çam (2017) stated that there are positive relationships between teachers' SE perceptions and their TPCK in the study he conducted with primary school teachers. Akgün (2013), on the other hand, found that there was a positive relationship between pre-service teachers' web pedagogical content knowledge (PCK) levels and teacher SE perception levels. When these results are evaluated, it is possible to say that there are positive relationships between SE perception and CK. Considering the situation in terms of teaching processes, it is seen that teachers primarily focus on CK (Shulman, 1986). In CK, it is seen that teachers are ignoring pedagogical information and putting their field expertise at the forefront. This is one of the most important factors affecting teaching activities and SE belief. Shulman (1987) also incorporated pedagogical knowledge (PK) into CK in his work. Thus, PCK constituted the integrated structure of teacher knowledge. This structure demonstrated a skill that includes the interaction of teachers' content and PK (Öztürk & Horzum, 2011).

TPCK is expressed as an interaction complex formed between technology, pedagogic and content (Singh & Malik, 2022). In this structure, there are seven fields of knowledge formed by combining technology, pedagogy, and CK. They are; CK, PK, Technological Knowledge (TK), PCK, Technological Content Knowledge (TCK), and TPCK (Öztürk & Horzum, 2011).

Science education and teaching are important in almost every level of education and schools. Science course is also one of the basic courses in Turkey as in many countries (Türkmen, 2002). In formal education, students first meet science courses in primary school (Çıray et al., 2018). Thus, basic science education is given to the students by the classroom teachers. Therefore, science teaching occupies an important place in the teaching of primary school instructors (Huyugüzel Çavaş et al., 2013; Uluçınar et al., 2008). In Turkey, pre-service teachers take the course "Basic Science in Primary School" in their first year at universities. The content of this course, the subject and principles of science, the basic concepts of science, the place of science among other sciences, its historical development, the aims of science teaching, general information about science subjects in the elementary school curriculum, features and daily life in the form of its usage areas can be summarized. The purpose and importance of the laboratory in science education; security in the laboratory, scientific method, scientific process skills and how they are acquired; laboratory experiments related to primary school are studied by pre-service teachers in the second year at universities. In the third year of primary school teaching, pre-service teachers carry out studies on the characteristics of scientific knowledge and the scientific method, science and technology literacy, science-technology-society-environment relations, attitudes towards science, aims of science teaching, the historical development of science teaching in Turkey and the world, characteristics of primary school science program and its relations with other courses and scientific process skills (YÖK, 2018). In the fourth Grade at universities, pre-service teachers can experience what they have learned about science teaching in the real primary school environment through the teaching practice courses.

In science teaching it is aimed to create and disseminate a positive thinking structure by changing the wrong thinking structure that has been going on from the past to the present (Aktamış & Dönmez, 2016). For this reason, it is important to determine the attitudes and images of primary school teachers and primary school pre-service teachers, who teach science. Levine (2005) stated that metaphors can be used to determine attitudes and images. Metaphors are an important factor in revealing the hard-to-understand issues more easily and the sources of the problems clearly (Semerci, 2007). In addition, people use metaphors to transfer views, concepts, and terminology about a situation to an area they do not know well or know little about. Metaphors are particularly useful in

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understanding and describing a new phenomenon because they carry a well-known situation into an unknown situation. Thus, the metaphor facilitates the learning of new knowledge. Metaphors, however, are the form of thought and vision (Morgan, 1998). In recent years, a perspective has emerged based on the "mental metaphor theory" work by Lakoff and Johnson (2005). Lakoff and Johnson (2005) pointed out that our concept system was largely metaphoric. In this respect, the way we think about time, every phenomenon we experience, and everything we do daily are metaphorical aspects (Saban, 2009). According to the theory of mental metaphor, the basis of metaphor is to understand and experience one phenomenon according to another (Lakoff & Johnson, 2005). Therefore, the metaphor consists of the explicit or implicit specification that the X factor is like the Y factor. This is also the case of a metaphorical mental model, that is, allowing a certain mental chant to be reflected on another mental schema by establishing a relationship between the two disjunctive phenomena (Saban, 2009). Metaphor research with teachers and pre-service teachers is a suitable method to examine the relationship between teachers' professional definitions and contextual factors. It is a method used to examine metaphorical images, to reveal the roles of teachers in the classroom, beliefs, and assumptions about students and education (Ben-Peretz et al., 2003). However, when the aims of science teaching are examined, it is seen that importance is given to the elimination of negative thoughts towards scientific studies and science and to develop positive attitudes in individuals about the developing, changing, and self-renewing structure of science. Positive emotions should be tried to be developed for science and every situation that contributes to science (Aktamış & Dönmez, 2016). Over time, a need has arisen for a language to convey scientific knowledge and an area to embody abstract thought. In this context, metaphors have become an indispensable element (Kurt & Sarı, 2018). In this direction, it is important to determine the perceptions of the primary school pre-service teachers who are the part of teaching science in primary school, which is the first step towards science teaching. Doğan and Dönmez (2019) determined students' attitudes towards the mathematics lesson through the visual metaphors created by the students and drew attention to the importance of using metaphor images for this purpose. In other words, the examination of visual metaphors has a remarkable place in determining individuals' feelings, thoughts, and perspectives. In this respect, it is observed that the evaluation of visual metaphors created by the pre-service primary teachers related to science teaching is important.

SE has an important place in the literature of studies related to science teaching (Altunçekiç et al., 2005; Andrew, 1998; Britner & Pajares, 2006; Hamurcu, 2006; Lent et al.,1984; Morrell & Carroll, 2003; Morgil et al., 2004; Yaman et al., 2004). However, there was no research comparing SE beliefs and TPCK of teachers or pre-service teachers regarding science teaching. In this context, it is thought that evaluating science teaching SE belief levels and the TPCK of pre-service teachers in education faculties may provide a future projection about science teaching in primary school. Therefore, this research can shed light on the issues that need to be studied in the field of science teaching within the scope of pre-service primary teachers.

In light of these mentioned, the main question of this research was "How do pre-service teachers relate to the level of SE of science teaching, levels of technological PCK, and the visual metaphors make about science teaching?" In this direction, answers were sought for the research's sub-questions.

- What are the science teaching SE levels of pre-service teachers?
- What are the levels of TPCK of pre-service teachers?
- Is there any relationship between SE levels and TPCK levels of pre-service teachers?
- What kind of visual metaphors do the pre-service teachers have for science teaching?
- Are there any differences in visual metaphors of pre-service teachers for science teaching according to the level of science SE and TPCK?

Research Methodology

Design

When qualitative and quantitative methods are combined, within a research or sequential work, it is described as a mixed method research (Creswell, 2003; Johnson & Onwuegbuzie, 2004; Tashakkori & Teddlie, 1998). In this respect, since both qualitative and quantitative data were used, the research design was determined as mixed. Quantitative method was preferred to determine the SE levels and TPCK levels of pre-service teachers and to reveal the relationship between these two variables. Qualitative research methods were also used to see pre-service teachers' metaphorical perception about science teaching. The data for this research was collected in the fall semester of the 2019 teaching year.

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Sample

In this research, a purposive sampling method was preferred. The main goal of purposive sampling is expressed to focus on particular characteristics of a population that is of interest, which will best enable to answer the research questions (Rai & Thapa, 2015). Science teaching is taught in the 3rd grade's second semester in Primary School Teacher Education program. The pre-service teachers in the sample should have taken this course to be appropriate for the subject and purpose of the study because it was planned to examine the teachers' readiness, and to analyze the data obtained from the pre-service teachers who took the course / the courses related to science education in the curriculum. For this reason, the third and fourth-grade pre-service teachers were worked with. As a result, the sample of the research was composed of 43 pre-service teachers who were studying in the third year, and 32 pre-service teachers were studying in the fourth year in the primary school teacher education program. Table 1 gives a detailed description of the sample of the research.

Table 1
Sample of Research

Department	Grade				Total
	3rd Year		4th Year		
	Female	Male	Female	Male	
Primary School Teacher Education	27	16	20	12	75

In the process of determining the study group within the scope of the research, information about the content and process of the research was given to the pre-service teachers and the research process was started with those who were willing. In addition, a certificate of approval was obtained from the ethics committee of Yıldız Technical University.

Instrument and Procedures

A metaphorical perception form that pre-service teachers were asked to draw what came to their minds when science teaching was called was used to examine the symbolic perceptions of pre-service teachers about science teaching. The Science Teaching Self-Efficacy Scale (STSES) developed by Gözüm (2015) was used to examine the science teaching SE levels of the pre-service teachers. 5-Point Likert-type scale consisting of 46 items was used. 28 items are positive, and 18 items are negative. The scale is a 5-Point Likert-type scale consisting of 46 items, 28 are positive, and 18 are negative. In the scale items prepared by taking into account the concept of SE in Bandura's Social Learning Theory and the relationship between this concept and the theory, to be understood a single statement by the participants, the expressions of SE were used without expressing the events and cases. In the scale development process, current teacher training conditions, teacher training programs, and teacher qualifications related to science teaching were taken into account (Gözüm, 2015). Positive and negative samples of the scale items prepared in this sense are given in Table 2.

Table 2
STSES The Sample of Positive and Negative Scale Items

Positive	Negative
I can give children the ability to make observations to improve their science learning skills	I cannot prepare practical applications related to theoretical knowledge on science subjects.
I can interpret the results of experiments that do not match the theoretical knowledge of the children's experiments.	I may not be able to teach the science concepts appropriate to the level of children during science teaching.
I can take precautions against security problems during science experiments.	I don't think I'm good enough to experiment.

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The "TPCK Scale" developed by Schmidt and others (2009) and adapted to Turkish by Özturk and Horzum (2011) was used to examine the SE of the technology teachers. The scale consists of a total of 47 items and technology knowledge (TK), and CK, including seven sub-dimension constitutes which are PK, PCK, TCK, TPK, and TPCK. It is a 5-point Likert-type measure and contains expressions such as "Strongly disagree", "Disagree "Neither agree or disagree", "Agree" and "Strongly agree". The examples of questions prepared according to 7 sub-dimensions of the TPCK scale prepared in this sense are given in Table 3.

Table 3
The Examples of Questions Prepared According to 7 Sub-Dimensions of the TPCK Scale

Sub-Dimension	Item
TK	I can adapt to important new technologies.
CK	I have enough science knowledge.
PK	I can evaluate students' learning in many ways.
PCK	I know how to choose effective teaching approaches to guide students to learn and think about science.
TCK	I know the technologies I can use to understand and study science.
TPK	I can choose technologies that will increase the impact of teaching approaches for a course.
TPCK	I can teach a course by combining science-related technologies and teaching approaches appropriately.

To avoid any effect on pre-service teachers of the scale, firstly, the metaphorical perception form was applied, and then the STSES and TPCK scale were applied.

Data Analysis

When analyzing collected data by metaphoric perception form, the visuals created by all the pre-service teachers were examined in detail, and a visual list was created. Then, appropriate categories were created and placed in categories consistent with the contents of the visuals in the list. In this process, pre-service teachers were given code names as C1, C2, … . Next, the data collected with the STSES were analyzed. Table 4 shows the scoring key for this scale. In this respect, the score obtained from the scale consisting of 46 items is in the range of 46 and 230 points.

Table 4
STSES scoring key

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Positive Question Score	1	2	3	4	5
Negative Question Score	5	4	3	2	1

The total score distribution for the data collected with both scales was analyzed, and the range was calculated. To determine pre-service teachers at low, medium, and high SE levels, the categorization was made by dividing the range value by 3. In addition, Pearson Correlation analysis was performed to compare the levels of science education SE and TPCK of pre-service teachers, based on total scores and sub-dimensions. SPSS 22 statistical analysis program was used to analyze the quantitative data obtained.

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Research Results

Findings of Obtained from STSES and TCPK Scale

When the data obtained from STSES was examined, the score of the person who got the lowest score among 75 pre-service teachers was calculated as 99, and the score of the person who got the highest score was calculated as 230. SE levels of pre-service teachers in the research were categorized as low, medium, and high. With the division of the range value into three, it was determined to be low between 99-148 points, the medium between 149-185 points, and high between 186-230 points. The findings obtained in this respect are shown in Table 5.

Table 5
Science Teaching SE Levels of Pre-service Teachers

Level	*f*	%
Low	16	21
Medium	41	55
High	18	24

As seen in Table 5, more than half (55%) of pre-service teachers had moderate science teaching SE. Pre-service teachers with moderate and high SE constituted the majority (79%) of all pre-service teachers.

When the data gathered with the TPCK Scale were analyzed, the score of the pre-service teachers who got the lowest score was determined as 83, and the highest score was 235. With the breakdown of the value of Range, it was determined as 83-142 points low, between 143-189 points medium, and 190-235 points high level. The findings obtained in this direction are shown in Table 6.

Table 6
TPCK Levels of Pre-service teachers

Level	*f*	%
Low	10	13
Medium	42	56
High	23	31

As seen in Table 6, more than half (56%) of pre-service teachers had moderate TPCK. The middle and high-level pre-service teachers constituted the majority (87%) of all pre-service teachers.

A Pearson correlation analysis was conducted to determine the direction and severity of the relationship between the total scores of the two pre-service teachers. Table 7 shows the results of the analysis.

Table 7
Analysis of Pearson Correlation Between Scale Scores (N=75)

		STSES Total Score	TPCK Scale (TPCKS) Total Score
STSES Total Score	*r*	1	.643
	p		.0001

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When the results of the analysis in Table 7 were examined, it was seen that there was a high correlation between grade points of pre-service teachers on two scales (r = .643).

A Pearson correlation analysis was conducted to determine the relationship between the total scores of the pre-service primary teachers from the STSES, the total points they received from the TPCKS, and the scores based on the sub-dimensions. Table 8 shows the results of the analysis.

Table 8
Pearson Correlation Analysis Between STSES Total Scores and TPCK Subscales (N=75)

		STSES Total Score	TPCKS TK Lower Dimension	TPCKS CK Lower Dimension	TPCKS PK Lower Dimension	TPCKS PCK Lower Dimension	TPCKS TCK Lower Dimension	TPCKS Technological Pedagogical Knowledge (TPK) Lower Dimension	TPCKS TPCK Lower Dimension
STSES Total Score	Pearson Correlation	1	.375**	.642**	.546**	.476**	.585**	.580**	.648**
TPCKS TK Lower Dimension	Pearson Correlation	.375**	1	.716**	.608**	.549**	.616**	.507**	.470**
TPCKS CK Lower Dimension	Pearson Correlation	.642**	.716**	1	.814**	.789**	.810**	.644**	.798**
TPCKS PK Lower Dimension	Pearson Correlation	.546**	.608**	.814**	1	.770**	.798**	.723**	.758**
TPCKS PCK Lower Dimension	Pearson Correlation	.476**	.549**	.789**	.770**	1	.699**	.711**	.792**
TPCKS TCK Lower Dimension	Pearson Correlation	.585**	.616**	.810**	.798**	.699**	1	.793**	.788**
TPCKS Technological Pedagogical Knowledge (TPK) Lower Dimension	Pearson Correlation	.580**	.507**	.644**	.723**	.711**	.793**	1	.848**
TPCKS TPCK Lower Dimension	Pearson Correlation	.648**	.470**	.798**	.758**	.792**	.788**	.848**	1

When the results of the analysis in Table 8 were examined, it was seen that the total scores of the pre-service teachers' SE scale of the teachers were highly correlated with the CK Sub-dimension and TPCK Sub-dimension; PK Sub-dimension, PCK Sub-dimension, TCK Sub-dimension, and TPK Sub-dimension and moderate-intensity correlation; TK appeared to be weakly correlated with the lower dimension.

According to these findings, pre-service teachers' science teaching SE levels were related to the total scores of TPCK, and the scores obtained from sub-dimensions. These variables affect each other.

Findings of Visual Metaphors

When the metaphors created by the prospective teachers were analyzed, it was seen that the metaphors were produced in the headings and subheadings shown in Table 9.

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Table 9
Visual Metaphor Information About Science Teaching by Pre-service teachers

Category	Subcategory	*f*	%
Teaching Environment	Laboratory and experiment	38	29.7
	Projection use	10	7.8
	Other	14	10.9
	Total	62	48.4
Science Subjects	Psychics	14	10.9
	Chemistry	8	6.3
	Biology	20	15.6
	Total	42	32.8
Topics related to daily life		10	7.8
Tools / Materials		6	4.7
Other		8	6.3
Final total		128	100

When the data in Table 9 was examined, it was seen that the category with the highest metaphor formation was the teaching environment, with 48.4%. The metaphor for the teaching environment was often a laboratory, experiment in the laboratory, beaker-lab tube use, lab with large and long gates, demonstration, or presentation from the project. In addition, some pre-service teachers produced metaphors in the laboratory, such as using a microscope, having the blackboard in the environment, and the students listening to the class. The second category with the highest metaphor of 32.8% was the science subjects' category. The metaphors created in this category were divided into three subcategories: physics, chemistry, and biology. The examples of metaphors created in the subcategory of physics were; power, leverage, balance, speed/distance problems, space, planets, sun, stars, world, magnetism, electric circuit, and sound waves. The examples of metaphors created in the subcategory of chemistry were; evaporation, condensation, matter cycles, natural phenomena, and the molecular structure of the atom. The examples of metaphors created in the subcategory of biology were; plants, the spiral structure of DNA, human/animal anatomy, ecosystem, animals, and food chain. In the category of topics related to daily life were metaphors such as recycling, home, life, nature, pollution, and sunlight utilization. Finally, metaphors belonging to tools such as lenses, magnifiers, technological tools, and protective glasses were created tools. Apart from these, some pre-service teachers produced metaphors such as instructors, burning light bulbs, and scientists.

When the findings obtained within the scope of the research were evaluated in general, it was concluded that prospective teachers' scores on the STSES and the TPCK scale correlated positively with each other. This result was associated with the visual metaphors of the pre-service teachers about science teaching within the scope of the research. Qualitative similarities were found in the metaphors of the pre-service teachers in the low, middle, and high categories.

When the drawings of pre-service teachers with low SE levels were examined; it was determined that the drawings were much simpler than the other drawings, they were not detailed, they were easily overlooked, they were very unstressed, and they could be described as childlike. They were in the form of a painting. The drawing of the pre-service teacher C33 is given in Figure 1 as an example.

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Figure 1
The Visual Metaphor Generated by The Participant Pre-service Teacher (C33)

While some of the teachers in this category contained their drawing concepts, it was observed that there were missing or conceptual errors in the drawings. Figures 2 and 3 are visual metaphors created by the participants C25 and C65.

Figure 2
Conceptual Error-Containing Metaphor (Drawn by C25)

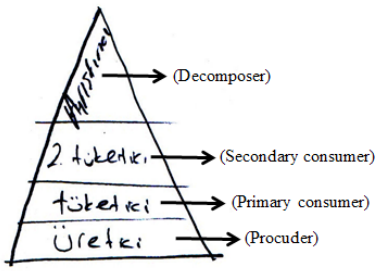
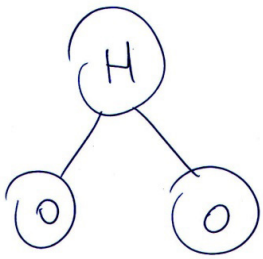


Figure 3
Conceptual Error-Containing Metaphor (Drawn by C65)



It was seen that the food chain was drawn in the metaphor in Figure 2. Visually, the steps of the food chain were named. Considering the three steps, it was seen that the steps were named correctly but it was seen that a singular expression was used in the steps in which a plural expression needed to be used. For example, in the image, the 4th step was called "decomposer". However, as it was known, the decomposers were not in a single step. They were in all the stages of the food chain. Therefore, it was seen that there was a conceptual mistake in the visual about the names of steps. In the metaphor in Figure 3, it was seen that the molecular structure of the water was tried to visualize (the created image was confirmed by the informal interview with the pre-service teacher, which was formed as the molecular structure of the water). However, as shown in the picture, even if the molecular structure was not considered in detail about atoms and bonds, in the form of H_2O, it was seen that 1 Hydrogen and 2 Oxygen atoms were used visually.

In comparison, 2 Hydrogen and 1 Oxygen atoms must be combined. So here, too, there was a conceptual error in this respect. This situation can be interpreted as a result supporting that the level of field knowledge of pre-service teachers with low science SE may be weak. It was also seen that some of the pre-service teachers in this category left the metaphorical perception form empty or unable to form any metaphors even though they had filled the scales. When the drawings of pre-service teachers whose SE levels were moderate were examined, it was observed that these drawings were drawn more with labor, the details in the drawings were increased, and the conceptual drawings made were more accurate. This result was more clearly understood when comparing the images given in Figure 4 and Figure 5.

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Figure 4
The Metaphor Formed by The DNA Helix (Drawn by C26)

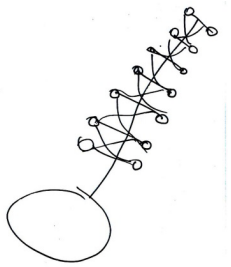
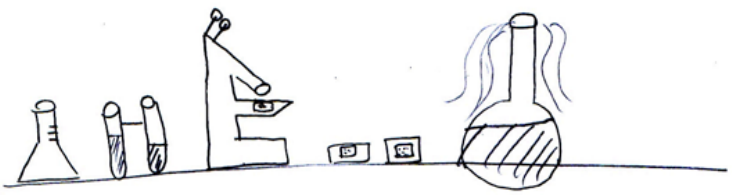


Figure 5
Metaphor Formed by DNA Helix (Drawn by C9)

In Figure 4, it was seen that the DNA models generated by C26 pre-service teachers in the low SE level categorization and P9 pre-service teachers in the middle SE level in Figure 5. (The generated image was confirmed by the informal interview with the pre-service teachers, which was generated as a DNA helix model after the application). Compared to the drawings, P9's drawing was more carefully drawn, closer to reality, and more conceptually less error-free.

In the drawings of the pre-service teachers in the middle-level SE category, the drawings about the laboratory environment and the experimental equipment started to be given more weight shown in Figure 6.

Figure 6
Metaphor with Experimental Tools Created by a Pre-service Teacher (C13)



In addition, it was observed that the images created about the environment were designed as an ideal environment for science education. Figure 7 and Figure 8 show sample visual metaphors in this sense.

Figure 7
Regulated Class Metaphor Created by A Pre-service Teacher (C19)

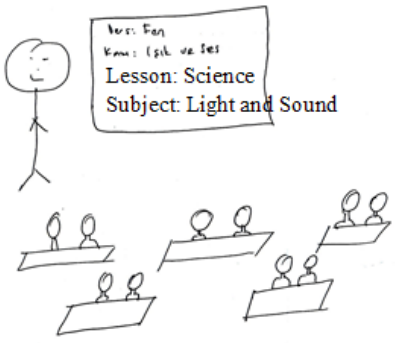
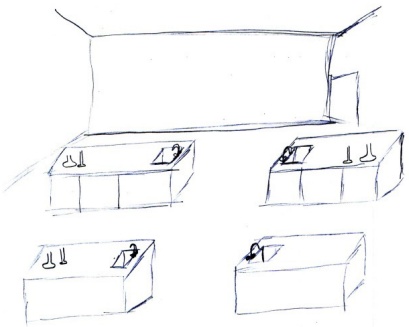


Figure 8
Regulated Laboratory Metaphor Created by A Pre-service Teacher (C39)



When examining the two metaphors created by the pre-service teachers at the middle SE level in Figure 7 and Figure 8, they saw laboratory environments that pre-service teachers create in their minds. In the classroom,

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they were notable of detail. For example, when the students were seated in two, the placement of rows was in such a way that they did not obstruct the student's views and the teacher's instructions of sound and light. In the laboratory, it was seen that there was a certain order. The sinks and the equipment and tools were included in the research tables. When the metaphor in Figure 1 created by a low SE pre-service teacher was examined, it was seen that the pre-service teacher had visualized the environment where he or she was present in the classroom without adding any comment.

When the drawings of the pre-service teachers in the high SE category were examined, they were drawn in much more detail than the other pre-service teachers. At the same time, it was observed that while drawing was made, attention was paid to the accuracy of the details. Figure 9 shows C54 pre-service teacher, and Figure 10 shows P8 pre-service teacher metaphor.

Figure 9
Visual Metaphor Generated by a Pre-service Teacher (C54)

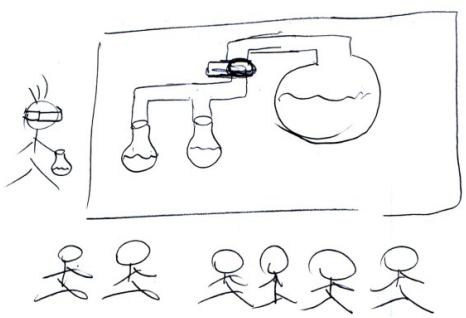
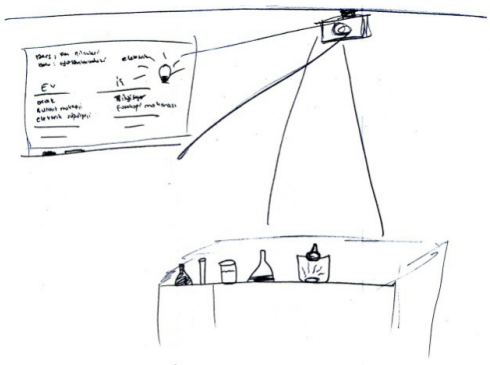


Figure 10
Visual Metaphor Generated by a Pre-service Teacher (C8)



When the image in Figure 9 was examined, it was seen that the students observed the experiment in an environment where the experiment was performed. The experimenter had protective goggles. In addition, the environment in which the experiment was performed was drawn as an isolated environment. When we consider the experimental apparatus, it was seen that the experimental vessels and the created apparatus were drawn carefully and properly. In the image in Figure 10, it was seen that the writing board, projection, and test equipment were found. It was seen that both the content of the lesson was enriched and how the experiment was made from the projection tool. Considering the drawings, the pre-service teachers in the high SE category formed their metaphors in much more detail and cared to avoid making mistakes in the visual elements. However, the generated visuals suggested that the pre-service teachers in this category could be environmentally conscious individuals. As a matter of fact, P29 pre-service teacher described the concept of recycling as the first thing that came to mind regarding science teaching (Figure 11). In addition, it was observed that the pre-service teachers in this category had more complicated drawings and some of the drawings contained certain processes related to science teaching (Figure 12).

Figure 11
Visual Metaphor Created by a Pre-service Teacher (C29)

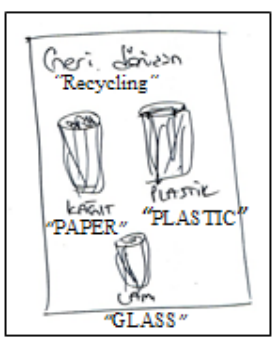
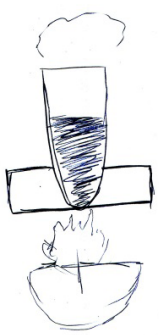


Figure 12
Visual Metaphor Created by a Pre-service Teacher (C30)



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When pre-service teacher (C29) was asked to create a metaphor for science teaching, the first thing that came to her mind was the subject of recycling. In other words, it was seen that science teaching was directly associated with daily life, and in this sense, the science course was internalized. When the drawing of the pre-service teacher (C30) with a high SE level was examined, it was seen that a liquid material was heated in the test tube. When we consider drawings, including the used spirit stove, the shape of the test tube, and the gas from the top of the test tube, it was seen that the visuals were detailed and were created with care.

Discussion

Within the scope of the research, the SE levels of primary school pre-service teachers who will be teaching at the primary school level are discussed in terms of various variables. It was observed that most pre-service teachers in the research group had moderate and high SE when the level of SE was analyzed. It was found that similar studies had similar findings in this respect (Oğuz, 2012; Yılmaz et al., 2007). The high level of SE of the pre-service teachers can be expressed as a sign that they see themselves as sufficient about teaching they will undertake in their teaching lives and that they have confidence in this issue. In this sense, the higher the SE levels of the pre-service teachers, the higher the awareness about the related issues can be expressed. Science teaching has been particularly related to technological developments in the global world since the 21st century (Hançer et al., 2003). In other words, it is expected that the subjects of science teaching and technology teaching will be parallel in many ways. Therefore, it was deemed necessary to examine the knowledge levels of technological pedagogical content of pre-service teachers. The results obtained were in parallel with the results of SE. In other words, most TPCK levels are moderate and above. When the subscales of the scale are considered, they can be interpreted as having sufficient knowledge in the fields of technology, content, pedagogical, pedagogical content, technological content, technological pedagogical, and technological pedagogical content, that they see themselves well and trust themselves. When the relationship between scores on the STSES and TPCK scale and total scores of sub-dimensions were examined, it was concluded that there was a positive relationship among all of them, and even a majority had a high positive correlation. This can be expressed as a supporting result of all the previous findings. Many researchers seem to support this situation (Bandura et al, 1996; Choi, 2005; Landis et al., 2007; Usher & Pajares, 2006; Zimmerman et al., 1992).

Generally, the visual metaphors created by pre-service primary teachers related to science teaching are examined. Most of the metaphors created (80%) are related to the teaching environment and science subjects. In other words, the first metaphors that came to the minds of the pre-service teachers related to science education were in this direction. When the metaphors were evaluated in terms of their contents, it was seen that the metaphors the pre-service teachers created based on their SE level increased from the general to the specific. This may be interpreted as an indication that the level of knowledge of low SE pre-service teachers expressed above is also low. There was little detail in the visuals created by pre-service teachers at a low SE level, and the drawings were filled with non-subject plugins. In addition, there were conceptual errors in the drawings. Teachers at intermediate SE levels produced a wide variety of metaphors.

Teachers at medium SE levels produced a wide variety of metaphors. The fact that there are a lot of pre-service teachers with a medium level of SE can be expressed as a reason for more metaphors to be produced. It was also observed that metaphors at this level were becoming more related to science and science teaching. However, more specific details began to appear in the pictures. Conceptual errors were reduced. In the drawings of pre-service teachers at a higher level of SE, it was observed that there were drawings focused on a specific subject or situation rather than general drawings. It was observed that the details were increased, and all the characteristics of the situations depicted were considered. The level of conceptual errors was much lower. It was also seen that there were drawings for affective learning among metaphors that could be interpreted as more internalized teaching of science. Although the pre-service teachers with different levels of SE created visual metaphors in similar categories, these metaphors differed from one another in terms of both conceptual and level of detail. For example, a low SE pre-service teacher painted only one test tube in the experimental category, and a high SE pre-service teacher portrayed the protective glasses used when performing this experiment. It was seen that the use of projections in the class, as another category, was drawn by prospective teachers at all levels. For teachers at low SE levels, the projection was an aesthetic figure, while the higher the SE level, the higher it was observed that the image created in accordance with the intended use was included. Again, the higher the SE of pre-service teachers, the more innovative and up-to-date issues such as solar energy, pollution, recycling, etc., they were drawing about.

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In this study, it was determined that there was a positive correlation between the academic achievement of pre-service teachers in science courses in their bachelor years and their SE beliefs, total scores of technological pedagogical content, and the quality of visual metaphors they formed. Accordingly, the higher the academic achievement, the higher the total scores of students' SE beliefs in the TPCK were seen. In addition, in the visual metaphors they created, conceptual errors were reduced, the situation depicted was expanded to more detailed drawings than general drawings, and the quality of the drawings was improved.

Conclusions

As a result of the research, it was found that TPCK was directly related to pre-service teachers' SE beliefs. For this reason, by performing studies related to TPCK during the undergraduate period, pre-service teachers of the future are necessary to work to strengthen their SE beliefs. At this point, measuring the SE levels of pre-service teachers will contribute to finding out which pre-service teachers are weaker in terms of TPCK and should be specially supported. In this way, it can be predicted which student will be at a low level in terms of TPCK before a course such as science teaching at the undergraduate level of the primary school teaching department is taught. Thus, those pre-service teachers can be provided with extra support in this direction. With this study, it has been seen that in the field of teacher training, the SE belief of the pre-service teachers and the TPCK are closely interconnected in the context of science teaching and should be evaluated together as they affect each other. The fact that this study examined metaphorical perceptions through visual metaphors also makes the research findings valuable because it has been observed that pre-service teachers present more detailed and internal data through these visual metaphors than metaphors expressed only with words. For these reasons, it is thought that the study has important contributions to the literature in terms of the findings and results obtained.

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Zeynep Yildiz PhD, Associate Professor, Faculty of Education, Yildiz Technical University, A-312, Esenler, Istanbul, Turkey.
E-mail: zeynepyildiz.2005@hotmail.com
ORCID: https://orcid.org/0000-0002-1439-3592