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A longitudinal investigation of the preservice science teachers' beliefs about science teaching during a science teacher training programme

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ABSTRACT

The aim of this longitudinal study was to investigate the changes in preservice science teachers' beliefs about science teaching during a science teacher training programme. The study was designed as a panel study, and the data were collected from the same participants at the end of each academic year during a four-year period. The participants were composed of 76 preservice teachers, and the DASTT-C was used as the data collection tool. As a result of the study, it was determined that the students had conventional teaching beliefs after the first years of the teacher training programme. Moreover, the mental teaching styles of preservice teachers about the science teaching were found to undergo changes throughout their undergraduate education. Participants' beliefs about conventional teaching started to change, especially after they first took a science method course in their third year and their beliefs shifted towards student-centred teaching. Implications for science teacher training programmes were also addressed.

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Science teaching; preservice teachers' beliefs; teacher training programme; longitudinal study; the DASTT-C

Introduction

Since the teachers' beliefs about teaching and learning have a strong effect on their classroom practices (Pajares, 1992; Richardson, 1996), teachers' and preservice teachers' beliefs about teaching are emphasised in studies related to the science teaching (Markic, Sulaiman, & Ismail, 2011). It is known that the teacher training programmes play a crucial role in the creation of teachers' beliefs (Hancock & Gallard, 2004). Therefore, there are many researchers investigating the effects of teacher training programmes or several courses in these programmes on the preservice science teachers' beliefs about science teaching (e.g. Doyle, 1997; Minogue, 2010). Expressing that the longitudinal studies are needed for investigating the effects of teacher training programmes on preservice teachers' beliefs about science teaching, Markic and Eilks (2013) point out that the number of longitudinal studies is too few. Their explanation for the lack of studies is that the longitudinal and panel studies require very long time (e.g. seven years for a study with German preservice teachers). Because of the insufficient number of

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longitudinal studies available, this study was designed as a longitudinal study investigating the changes in preservice teachers' beliefs about science teaching during a four-year science teacher training programme.

There are three different longitudinal study designs: trend, cohort and panel studies. Among these longitudinal designs, panel design was chosen in this study. Panel design studies are less affected by external factors compared to other longitudinal designs since the data are collected from the same participants throughout the study. By four years of data collection at the end of each academic year about the mental models of preservice teachers enrolled in a science teacher training programme, yearly distribution of preservice teachers' mental teaching styles about science teaching was investigated to determine whether there was a difference in their beliefs about science teaching (teacher-centred, student-centred) by years.

Beliefs about science teaching

Bandura (1986) expresses that belief is the most important indicator in determining behaviours in people's lives, and it is widely known that belief is a strong determinant of behaviours (Nespor, 1987). Especially, the beliefs of 'teachers' are the ideas that influence how they conceptualise teaching. These ideas encompass 'what it takes to be an effective teacher and how students ought to behave' (Pajares, 1992, p. 322). Calderhead (1996) classified teachers' beliefs into five groups. These are the beliefs about (i) student and learning, (ii) teaching, (iii) learning how to teach, (iv) the roles of the students and teachers and (v) content. Wallace and Kang (2004) state that teachers' beliefs about their students, the learning of the students, the nature of science, epistemology and teacher roles are the basics of their belief systems.

Emphasising the importance of the relationship between teachers' beliefs about teaching and their teaching styles, Finson, Pedersen, and Thomas (2006, p. 8) state that 'the teaching style teachers use may arise from their personal beliefs and self-efficacy about science teaching and their perceptions regarding the work of scientists'. Researchers classified teachers in different groups in terms of their beliefs about science teaching and their teaching styles. Tsai (2002) suggested a triple categorisation in terms of beliefs about teaching. These categories are: traditional, process and constructivist. Similarly, Porlán and Martín del Pozo (2004) used a triple categorisation as traditional, technical and alternative models. Likewise, Thomas, Pedersen, and Finson (2001) also created a triple categorisation, and the teaching styles of teachers are named as exploratory, conceptual and explicit in terms of beliefs about science teaching.

Categories created by other researchers show similarities with the aforementioned classifications. When the properties of the categories are examined, it can be seen that all categorisations carry similar meanings but the difference is in the naming of the categories. This study was based on triple categorisation developed by Thomas et al. (2001). The triple categorisation of Thomas et al. (2001) is based on three different teaching styles emphasised in the study of Simmons et al. (1999). Based on these previous literatures, this study involves three teaching styles, which are exploratory, conceptual and explicit.

In an exploratory teaching style, a curriculum is open to students' interests, and the teacher leads and guides student activities. In this teaching style, the teacher focuses on

students' questions as an instructional objective, and alternative assessment approaches are used to measure student learning and knowledge. In conceptual teaching style, the teacher believes that students are in the need of conceptual learning experiences. The content organised around key concepts is based on research and organised by the teacher. The lessons involving group work and hands-on activities are teacher-centred and the assessments through tests focus on important concepts. In explicit teaching style, the teacher believes that students lack knowledge, and this issue should be addressed in the teaching process. The curriculum focuses on some specific outcomes in this teaching style in which the teacher is the conveyer of information. Assessment activities focus on science content knowledge through tests (Thomas et al., 2001).

Investigating the beliefs about science teaching and drawings

In studies aiming at determining science teachers' and preservice science teachers' beliefs about teaching, it is observed that different data collection tools such as questionnaires (e.g. Al-Amoush, Markic, Abu Hola, & Eilks, 2011; Boz & Uzuntiryaki, 2006; Porlán & Martín del Pozo, 2004; Van Driel, Bulte, & Verloop, 2007), interviews (e.g. Boz & Uzuntiryaki, 2006; Skamp & Mueller, 2001; Tatar, 2015) metaphors (e.g. Seung, Park, & Narayan, 2011), observations and field notes, video recordings and lesson plans (e.g. Wallace & Kang, 2004) are used. Moreover, many researchers have used drawings as an alternative in determining beliefs about science teaching (e.g. Minogue, 2010; Ng, Nicholas, & Williams, 2010). Mental models of teachers and preservice teachers are easily revealed, thanks to drawings (Minogue, 2010). Thomas et al. (2001) state that there is a strong relationship between mental models and beliefs about science teaching. According to Norman (1983),

> mental models provide (a) a belief system, reflecting beliefs acquired through observation, instruction, or inference; (b) observability, providing correspondence between the mental model and the physical world; and (c) predictability, allowing a person to understand and anticipate behavior of a physical system. (as cited in, Thomas et al., 2001, p. 296)

The drawings are very effective in determining mental models, or in other words, beliefs about science teaching. Since drawings operate as text which maintains clear visions of internal insights (Hancock & Gallard, 2004; Minogue, 2010; Weber & Mitchell, 1996), drawings can make it possible for preservice teachers to think about the context, the pattern of the objects in physical spots and interactions in their illustration of a mental form and immediately capture an image of the views of them. Moreover, drawings are rich information sources reflecting the teachers' mental models about themselves and their students (Hancock & Gallard, 2004). When relevant literature is reviewed, it is observed that the most common drawing test used for exploring the mental models related to science teaching is Draw-A Science-Teacher-Test-Checklist (DASTT-C), which was developed by Thomas et al. (2001) (e.g. Finson et al., 2006; Minogue, 2010; Ucar, 2012). According to Thomas and Pedersen (2003, p. 328), the DASTT-C

> could be a useful tool to help teachers recollect memorable episodes within their own ideas, beliefs, and personal theories about how to teach elementary science, consider alternative theories, and work toward a preferred image of themselves as elementary science teachers.

Therefore, there is a consensus among these researchers that the DASTT-C can be used for determining the beliefs about science teaching.

Preservice teachers' beliefs about science teaching and the changes in the beliefs

The importance of the effects of science teachers' beliefs on their classroom activities is emphasised by a number of researchers (Koballa, Gräber, Coleman, & Kemp, 2000; Tsai, 2002). It is also widely known that the teacher training programmes play a crucial role in the creation of their beliefs (Hancock & Gallard, 2004). It is documented that preservice teachers begin their teacher training programmes having beliefs based on their previous educational experiences (Doyle, 1997; Hollingsworth, 1989; Simmons et al., 1999; Skamp & Mueller, 2001). Some researchers argue that these beliefs are resistant to change (Koballa et al., 2000; Skamp & Mueller, 2001), while others argue that these beliefs can be changed (Doyle, 1997; Ucar, 2012). According to the relevant studies on this topic, some changes in the preservice teachers' beliefs were determined by the effect of the education given in teacher training programmes and especially during the method courses (Ambusaidi & Al-Balushi, 2012; El-Deghaidy, 2006; Hancock & Gallard, 2004; Minogue, 2010). Therefore, researchers argue that teacher training programmes should focus on changing preservice teachers' conventional teaching beliefs (Ucar, 2012; Yilmaz-Tuzun, 2008). For the same reason, it is emphasised that teacher training programmes should involve learning experiences that can alter beliefs held by preservice teachers (Yilmaz, Turkmen, Pedersen, & Huyuguzel Cavas, 2007).

Some researchers argue that with the effects of conventional science teaching preservice teachers encountered (Calderhead & Robson, 1991; Thomas et al., 2001) during their student days (elementary, secondary education), preservice teachers begin their teacher training programmes with conventional science teaching beliefs (Bendixen,, Hofer, & Pintrich, 2002; Doyle, 1997; Tatar, Yıldız-Feyzioğlu, Buldur, & Akpınar, 2012). In his longitudinal study investigating the effects of teacher training programmes on preservice teachers' beliefs about teaching, Doyle (1997) determined that preservice teachers had a teacher-centred teaching belief at the beginning of the teacher training programme, but as a result of the education given, a significant change occurred in their beliefs. At the same time, in their longitudinal study investigating preservice science teachers' beliefs about science teaching, Ambusaidi and Al-Balushi (2012) used the DASTT-C before and after three different courses (Science Methods I, Science Methods II and Practicum) and they determined that method courses led to a change in preservice teachers' beliefs.

As can be seen, an important result of studies on preservice science teachers' beliefs about science teaching is that preservice teachers' undergraduate studies and especially method courses had a profound effect on their beliefs about science teaching (Ambusaidi & Al-Balushi, 2012; Hancock & Gallard, 2004; Minogue, 2010; Ng et al., 2010; Ucar, 2012). When the studies about the effects of method courses on preservice teachers' beliefs were reviewed, it was observed that some studies investigated the effects of only a single-method course (El-Deghaidy, 2006; Hancock & Gallard, 2004; Minogue, 2010; Seung et al., 2011) while some others investigated the effects of multiple-method courses (Ambusaidi & Al-Balushi, 2012). It was determined that method courses led to some changes on preservice teachers' beliefs according to results of the studies mentioned above.

Science teacher training system in Turkey

The teacher training system of Turkey is carried out in universities affiliated to Higher Education Council. The teacher training programme in each university is carried out under the control of this council and there is only one type of teacher training programme offered by the colleges of education in Turkey (Ucar, 2012). Graduates from all secondary schools have to take a central exam to enrol in an undergraduate programme, including the teacher training programme. Trained for teaching middle school science in 5–8th grades, the students of elementary science teacher training programme graduate as science teachers after a four-year undergraduate education. The credits of compulsory major area courses, branch courses and general education courses during their four-year undergraduate education are presented in Table 1.

As can be seen in Table 1, preservice science teachers take major area courses such as 'General Physics', 'General Chemistry', 'General Biology' and 'General Physics Laboratory', etc. in their first two years. The method courses such as 'Special instruction methods in science', 'Nature and history of science' and 'Laboratory applications in science education' are given in the third and fourth years. On the other hand, science teacher candidates take general education courses such as 'Introduction to Education', 'Educational Psychology', 'Measurement and Education' in each year of the training programme.

The preservice science teachers studying at teacher training programmes are licensed to work as science teachers in schools affiliated to Ministry of National Education after graduating the four-year undergraduate programme.

The significance and aim of the research

The way that preservice science teachers consider themselves in their future classrooms is very important and valuable because they are the teachers of the future (Elmas, Demirdöğen, & Geban, 2011). In this sense, the understanding of preservice teachers' beliefs about science teaching and the effects of teacher training programmes on those beliefs are important topics (Ambusaidi & Al-Balushi, 2012; Doyle, 1997; Ucar, 2012). During teacher training programmes, initial conventional teaching beliefs, which are derived from the previous learning experiences of preservice teachers (Bendixen, et al., 2002; Calderhead & Robson, 1991; Hollingsworth, 1989; Pajares, 1992; Thomas et al., 2001), are expected to shift towards student-centred teaching beliefs, especially during the method courses. Otherwise, preservice teachers holding conventional science teaching beliefs cannot be expected to prefer a modern student-centred teaching approach and these preservice teachers would use conventional teaching techniques once they became teachers (Yilmaz-Tuzun, 2008).

Table 1. Science, science methods, and educational sciences courses offered during Turkey's four-year elementary science teacher training programme (Ucar, 2012).

	Physics	Chemistry	Biology	Other[a]	Science method	Educational sciences
First year	10	10	–	–	–	6
Second year	5	5	10	–	–	6
Third year	2	2	4	5	12	8
Fourth year	–	–	4	2	11	9
Total	17	17	18	7	23	29

[a]Earth science, environmental science, astronomy.

Due to the important expectations from the teacher training programmes, it should be focused whether these programmes lead to a change in preservice science teachers' beliefs about teaching, and this issue should be investigated especially through longitudinal studies.

In spite of the requirement of a long period of time (Markic & Eilks, 2013), preservice science teachers' beliefs about science teaching during their four-year undergraduate education were determined, and changes in their beliefs were investigated in the current longitudinal study. This study was carried out with the same preservice teachers during a period of four years; therefore, the changes in the beliefs of preservice teachers' about science teaching were investigated throughout the whole teacher training programme.

There are previous longitudinal studies related to this topic (Ambusaidi & Al-Balushi, 2012; Doyle, 1997; Skamp & Mueller, 2001); however, these studies were either limited by one or a few courses (Ambusaidi & Al-Balushi, 2012; El-Deghaidy, 2006; Hancock & Gallard, 2004; Seung et al., 2011) or were carried out for a short period of time (Doyle, 1997; Skamp & Mueller, 2001). The data of this study were not limited to any courses; instead, the data were collected throughout the teacher training programme spanning a four-year period.

It is clear that the investigation of preservice teachers' beliefs about science teaching by merely using DASST-C is not enough to reveal the effects of all factors of teacher training programme on these beliefs. There are many factors (e.g. field courses, pedagogic courses, method courses, the roles of course instructors, etc.) that have an effect on preservice teachers' beliefs about science teaching during their education, and the data obtained from the DASST-C, which is used for limited purposes, are not sufficient to comment on all of these factors. However, this study is valuable since it investigated the preservice teachers' beliefs about science teaching for a long period of time. In this study, a longitudinal viewpoint, which is recommended in literature but used in limited number of studies (Markic & Eilks, 2013) because of some difficulties such as the difficulty in reaching the sample and the requirement of a long period of time (Fraenkel & Wallen, 2000), was provided. In light of explanations above, the aim of this study was to investigate whether preservice science teachers' beliefs about science teaching changed during the teacher training programme. Within the scope of this general aim, following research questions were investigated:

RQ1: What is the distribution of preservice science teachers' mental models about science teaching during their four-year undergraduate teacher training programme?

RQ2: Is there any significant difference in preservice science teachers' beliefs about science teaching (teacher-centred, student-centred) in terms of the year in their undergraduate teacher training programme?

Methodology

Research design

This longitudinal study is designed for investigating the changes in the beliefs about science teaching of preservice science teachers from a state university in Turkey during their four-year undergraduate education between the years of 2009 and 2013. Longitudinal studies can be designed in three different ways: as a trend study, cohort study and panel

study (Fraenkel & Wallen, 2000). In a trend study, the data are collected at different points in time from different samples of a research population whose members can change. On the other hand, in a cohort study, the data are collected at different points in time from different samples of a research population whose members do not change. While the panel studies are similar to the cohort studies in the way their populations are constituted from the same individuals, the main difference between two designs is that the sample of the panel study should always include the *same individuals*. Since the data were collected from the same participants during the period of four years, the panel design was used in this study.

Sample

The participants were composed of 76 preservice science teachers studying at a science teacher training programme at a state university in Turkey between 2009 and 2013. At the beginning of the study, there were 98 preservice teachers. However, because of the mortality, which is a frequent problem in panel studies (Fraenkel & Wallen, 2000), the research was completed with the data of 76 preservice teachers who participated in all of the measurements in four years.

As mentioned briefly in introduction, the preservice teachers participating in this study received education for eight semesters during four years. During the first four semesters, they took mainly major area courses such as 'General Physics', 'General Chemistry', 'General Biology' and 'General Physics Laboratory'. During fifth and sixth semesters, they took method courses such as 'Special Instruction Methods in Science', 'Nature and History of Science' and 'Laboratory Applications in Science Education'. In these courses, the preservice teachers learned especially special teaching methods in science teaching (e.g. inquiry-based learning, multiple intelligences, conceptual change, 5E model, etc.), the nature of science and teaching, the types of experiments that could be used in science teaching and their practices. During the fourth year of undergraduate education, they started to go to practice schools. During the seventh semester, they observed the practice teachers in the schools for 4h a week. During the eighth semester, participant preservice science teachers started to give lectures at middle school grades 5–8 for 6 h per week. On the other hand, they had taken general education courses such as 'Introduction to Education', and 'Educational Psychology' in each year of their teacher training programme.

Data collection

The data were collected by using the DASTT-C between 2009 and 2013 (during four years). The data collection process was carried out at the end of each academic year of the teacher training programme. The DASTT-C was not delivered to the participants at the beginning of the programme because it was considered that the drawings of participants would not be beneficial in terms of the aims of the study before the participants took any course since the preservice teachers had no professional education at the beginning of the programme. Also, an evaluation of the entire programme was not among the main aims of the study. The data collection tool was applied to the participants by the same researcher for four years. The duration of use of the research instrument was about 20–25 minutes.

Research instrument

Developed by Thomas et al. (2001), the DASTT-C was used in this study as the research instrument. Draw-A-Scientist-Test was initially developed by Chambers (1983) for determining students' perceptions about scientists. Finson, Beaver, and Cramond (1995)developed Draw-A-Scientist-Test Checklist [DAST-C] for revealing alternative images and making evaluations more easily. Thomas and her colleagues revised the DAST and developed DASTT-C (Thomas et al., 2001).

The DASTT-C is composed of a drawing test in two parts and a checklist, which was developed for analysing the drawings. The first dimension of the drawing test is composed of an empty box, where preservice teachers draw on, and a section where preservice teachers can explain teacher and student roles in the drawings (Figure 1).

In the first part of the DASTT-C, preservice teachers are asked to draw themselves as science teachers on empty boxes. In the second part, they are asked to provide a written answer to the questions of 'what is the teacher doing?' and 'what are the students doing?' related to their drawings. The drawing test is analysed by researchers according to the checklist considering both drawings and explanations about the drawings.

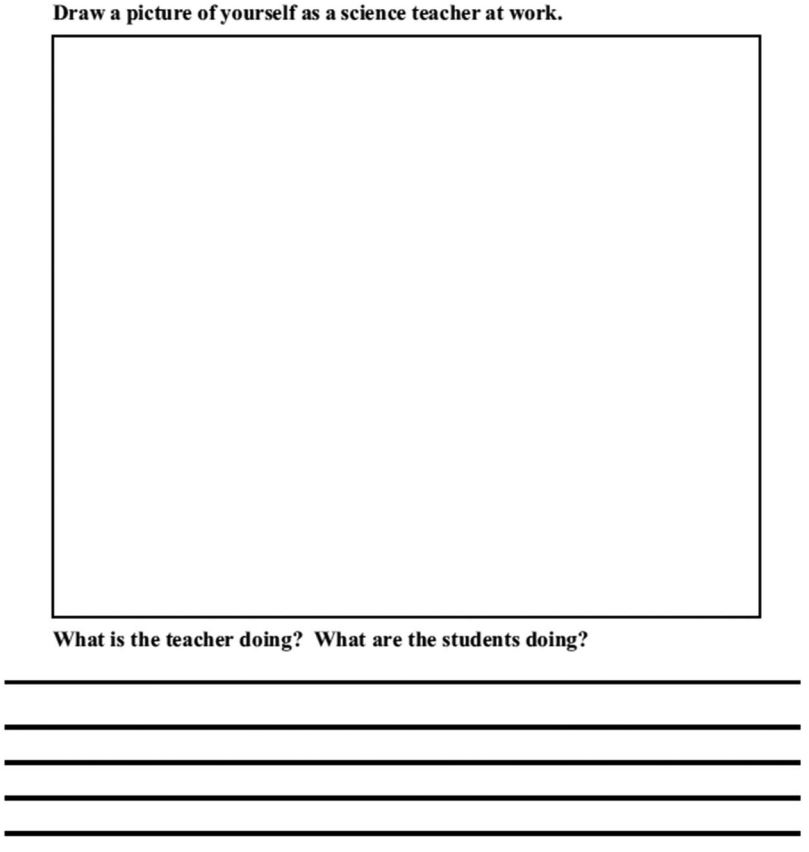

Figure 1. DASTT-C.

There are three dimensions in the checklist as 'teacher', 'student' and 'learning environment'. There are a total of 13 sub-dimensions: 5 in the teacher dimension, 3 in the student dimension and 5 in the learning environment dimension. During the analysis of drawing tests, if the situation of the sub-dimension is present in the drawing, it gets 1 point, and if not, it gets 0. In this way, preservice teachers can get a maximum of 13 points and a minimum of 0 point. Based on previous literature, a range of 0–4 points in DASTT-C reflects exploratory, a range of 5–9 points reflects conceptual, and a range of 10–13 points reflects explicit teaching styles (Thomas et al., 2001). Thomas et al. (2001) also state that a point range between 7 and 13 reflects teacher-centred and a point range between 0 and 4 reflects student-centred teachings. From a different viewpoint, the higher scores show that a teacher-centred teaching is preferred and lower scores show that a student-centred teaching is preferred.

In this study, the data were collected through a drawing test since drawing tests make it easier to determine the mental models of teachers and preservice teachers (Minogue, 2010) and they are efficient (Hancock & Gallard, 2004; Minogue, 2010; Weber & Mitchell, 1996). Moreover, the participants not only drew something but made written statements as well. Thus, participants' mental models about teaching were explored by not only the drawings but also with their responses to the open-ended questions. No other qualitative data collection tool was used since the qualitative data were obtained by this way.

Data analysis and reliability

The findings were obtained through the analysis of drawing tests mentioned above. In order to increase the reliability of the scoring of drawings, the researcher and two different science teaching specialists independently analysed the drawings of 10 preservice teachers who are not included in the sample of this study. The fit between analyses was determined by Kendall's coefficient of concordance, which aims at investigating the fit between assessments done by more than 2 evaluators on the same group. According to the test results, a significant concordance ($W = .77$, $p < .05$) was determined among the assessments of three evaluators on the 10 different drawings. Although the concordance coefficient was significant, in order to increase the coefficient value and determine the discordances in analyses, researchers got together to compare analysis results. The opinions about discordances in analyses were exchanged. Afterwards, researchers independently analysed the drawings of another 10 different preservice students. At the end of the second analysis, a significant concordance ($W = .90$, $p < .05$) was determined among assessments done by three evaluators on the drawings of the 10 different preservice teachers. This value reflects a good concordance between evaluators.

Thomas et al. (2001) reported the internal reliability KR 20 coefficient as .82 in their study where they developed the DASTT-C. On the other hand, KR 20 coefficient was calculated to be as .74, .80, .80, .71, respectively, for each measurement in this study during the four-year period.

Repeated-measures analysis of variance (ANOVA) test was used to determine whether there is a significant difference between preservice science teachers' beliefs about science teaching during their four-year undergraduate teacher education programme. Participants' DASST-C scores from each academic year were compared in terms of years through ANOVA.

Findings

The findings about the distribution of preservice science teachers' mental models about science teaching in terms of year

The first research question of this study was expressed as 'what is the distribution of preservice science teachers' mental models about science teaching by the year through their undergraduate teacher training programme?' The information about the distribution of preservice teachers' mental models in terms of year is presented in Table 2.

As can be seen in Table 2, it is observed that 'Explicit' teaching style was generally preferred by students after their first and second years, but 'Exploratory' teaching style was usually preferred by students after their third and fourth years.

The graphic of the distribution of preservice teachers' mental models in terms of the year in the teacher training programme is demonstrated in Figure 2.

As can be seen in Figure 2, as the year in the programme increases, the likelihood of preferring explicit teaching style decreases, while the likelihood of preferring conceptual and especially exploratory teaching style increases. These findings show that preservice teachers hold teacher-centred beliefs after their first years; however, they start to hold student-centred beliefs, especially with the effects of method courses given in the third year and later on.

To be able to reflect the change in preservice teachers' beliefs about science teaching in detail, the drawings and the explanations about drawings of a preservice teacher on each year are presented below (Figure 3).

The explanations of a subject (S_{73}) about drawings are as follows:

- First Year: The teacher is covering the topic of the day. The students are listening to their teacher carefully. Then, the teacher is asking whether they comprehended or not. If the students don't understand, the teacher explains it again, and if they all understand, the teacher ends the lesson.
- Second year: The teacher is conveying some information about the topic he/she's going to cover in the beginning of the lesson. In order to support the information and make them permanent, the teacher explains the topic by giving examples with the use of a projector. Afterwards, the teacher makes the students practise what they learnt in an experiment.
- Third Year: The teacher is conducting experiments with students in a laboratory. He/she helps students about the experiments when needed. The teacher covers the topic in a laboratory so that students can learn by experiencing. Thus, he/she helps students with permanent learning and handcraft skills.
- Fourth Year: The teacher gives preliminary information about the experiment they are about to conduct. There is a U-shaped laboratory setting, and there is one student

Table 2. The distribution of preservice teachers' ($n = 76$) mental models in terms of year.

	Exploratory (*n*)	Conceptual (*n*)	Explicit (*n*)
First year	4	17	55
Second year	12	32	32
Third year	39	32	5
Fourth year	51	23	2

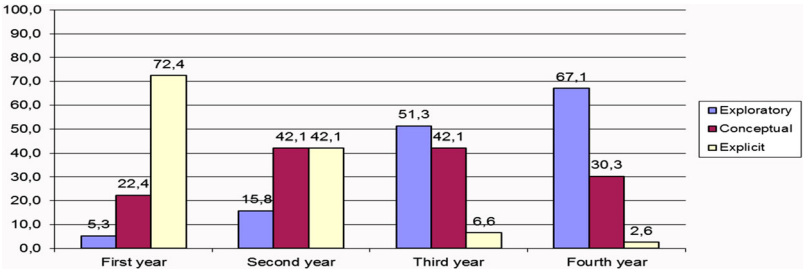

Figure 2. The distribution percentile of preservice teachers' mental models about science teaching in terms of year.

group consisting of four people on each desk. These students conduct their experiment according to collaborative learning. The teacher here is a guide. He/she helps students when needed. When all of the students complete experiments, they use the argumentation technique with the guide of the teacher and draw a general conclusion.

As can be seen in drawings and explanations, the subject S_{73} got 10 points for drawing at the end of the first year. This score shows that the preservice teacher prefers explicit teaching style after the first year. In his explanation about his drawing, the subject states that the teacher is explaining the topic and the students are answering the questions of the teacher. When the classroom setting is examined, it is observed that desks are

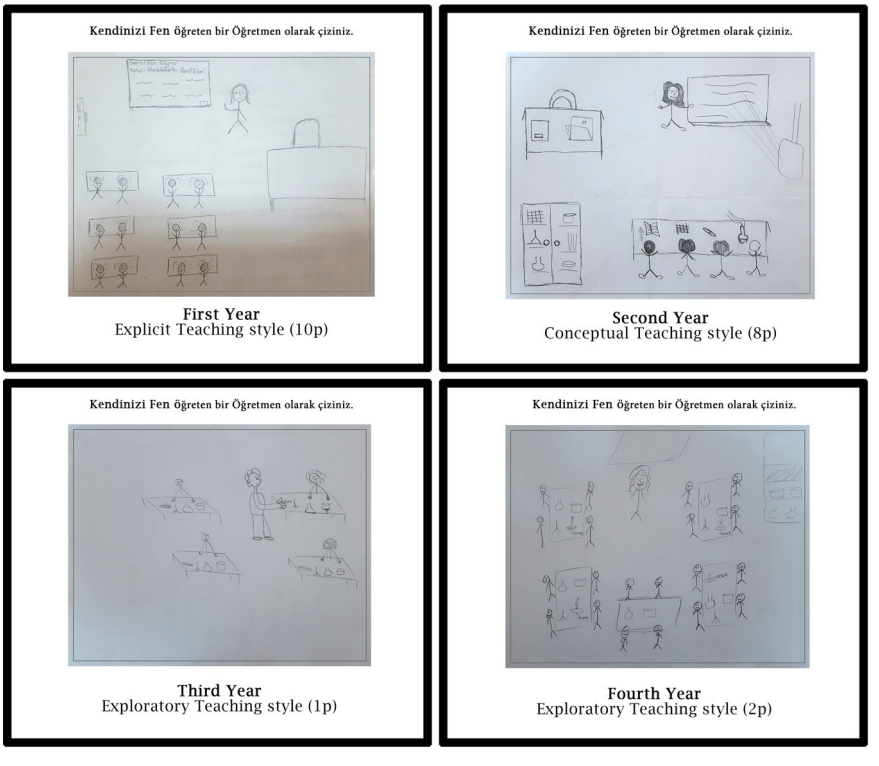

Figure 3. The drawings of a subject (S_{73}) in first, second, third and fourth years.

located in a conventional way and students are always sitting. Moreover, the teacher is using the board actively; she is in a central position of the classroom and the teacher's desk is in front of student desks.

When the subject's (S_{73}) drawing at the end of the second year is examined, it is seen that he got eight points, meaning he preferred conceptual teaching style after the second year. In his explanation about the drawing, he states that the teacher conveys information at the beginning of the lesson, explains the topic with use of examples and also makes the students conduct the experiments. Different from the drawing at the end of the first year, the classroom is not organised in a conventional way, and there are instruction materials on the desks of students. Similar to the drawing at the end of the first year, it is observed that the teacher and the teacher's desk are in a central position and the teacher uses the board actively.

When the drawing and explanations of the same subject are examined, it is seen that he got one point in the drawing test and preferred Exploratory Teaching Style. In his explanation about the drawing, the subject states that the teacher guides students while they are conducting experiments and students learn by doing. When the learning environment is observed, it draws attention that the position of the desks is not conventional and the teacher is not in a central position, but instead she walks around the classroom.

It is observed that the same subject got 2 points in the drawing test and similar to the third year, he preferred Exploratory Teaching Style. In his explanation about the drawing, the subject states that students conduct the experiment themselves and the teacher guides them. Moreover, the subject expresses that the teacher uses modern learning methods such as argumentation and collaborative learning. When the classroom setting is observed, it stands out that the desks are organised in U shape and students conduct activities in groups.

As can be understood from drawings and explanations, it can be said that the subject prefers teacher-centred teaching at the end of the first year; he prefers both teacher- and student-centred teaching at the end of the second year; and prefers student-centred teaching after the third and fourth years. This finding shows that teacher training programme has an effect on preservice teacher's belief about science teaching. With reference to the drawings and explanations, it can be stated that the teacher-centred belief of the preservice student, who began the teacher training programme with this belief probably because of his former educational experiences, (elementary, secondary schools) can be altered owing to the education given, and this belief heads towards a more student-centred teaching belief.

The findings about how preservice science teachers' beliefs about science teaching differed in terms of year

The second research question of this study is expressed as 'is there a significant difference between preservice science teachers' beliefs about science teaching in terms of their year in their undergraduate teacher training programme?' The mean scores and standard deviation values obtained by preservice teachers from drawing tests aiming at determining their beliefs about science teaching are presented in Table 3.

When the data in Table 3 were examined, it was observed that preservice teachers' beliefs about teacher-centred teaching shifted towards more student-centred teaching

Table 3. The mean scores and standard deviation values of drawing tests' results.

Year in the programme	*n*	*M*	SD
First year	76	9.76	2.53
Second year	76	8.13	3.16
Third year	76	4.63	3.00
Fourth year	76	3.84	2.48

beliefs as the year increases in terms of the mean scores of drawing tests. It was determined that this shift showed an increase especially after the third year and kept changing through the fourth year. Since longitudinal studies have a high statistical power (Pallant, 2007), a repeated-measure ANOVA test was planned to be used in the investigation of whether preservice teachers' scores obtained from drawing tests demonstrated a significant difference.

Before conducting the repeated-measure ANOVA, it was checked that whether assumptions of this test were met. The insignificant result of the Mauchly test ($p > .05$) indicated that the sphericity assumption, which is required to be satisfied for repeated-measures analysis, was met. The results of the repeated-measure ANOVA are presented in Table 4.

In Table 4, it is seen that preservice teachers' DASTT-C scores differed significantly ($F(3, 225) = 119.23$, $p < .001$). The calculated effect size (Eta-squared = .61) value shows that the year in the undergraduate teacher training programme has a large effect on the change of the belief about science teaching (Cohen, 1988).

It was previously mentioned that the DASTT-C, the data collection tool used in the research, has three dimensions as 'Teacher', 'Student' and 'Learning Environment'. The scores of preservice teachers are calculated by summing the points obtained from a total of 13 items, where five of them constitute the Teacher dimension, 3 of them constitute the Student dimension and the remaining five constitute the Learning Environment dimension. The mean scores and standard deviation values of the scores of preservice students obtained from each sub-dimension are presented in Table 5.

Within the scope of this study, whether preservice teachers' beliefs about science teaching differed in terms of sub-dimensions as the year increased was also investigated. The repeated-measure ANOVA results showed that preservice teachers' mean scores obtained from each of three sub-dimensions differed significantly from each other (Teacher Dimension; [$F(3,225) = 71.82$, $p < .01$)], Student Dimension; [$F(3,225) = 73.40$, $p < .01$)], Learning Environment Dimension; [$F(3,225) = 64.24$, $p < .01$)]. Moreover, the effect size values calculated for dimensions (Teacher; Eta-squared = .61, Student; Eta-squared = .50, Learning Environment Eta-squared = .46) showed that the year in the programme variable had large effect on the change of beliefs about dimension (Cohen, 1988). On the other hand, the significant differences between each sub-dimensions were determined to be between similar

Table 4. The results of the repeated Measures of ANOVA.

Source	Sum of squares	df	Mean square	*F*	*P*	Eta-squared	Significant difference
Between subjects	1.228.92	75	16.39				
Measure	1.811.21	3	603.74	119.23	<.001	0.61	1–2, 1–3, 1–4 2–3, 2–4
Error	1.139.29	225	5.06				
Total	4.179.42						

Table 5. The mean scores and standard deviation values of scores obtained from drawing test.

		Teacher		Student		Environment	
Year	*n*	*M*	SD	*M*	SD	*M*	SD
1	76	4.30	0.75	1.88	0.99	3.58	1.40
2	76	3.66	1.33	1.53	1.06	2.95	1.45
3	76	2.43	1.45	0.55	0.81	1.64	1.31
4	76	1.97	1.32	0.38	0.69	1.49	1.16

years (1–2, 1–3, 1–4, 2–3, 2–4). The findings showed that preservice teachers' beliefs about teacher, student and learning environment related to science teaching underwent a significant change, especially after the third year with the effects of courses given during undergraduate education.

Discussion

As a result of this study which was conducted with the aim of investigating the preservice teachers' beliefs about science teaching longitudinally throughout the teacher training programme, it was determined that preservice teachers usually preferred Explicit teaching style after the first and second years of the teacher training programme while they preferred Exploratory teaching style after the third and fourth years. It was concluded that preservice science teachers had conventional beliefs about science teaching after the first year of the programme since they depicted a traditional teacher role. A possible reason for this situation can be the effects of their previous experiences as students. A remarkable number of studies related to this situation support this possibility. For example, studies conducted with Turkish preservice teachers (Al-Amoush, Usak, Erdogan, Markic, & Eilks, 2013; Boz & Uzuntiryaki, 2006; Tatar et al., 2012; Ucar, 2012) and preservice teachers in other countries such as Germany, Jordan, and Malaysia (Al-Amoush et al., 2011; Markic & Eilks, 2013; Markic et al., 2011) came up with similar results.

Several researchers (Boz & Uzuntiryaki, 2006; Calderhead & Robson, 1991; Pajares, 1992) link this situation with the former educational experiences of preservice teachers. Many researchers (Bendixen, et al., 2002; Doyle, 1997; Thomas et al., 2001) argue that preservice teachers begin teacher training programmes with conventional science teaching beliefs sourcing from their experiences about science learning in elementary and secondary schools (Bendixen, et al., 2002; Calderhead & Robson, 1991; Hollingsworth, 1989; Pajares, 1992; Thomas et al., 2001). If no change occurs in preservice teachers' beliefs about teaching, who begin the teacher training programmes with conventional teaching beliefs, it is very likely that these preservice teachers will use conventional teaching techniques when they become teachers (Yilmaz-Tuzun, 2008). This is because the teachers' beliefs affect their teaching practices (Pajares, 1992). Within this context, science teacher educators have a vital mission. They should make it possible for preservice teachers to change their beliefs about science teaching through courses and especially method courses given in teacher training programmes (Seung et al., 2011) because the preservice teachers are expected to graduate from these programmes having competencies and beliefs which are in compliance with the exploratory teaching style such as using student-centred teaching methods, evaluating the students in terms of multiple dimensions, and making use of a variety of materials. At this point, method courses play a major role (Abell, 2006) because method courses are to be taught primarily by the field

experts in many universities (the university in the current study met this condition) while other courses can be taught by instructors who are not experts on the science education major. Within this context, it is expected for these courses to be delivered with the aim of improving the preservice teachers' mentioned aspects, and the instructors are expected to lead a change in preservice teachers' competencies and beliefs by placing emphasis on this issue and modelling (Yilmaz-Tuzun, 2008). In other words, method courses are expected to support the preservice teachers' constructivist views about science teaching and learning (Seung et al., 2011).

When the findings for the second research question of the study were examined, it was observed that as the year in the teacher training programme increased, preservice teachers' beliefs changed from a teacher-centred frame towards a student-centred frame. It was determined that changes in the beliefs about science teaching started at the end of the third year and kept on changing in the fourth year. It is concluded that these changes are likely to be the outcomes of the method courses such as 'Special instruction methods in science', 'Nature and history of science', 'Laboratory applications in science education' which are taken for the first time in the third year of the teacher education programme. This conclusion is based on previous research findings in which method courses were reported to have an effect on the creation or the change of preservice teachers' beliefs about science teaching (Ambusaidi & Al-Balushi, 2012; Hancock & Gallard, 2004; Minogue, 2010; Ng et al., 2010; Ucar, 2012). As a result of reform attempts in recent years, constructivism stepped forward in Turkey like many countries around the world (Boz & Uzuntiryaki, 2006). Since method courses in science teacher training programmes are designed for instilling the constructivist approach, these courses have a chance to trigger changes in preservice teachers' beliefs (Ucar, 2012).

As a result of the research, it was determined that the methods course had an effect on preservice teachers' beliefs about teaching. In a similar study involving 50 preservice teachers, Minogue (2010) investigated the effect of a method course on preservice teachers' beliefs about science teaching. As a result of his study, in which he collected pre-course and post-course data with the drawing tests, he determined that preservice teachers' beliefs changed from teacher-centred towards student-centred. In another study using a similar research method, El-Deghaidy (2006) determined that science teaching method course had an effect on preservice teachers' beliefs about science teaching. As can be seen, these researchers usually focused on the effect of a single course. However, as mentioned previously, in their longitudinal study, Ambusaidi and Al-Balushi (2012) investigated the effects of three different courses. The researchers collected data through the drawing test, and they investigated the effects of courses on preservice teachers' beliefs about science teaching by conducting the drawing test three times before the Science Method I course, after finishing this course and after finishing Science Method II course and Practicum. As a result of their study, they determined that only Science Method I course had a significant effect but Science Method II course and Practicum did not lead to a significant difference. This result shows similarities with the results of the current study because as mentioned earlier, preservice teachers' beliefs differed significantly after they took method courses in third year for the first time; however, although the change kept on in the fourth year, the courses of the fourth year did not lead a significant difference in the current study. One of the possible reasons behind this situation may be that the major change in the preservice teachers' beliefs resulted from the contemporary

teaching and learning approaches, student-centred activities and teaching methods that they encountered in method courses they took for the first time.

Another possible reason for this situation can be explained by that preservice science teachers in Turkey go to schools for practice in the fourth year of their teacher training programmes, and the instructional practices of practising teachers in schools can have an effect on beliefs of preservice teachers. The teachers with explicit or conceptual teaching beliefs may have repressed the student-centred teaching beliefs of preservice teachers.

Similar results were obtained in the study of Markic and Eilks (2013) where the researchers determined that the preservice teachers' beliefs about teaching deteriorated and turned into traditional beliefs after they started to go to practice schools in the fifth semester of the teacher training programme. Markic and Eilks (2013) concluded that participants' interactions with veteran teachers and the difficulties they had in planning and carrying out the teaching process on their own would have impacted the deterioration in preservice teachers' beliefs.

Conclusion, limitations and implications

As a result of this longitudinal study, it was determined that preservice teachers begin the teacher training programme with conventional teaching beliefs and these beliefs changed towards a more student-centred teaching after the third year when they took method courses for the first time. The results of this study are limited to 76 preservice teachers who graduated from a science teacher training programme of a state university in Turkey. This sample is not expected to represent all of the Turkish preservice science teachers but it can be expressed that the subjects of the current study demonstrate similar characteristics and academic attributes to other Turkish preservice science teachers since teacher training programmes in Turkey are uniform and carried out in universities under the control of the Higher Education Council (Ucar, 2012). Since the results of this study are limited by Turkish preservice teachers, it is recommended that similar studies can be conducted in other countries. By this way, both the changes originating from the countries' regional, socio-economic and cultural differences and the effects of different teacher training programmes of other countries can be investigated interrelatedly. Another limitation of the study is subject loss, which is a common problem in panel studies (Fraenkel & Wallen, 2000). Twenty-two preservice teachers were excluded from the research, which started with 98, owing to a variety of reasons (dropout, grade repetition, not graduating, etc.), and there were 76 preservice teachers in the research when it ended. In order to overcome this limitation of longitudinal studies, future researchers are recommended to start their studies with larger samples. By this way, the threats due to subject loss can be minimised. Another limitation of the research is sourced from data collection through the DASTT-C. It is known that different data collection tools, such as questionnaires, interviews, observations and field notes are used in research studies investigating preservice teachers' beliefs about teaching. Moreover, investigating the possible effects of many other factors of a teacher training programme only by using DASTT-C is an important limitation for the study. For this reason, it is recommended for researchers to diversify data by using drawing tests as well as aforementioned data collection tools in future studies. By this way, data diversity can be enhanced. Moreover, the studies

based on qualitative research designs will help researchers to investigate deeply and understand the effects of other elements other than teacher training programmes and method courses on preservice teachers' beliefs.

Another limitation of this study was sourced from determining the mental models of preservice teachers about science teaching at the end of the first academic year but not at the beginning of the teacher training programme. This limitation inhibits commenting on what beliefs the participants held at the beginning of the programme. However, the reason for this limitation is that the drawings of participants would not be beneficial in terms of the aims of the study before the participants took any undergraduate-level courses since the preservice teachers had no professional education at the beginning of the programme. However, it is recommended for future studies to measure the preservice teachers' beliefs at the beginning of the programme to overcome this limitation. The advantage of measuring the preservice teachers' beliefs about teaching at the beginning of undergraduate programme is that it can give a clue about their prior beliefs just entering to the undergraduate programme. Preservice teachers who had a student-centred education during the elementary and secondary school years can carry their beliefs to the teacher training programmes and therefore may impact their academic and professional development during the teacher training programmes.

Since it was determined that especially the method courses had effects on the change of preservice teachers' beliefs, in parallel with the results of other studies (e.g. Minogue, 2010; Seung et al., 2011), it can be recommended that a training related to constructivist-based (student-centred) teaching methods should be given in these courses. Teacher educators have an important role here. Not only teacher educators of method courses but also teacher educators teaching other courses are recommended to use student-centred approaches in their courses, as the experiences of preservice teachers have an effect on their beliefs about teaching (Calderhead & Robson, 1991). On the other hand, it can be recommended that method courses should take place not only after a specific year (e.g. starting from third year in Turkey) but in all years as well. Thus, preservice teachers will be able to witness student-centred teaching practices at the beginning of their undergraduate programme.

Although the teaching abilities of teachers in Turkey are tried to be improved through short-term in-service trainings, these trainings are generally less effective compared to long-term and comprehensive education practices, such as undergraduate teacher training programmes. This situation shows the necessity of paying attention to teacher training programmes once again and to the crucial importance of teacher training programmes for preparing qualified teachers. In conclusion, it must be noted that the teacher training programmes and their content should be planned and organised in a way that these programmes lead to preservice teachers preferring and employing student-centred approaches. Only this way, the training of qualified teachers and future teachers who play a vital role in the success of reform attempts in science education is possible.

Disclosure statement

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