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EXPLORING PEDAGOGICAL CHANGE IN PRE-SERVICE TEACHERS' SCIENCE TEACHING ORIENTATIONS DURING ARGUMENTATION-BASED TEACHING

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Abstract

This study aims to investigate the change in the science teaching orientations of pre-service science teachers using argumentation-based teaching via multiple measurement tools. In this mixed-method research, to evaluate the change experimentally, firstly, argumentation-based teaching practices in socio-scientific issues (SSIs) were carried out. Card sorting activity and focus group discussion forms were applied with 29 pre-service science teachers pre- and post-teaching. Then, to detail the longitudinal effects of the teaching, six pre-service teachers who were selected purposively were asked to perform micro-teaching in different SSIs in the primary/secondary school science curriculum. In this process, data were obtained from the observation, interview and lesson plan. Descriptive statistics were used in the analysis of the quantitative data, whereas the constant comparative method was used with the NVivo program in the analysis of the qualitative data. Thanks to argumentation-based teaching, it was found that the pre-service science teachers' SSI-specific science orientations improved. It was also found that they related themselves to more than one reform-based SSI-teaching type. It was noteworthy that they reflected the change in science orientations on their teaching practices, and the goals of their teaching included SSI dimensions. In terms of other pedagogical content knowledge components, they made their orientations more compatible with their knowledge of teaching strategies.

Keywords: Science teaching orientations, socio-scientific issues (SSI), pedagogical content knowledge (PCK), pre-service science teachers, and mixed-method research.

INTRODUCTION

Realization of a science teaching vision of raising science-literate individuals is a process that relies on the effective integration of the science, engineering, technology, society and environmental domains (Ministry of National Education [MNE], 2006). To strengthen the human structure of the society, it is aimed to raise qualified individuals who turn knowledge into social benefit through inclusive education (Development Plan, 2019). Socio-scientific issues (SSIs), one of the learning contents of the science teaching curriculum (MNE, 2013, 2017), and teaching of SSIs play an important role in accelerating this process. This is because, with the changing community life and education approach, SSIs have importance in raising generations who are able to use scientific knowledge in solving real-life problems and equipped with pedagogical reasoning and scientific-discussion skills (National Research Council, 2011).

SSIs are controversial issues that conceptually include social scientific dilemmas, contain uncertainty in their answers, require reasoning and consist of unclear problems (Sadler, 2004; Sadler & Zeidler, 2004; Zeidler & Nichols, 2009). SSIs that take place in our daily life on the global, national and regional levels include "scientific, environmental, economic, social, ethical/moral and political" dimensions (Ratcliffe & Grace, 2003). The content of SSIs widens with the changing needs of our age. Nuclear energy, GMO, cloning, artificial intelligence, drone, robotics, and treatment methods take place among the current SSIs of recent years (Topçu, 2015). Today, because of diversity in terms of priority strategies followed against the spread of the pandemic, COVID-19 is a global socioscientific issue (Topçu, 2020). Therefore, to create understanding and awareness for SSIs that affect all aspects of our lives and to use high-level thinking skills, scientific knowledge in decision-making and finding solutions about SSIs (Sadler, 2011) are extremely important in preparing students for real life. In this framework, there are research results regarding teacher practices and opinions that it is difficult to integrate SSIs into education (Han-Tosunoğlu & İrez, 2017; Pitpiorntapin & Topcu, 2016; Sadler et al., 2017). Factors such as misperceptions about SSIs, lack of experience and knowledge in SSI-teaching are among the reasons for these consequences (Bayram-Jacobs et al., 2019; Topçu, 2015). In the effective integration process of SSIs into education, pedagogical content knowledge in turning of content knowledge into pedagogical knowledge (Baxter & Lederman, 1999) appears as a new and necessary knowledge base.

Pedagogical content knowledge (PCK) which entered the literature with Shulman (1986), is among the knowledge bases of teaching. PCK is the reflection of the components of knowledge and beliefs about "curricula, teaching goals and objectives (orientations), learners' understanding, instructional strategies and assessment" on science teaching. The component of science teaching orientations affects other PCK components. Moreover, it reflects the teacher's knowledge and beliefs about the goals and objectives of science teaching (Magnusson et al., 1999). In the literature, there are many terms used for the concept of orientation, such as *teaching concepts*, *teaching approaches*, *teaching objectives* and *beliefs* (P.J. Friedrichsen et al., 2009). Moreover, several models that include the science teaching orientation component of PCK have been proposed (P. Friedrichsen et al., 2011; Gess-Newsome, 2015; Grossman, 1990; Magnusson et al., 1999; Park & Oliver, 2008). The orientation types and dimensions in these models vary on a scale between *traditional-teacher-content centered orientations* and *constructivist-student-learning centered orientations* (Gao & Watkins, 2002; Käpylä et al., 2009). In this spectrum, the science teaching orientation that guides teaching approaches (Padilla et al., 2008) is an important indicator of in-class practices (Gess-Newsome, 2015) and affects professional PCK development (Brown et al., 2013).

When the literature is examined, it is noteworthy that studies focus on identification of current science orientations (Güven et al., 2019; Ladachart, 2019; Ramnarain et al., 2016; Şen & Nakiboğlu, 2019). It is also important to investigate the dynamic relationship between development in science orientations and in-class practices (Campbell et al., 2014; Luft & Roehrig, 2007). Considering the topic-specific nature of teaching orientations and the situation that multiple orientations may be obtained, it is difficult to evaluate orientations (P. Friedrichsen et al., 2011; Kind, 2009; Shulman, 2015). So, orientations are examined through multi-evaluation tools such as content representation form: CoRe, pedagogical-professional experience repertoires: PaPeRs (Loughran et al., 2006), pedagogy of science teaching test: POSTT (Cobern et al., 2014), card sorting activity (P.M. Friedrichsen & Dana, 2003), observation and interview. The finding that science teaching orientation is resistant to change (Brown et al., 2013) reveals that there is a need for professional development programs that are well-designed for future science teachers (Ladachart, 2019).

Given that teaching SSI is a new pedagogy and an educational reform (Bayram-Jacobs et al., 2019), this study is of importance in terms of examining the development of pre-service science teachers' science orientations for teaching SSI during argumentation-based practices. Besides, this study is important because the development of science orientations is determined via topic-specific multi PCK evaluation tools on theoretical and practical levels. Departing from this, we sought answers to the following questions in this study:

i. What are the effects of argumentation-based teaching practices on the change of pre-service science teachers' science orientations for teaching SSI?

ii. How do the case study findings obtained from micro-teaching practices help explain the experimental design findings obtained from the argumentation-based SSI teaching process?

METHODS

This section includes information on the sample, research design, data collection tools and data analysis with the validity-reliability process.

Research Design

This study was carried out with the *embedded mixed-method design*, where a qualitative research method was applied following a quantitative research method (Creswell & Plano Clark, 2011). The scope of this design consisted of combining a *one-group pretest-posttest experimental design* and an *embedded multiple case study design*. The reason why we preferred *a single group in the design* was the fact that it is difficult to determine orientation due to its complex nature, and comprehensive evaluation of orientation in theory and action is needed. First of all, we obtained implementation permission and ethics committee approval from the institution for this research during one academic term. We used a "one-group pretest-posttest experimental design" to determine pre-service science teachers' SSI-specific science teaching orientations and explore the change in these orientations after argumentation-based SSI teaching practices. In the design, we obtained the orientation knowledge through pretest applications of "card sorting activity and focus group discussion." Afterwards, we introduced argumentation techniques, the nature of SSI and PCK to the pre-service science teachers. Moreover, we carried out argumentation-based SSI teaching modules prepared with expert recommendations. Following these practices performed for seven weeks, we investigated the changes in orientations by repeating the posttest applications of the same tools. Finally, we used an "embedded multiple case study" design. In this design, we selected six pre-service science teachers purposively to detail the longitudinal effects of teaching practices on the science orientations in depth. We asked them to carry out micro-teaching belonging to SSIs in different learning contexts. We obtained their science orientation knowledge in action from the "observation, interview and lesson plan."

Sample

The "purposive sampling technique" was used at the experimental design stage of this study. The sample of the study consisted of 29 fourth-year pre-service science teachers enrolled at the Faculty of Education of a State University in Turkey. Our reason why we preferred fourth-year pre-service teachers was the fact that they had completed many content and pedagogy courses. We chose them under factors such as voluntariness and accessibility. 26 of them (89.66%) were female, while 3 of them (10.34%) were male. Their mean age was 21.96. They had different levels of readiness for SSI. In the case study design of the study, on the other hand, the "maximum variation sampling method" was applied. Among the participants, we selected six pre-service science teachers with heterogeneous characteristics in terms of SSI-PCK levels as the sample. One of them (16.67%) was a male pre-service teacher, and five of them (83.33%) were female pre-service science teachers.

Data Collection Tools

"Card sorting activity, lesson plan, SSI-specific observation and focus group discussion forms" were used as the data collection tools of this study. The validity and reliability of the data collection tools were provided with the pilot study and the opinions of two science education experts in terms of "clarity, suitability to the target audience, covering SSI dimensions, orientations and time needed in practice".

Card sorting activity

In this study, the card sorting activity tool consisted of open-ended questions and various scenarios representing different teaching approaches to reveal the goals of SSI teaching. First of all, we wrote the scenarios to be compatible with the nine orientation types (*process, academic rigor, didactic, conceptual change, activity-driven, discovery, project-based, inquiry and guided inquiry*) defined in the literature (Aydın, 2012; P. Friedrichsen et al., 2011; Magnusson et al., 1999). Then, we took the opinions of two experts with a doctoral dissertation on PCK and over a decade of experience in science education. According to the feedback, the "academic rigor orientation" was not compatible with the updated science curriculum (MNE, 2017), and the "guided inquiry, process, discovery orientations" were lacking in terms of inclusion of research-inquiry and scientific process skills. In this context, the experts recommended that scenarios could be harmonized with new science teaching approaches by considering content acquisitions. Thus, we prepared the new scenarios to be compatible with "*presentation, conceptual change, project-based, inquiry, argumentation-based, problem-based, informal learning, STEM, drama/role-playing, technology-supported teaching methods*" and the nature of the SSI content. Considering the orientation types, there was a tendency from "direct teaching" towards the "reform-based approach." Some examples of the orientation scenarios from the card sorting activity are given below.

An effective way to teach students the goals-objectives of SSIs in the science curriculum is:

i. "to write the issue headings on the board and explain these issue headings in detail. To understand whether students learn scientific concepts and facts about the issue, questions are asked to students, and they are expected to answer these questions as described."

ii. "to enable students to use animations, simulations, digital narrations, social networks, tablet and smartboard applications that enable them to participate interactively in the learning process, to enable them to develop and implement multimedia-supported teaching activities."

ii. "to enable students to identify real-life problems about any SSI, to integrate mathematics, science, engineering and technology with an interdisciplinary approach, to create a model and to present this output at the end of the process."

iii. "to ask students to make their arguments about two contradictory situations on the issue by taking a leader role, to allow them to defend these claims, to ask students to discuss these situations in groups with data, evidence and confute counter-arguments."

For the application time and the clarity of the card sorting activity tool, we conducted a pilot study with two fourth-grade pre-service science teachers who did not participate in the sample. We received their confirmation regarding the comprehensibility of the tool's open-ended items and scenarios. Then, in the main implementation of this tool, we asked the pre-service science teachers to select scenarios that, *did not reflect these and that they were not sure of.* We also asked them to present reasons for their grouping in line with the literature (P.M. Friedrichsen & Dana, 2003, 2005). We applied the card sorting activity twice as pre- and posttest for one class hour.

SSI-specific PCK-based observation form

In this study, we prepared a micro-teaching observation form by considering the nature of SSI-specific PCK. We provided content validity of the form with two science education experts' opinions, the science curriculum (MNE, 2017) and the literature (Canbazoğlu Bilici, 2012; Sawada et al., 2002). Furthermore, we carried out the reliability and applicability testing of the form with two pre-service science teachers who were not included in the main study. As a result, the final version of the section representing the science teaching orientations knowledge of the form consisted of Likert-type items and multiple checkboxes. We observed six pre-service teachers' micro-teaching practices taking one class hour on average by systematic-participatory observation. We also filled out their practices in this form with two experts with doctoral degrees in science education. Besides, we recorded the micro-teaching practices with the participants' approvals and kept additional notes.

SSI-specific PCK-based focus group discussion forms

We prepared two different "semi-structured focus group discussion forms" for *the experimental and micro-teaching process* in line with two science education experts' opinions and the literature (Aydın, 2012; Canbazoğlu, 2008). We determined the comprehension of the questions and the average interview time via a pilot study. After the pilot study, we revised questions that the pre-service science teachers had difficulty understanding according to experts' feedback. In this context, the focus group discussion forms consisted of open-ended items that measured SSI-specific science teaching orientations. We completed the implementation of these focus group discussions in two class hours on average. We also recorded the discussions with the participants' approvals and kept additional notes.

PCK-based SSI lesson plan

In this study, we prepared a template of the lesson plan adapted for SSIs in line with two science education experts' recommendations and the literature (Bilican, 2017; Canbazoğlu Bilici, 2012). Firstly, we provided its applicability for different SSIs with two fourth-grade pre-service science teachers who were not included in the sample. Then, we asked six pre-service science teachers who carried out micro-teaching in SSIs to prepare their lesson plan. Thus, we aimed to determine their science teaching orientations reflected on their lesson plans. We also aimed to investigate whether there was a consistency between their lesson plans and micro-teaching practices in terms of the orientations. So, we achieved comparison of the ideal objectives in theory and the actual orientations in practice.

Data Analysis

The data analysis process was carried out in accordance with the nature of the "embedded mixed-method design." Firstly, we analyzed different types of data of the research's experimental design simultaneously and sequentially. We integrated data into each other. Then, we analyzed the qualitative data of the case study embedded in the experimental design and explained in relation to the experimental results.

We quantified the qualitative data obtained through the "observation form and lesson plan" by different analytical rubrics prepared for the data collection tools. The scoring of each section of the analytical rubric varied. For the lesson plan, the section with Likert-type expressions was scored as "0-2", whereas the section where the orientation types were specified was ranked by scoring as "0-4". For the observation form, the part with Likert-type expressions was evaluated as "0-2," and the part with checkboxes was evaluated by scoring as "0-3" according to the presence of observed behaviors (section A). The additional scoring criterion of the rubric was the level of observation in the micro-teaching of the planning in the lesson plan (section B). This level was in the range of 0-4 points. A scoring system like this is important in terms of using both theoretical and applied science teaching orientations data together by detailing each other. At the same time, the observation form and lesson plan contained different numbers of items. To make significant comparisons between the scores, we made a "standard score" calculation. The standard scores were calculated by the ratio of the total points taken by the pre-service science teachers to the maximum score that could be obtained from the tools.

We carried out an analysis of the qualitative data obtained through the "focus discussion and card sorting activity" according to the *constant comparative analysis* approach. We used the NVivo-12 Program in the analysis of the qualitative data. Besides, we used descriptive statistics to analyze the data of the card sorting activity. To ensure the validity and reliability of the results, we used the opinions of two experts with a PhD on PCK and over a decade of experience in science education. We also used the results on the internal consistency coefficient in the analysis process (Miles & Huberman, 1994). In addition to these, we made comparisons to different research results in the literature and reported direct quotations from the participants.

RESULTS

This section covers the quantitative and qualitative findings obtained from the pre-service science teachers consistently with the research questions and data collection tools.

Results Regarding the Change in SSI-Specific Science Teaching Orientations

The results regarding the change in the SSI-teaching orientations of the pre-service science teachers after argumentation-based teaching were reached via the "*card sorting activity, focus group discussion form*" of the experimental design process. Table 1 shows the descriptive analysis findings of the "pretest-posttest" phases of the card sorting activity.

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Table 1. Distribution of preference for SSI-teaching orientations (card sorting activity)

	Pretest						Posttest					
	Reflects me		Does not reflect me		I am not sure		Reflects me		Does not reflect me		I am not sure	
SSI teaching orientations	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
1-Presentation	8	27.6	19	65.5	2	6.9	3	10.3	25	86.2	1	3.5
2-Conceptual change	24	82.8	1	3.4	4	13.8	27	93.1	0	0.0	2	6.9
3-Project-based	15	51.7	2	6.9	12	41.4	22	75.9	2	6.9	5	17.2
4-Inquiry	16	55.2	2	6.9	11	37.9	29	100.0	0	0.0	0	0.0
5-Argumentation-based	16	55.2	3	10.3	10	34.5	29	100.0	0	0.0	0	0.0
6- Problem-based	21	72.4	4	13.8	4	13.8	29	100.0	0	0.0	0	0.0
7-Technology supported	13	44.8	10	34.5	6	20.7	26	89.7	0	0.0	3	10.3
8-Informal learning based	19	65.5	2	6.9	8	27.6	26	89.7	0	0.0	3	10.3
9-Drama/role-playing	11	38.0	9	31.0	9	31	22	75.9	3	10.3	4	13.8
10-STEM	8	27.6	5	17.2	16	55.2	23	79.3	0	0.0	6	20.7

According to the card sorting activity "pretest" findings, the "presentation, technology-supported and drama/role-playing" orientations did not frequently reflect their goals-objectives of SSI teaching. It was also found that they were not sure if the "STEM, project-based, inquiry and argumentation-based" orientations reflected themselves. It was determined that the first three types of orientation preferred were the "conceptual change, problem-based and informal learning-based" orientations. Thus, we could infer that they associated themselves with more than one SSI-teaching orientation.

According to the card sorting activity "posttest" findings, it was found that the "presentation" orientation did not reflect their goals-objectives of SSI-teaching. This orientation was followed by a very low rate of the "drama/role-playing" orientation. The reasons for this finding were the factors of "difficulty in adapting drama/role-playing properly to SSIs and causing distraction." It was also found that they had doubts about the "STEM and project-based" orientations in terms of reflecting their teaching. The reasons for this finding were the factors such as "since STEM is a new application, difficulty in transferring STEM to the classroom" and "project-based practice for SSI requires more time outside the school, anxiety about reaching the right source." It was seen that the orientation types frequently preferred were equally "inquiry, argumentation- and problem-based." These orientations were followed by the "conceptual change, technology-supported and informal learning-based" orientations. Since they preferred new and multiple SSI-teaching orientations in addition to the pretest findings, the positive effect of argumentation-based teaching was understood. To explain these findings, we asked the pre-service science teachers about the common features of the card sorting sequences in the posttest and to provide justifications about their opinions. In terms of common characteristics, categories that they thought reflected their goals of SSI-teaching were the "*research-inquiry, scientific discussion, problem-solving, solving misconceptions, using technology, excursion-observation and getting expert support*" categories. When the "presentation, drama/role-playing" orientations which they thought did not reflect them were analyzed for common features, the categories of "*failure to understand the topic well, causing a distraction* and *not being suitable for every SSI*" were reached. Considering the common features of "STEM and project-based" orientations in which they were not sure about reflecting them, the categories of "*difficulties caused by being a new practice* and *requiring a long time*" were obtained. Table 2 shows the findings about the "science teaching orientations theme" of the focus group discussion data collected from purposively selected ten pre-service science teachers in the experimental design.

Table 2. Findings of SSI-teaching orientations knowledge (pre-post focus group discussion)

Sub-theme	Category & code list (pre)	f	Category & code list (post)	f
Importance	No answer	4	Developing perspective on SSIs	4
	Providing ideas about problems	1	Revealing misconceptions	3
	Providing critical thinking	1	Avoiding misconceptions	3
	Enabling the student being innovative	1	Developing an inquiring perspective	1
	Determining misconceptions	1	Raising conscious individuals	1

	Revealing student skills	1	Revealing different views	1
	Expressing correct information	1	Informing about scientific studies	1
	Talking about current developments	1	Talking about current developments	1
	Requiring learning because it is in the MNE book	1	Revealing student skills	1
			Informal learning skills	1
			Creativity/imagination skills	2
			Critical thinking skills	2
			Problem-solving skills	1
			Analytical thinking skills	1
			Reflective thinking skills	1
			Enabling the student being innovative	1
			Ensuring that students express their opinions correctly	1
			for SSI such as organ donation	1
Functionality	No answer	7	Associating with daily life	8
	Associating with daily life	2	Using in everyday situations	1
	Using in any situation in life	1	Gaining professional experience in the related issue area	1

As seen in Table 2, there were two sub-themes regarding the SSI-teaching' goals and objectives, namely "importance for the student" and "functionality of the issue." In the "importance" sub-theme of the posttest, it was seen that four categories were common with the pretest findings (*revealing misconceptions, talking about current developments, revealing student skill* and *enabling students being innovative*). Additionally, seven new categories were identified. These were "*developing perspective on SSI, avoiding misconceptions, developing inquiring perspective, raising conscious individuals, revealing different views, informing about scientific studies* and *ensuring that students express their opinions correctly.*" It was observed that the two categories of the "functionality" sub-theme in the posttest were also determined in the pretest (*associating with daily life* and *using in everyday situations*). The additional category of "*gaining professional experience in the topic*" was also determined. To explain these findings, examples of direct quotations are given below.

"The purpose of SSI-teaching is to ensure that students have an idea for problems, to contribute to their critical thinking." (PST4$_{pretest}$)
"To determine misconceptions." (PST8$_{pretest}$)
"Talking about current developments and enabling the student being innovative." (PST5$_{pretest}$)
"The aim is to gain informal experience." (PST5$_{posttest}$)
"The aim is to increase the imagination and creativity skills of the student on the issues." (PST8$_{posttest}$)
"The goals of SSI-teaching are to avoid misconceptions because the issues are suitable for misconceptions." (PST10$_{posttest}$)

The "inquiry and argumentation-based" orientation types determined in the card sorting activity (posttest) and the "developing an inquiring perspective and revealing different views" categories determined in the post-focus group discussion showed similarity. So, it was revealed that the two data types consistently detailed each other.

Micro-Teaching Results Concerning SSI-Specific Science Teaching Orientations in Action

As a result of investigating the reflections of science orientations in different SSIs on micro-teaching practices, Table 3 shows the orientation scores of six pre-service science teachers.

Table 3. Science teaching orientation scores in practice obtained during micro-teaching

Level	PST	Data types	Orientation knowledge	Final total score	Orientation knowledge SS	Final total SS
L1	PST3	OF section A	3		.60	
Low		OF section B	3	6*	.75	1.35*
		LP	7	7	.58	.58
L2	PST1	OF section A	5		1.00	
Low		OF section B	4	9*	1.00	2.00*
		LP	6	6	.50	.50

L3 Medium	PST4	OF section A	5		1.00	
		OF section B	4	9*	1.00	2.00*
		LP	12	12	1.00	1.00
L4 Medium	PST2	OF section A	5		1.00	
		OF section B	4	9*	1.00	2.00*
		LP	9	9	.75	.75
L5 High	PST6	OF section A	5		1.00	
		OF section B	4	9*	1.00	2.00*
		LP	10	10	.83	.83
L6 High	PST5	OF section A	5		1.00	
		OF section B	4	9*	1.00	2.00*
		LP	9	9	.75	.75
Max. score to be taken		OF section A	5		1.00	
		OF section B	4	9*	1.00	2.00*
		LP	12	12	1.00	1.00
Mean scores of PSTs		OF section A	4.67		.93	
		OF section B	3.80	8.50*	.96	1.89*
		LP	8.83	8.83	.74	.74

PST-pre-service science teachers, SS-standard scores, OF-observation form, LP-lesson plan
*The level of implementation of the lesson plan is section B, it is added to the section A of the observation form, and the final total observation score is obtained.

In Table 3, pre-service science teachers are ranked from low to high by their PCK levels. When the "observation standard scores (SS)" were compared, it was found that five pre-service science teachers, except for PST3, reached the maximum score in orientation knowledge (SS_{max}=2.00). PST3 had a level below the mean orientation score (M=1.89) with their score of 1.35. Examining the standard scores obtained from the lesson plan, it was found that their lesson plan scores varied amongst each other. Except for two of them (PST3 and PST1), the other pre-service science teachers reached a score above the mean lesson plan score (M=.74). A pre-service teacher (PST4) achieved the maximum lesson plan score. It was understood that except one (PST3), the rest of them reflected the lesson plan exactly on their micro-teaching. Besides, their PCK levels (low, medium, high) and lesson plan and observation scores were not directly related. It is noteworthy that the lesson plan scores of the pre-service science teachers (except PST4) were lower than the observation scores. When we investigated the reason for this phenomenon, we saw that they had some difficulties in preparing the lesson plan. "Failure to directly reach the SSI in the textbook, to access to target references, to include SSI in the curriculum sufficiently, to use topic-specific strategies in proper order" were among these difficulties. Examining the "lesson plans," the pre-service science teachers' statements regarding the goals and objectives of the SSIs were as follows.

"To raise conscious producers and consumers, the following issues are mentioned: Biological control, definition of pesticides, their benefits and harms, alternatives instead of using pesticides. Thus, the student is informed." (PST3)

"The students are informed about the importance of the issue of technology and its place in daily life." (PST1)

"To correct students' misconception about cleaning-materials by asking questions to them. For a negative problem in daily life, they are asked to solve by defining this problem. They are introduced to cleaning-materials. The scientific process and their inquiry skills develop." (PST4)

"To raise awareness of what the chemical industries, their products, economic contributions to Turkey are. I let students solve the problem via an example scenario and make an argumentation on the effects of the chemical industries." (PST6)

When the lesson plan report examples were examined, it was found that the pre-service science teachers stated their SSI-teaching goals under various sub-themes. These sub-themes were "*associating with daily life, explaining scientific information correctly, developing scientific process skills, accessing information through research inquiry and discussion* and *establishing the science-*

technology-society-environment relationship.” They also emphasized the SSI dimensions of “economic, scientific, controversial, environment” among the teaching goals. According to their lesson plan, although there was a relationship between the science orientations and the components of PCK’s “assessment, curriculum, student understanding,” it was determined that “teaching strategies” and science orientations mostly interacted. It was found that all of their plans presented their teaching goals with the presentation orientation. It was also found that the pre-service teachers with low PCK levels preferred the presentation orientations, while those with medium and high levels preferred additional orientations (argumentation, inquiry, problem-based, etc.). Departing from this, we determined that the pre-service teachers on low PCK levels specified more traditional orientations, while those with medium and high levels stated orientations based more on the constructivist theory. To elaborate these lesson plan findings, Table 4 shows the types of science teaching orientations in practice used by the pre-service teachers in their SSI-teaching.

Table 4. Findings related to science orientation types used by PST (observation form)

Preferred science teaching orientations	**PST3**	**PST1**	**PST2**	**PST4**	**PST6**	**PST5**	**f**
Presentation	X	X	X	X	X	X	6
Question-answer	X	X	X	X	X	X	6
Research-inquiry		X				X	2
Argumentation		X		X	X		3
Technology-supported	X	X	X	X	X	X	6
Other orientations							
Material design			X				1
Experimentation				X			1
Activity-supported						X	1

It was seen that all pre-service science teachers stated their goals of SSI-teaching with the orientation types of “presentation, technology-supported and question-answer.” It was observed that the “argumentation” orientation followed these orientations. It was also noteworthy that new orientations (designing materials, experimentation, applying activities) were observed in addition to the already determined. So, it was concluded that they used new orientations due to the flexible practice of their lesson plan. To elaborate the observation and lesson plan data, the findings of the focus group discussion performed with six pre-service teachers after the micro-teaching practice are given below.

Table 5. Findings of micro-teaching focus group discussion related to science orientations

Theme (T)	**Sub-theme**	**Category**	**Subcategory**	**Code**	**f**
Science teaching orientation	Goal and objective	General goal-objective	Providing issue functionality	Using information in daily life	4
				Giving information facilitating daily life	2
				Providing operational information	2
				Association with daily life	2
			Emphasizing importance for the student	Involving student in the process	3
				Turning information into behavior	2
				Reducing issue to student’ level	1
				Attract student’ interest/attention	1
				Raising awareness about the issue	1
				Reinforcing topic via case studies	1
				Developing various skills	1
		Issue-specific goal-objective	Base stations	Use of base stations	1
				Benefits-harms of base stations	1
			Energy resources (ER)	Elimination of environmental problems	1
				Use of renewable energy sources	1
				The importance of renewable ER	1
			Chemical industry (CI)	Contribution of CI to economy	1
				Institutions contributing to the CI	1
			Acid-bases as cleaning material (CM)	Precautions for use of CM	1
			Space technology	Examples of space technologies	2

and space pollution	Causes of space pollution	1
	Effects of space pollution	1
	The use of space technologies	1
	Definition of space technology	1
Pesticides	Effects of pesticide use	1
	Pesticide types, harms, precaution	1
	Raising awareness about pesticide	1

As seen in Table 5, two categories related to science orientations (general and topic-specific goal-objective) were reached. It was found that the pre-service science teachers stated "general goals" related to daily life that "emphasize importance of the issue for student learning and ensure its functionality." They also stated "specific goals-objectives related to each SSI outcomes and content". When the data obtained from different data sources were compared, it was found that the "importance" and "functionality" contexts were determined commonly in the findings of the experimental design and micro-teaching. In the micro-teaching focus group discussion analyses, additional sub-themes were reached. These were "orientation types and ways to set goals." It was determined that the pre-service science teachers stated different references (curriculum, scientific report, papers, needs, internet, myself, book) as "ways to set goals." Moreover, they preferred the "argumentation, case study, question-answer and technology-supported" orientations as the "orientation type." Some direct quotations of the focus group discussion data describing these findings are given below.

"Due to the nature of the topic, to emphasize the importance of renewable energy resources to students." (PST5)

"It is one of our goals to improve various skills like discussion, etc." (PST6)

"While setting my goals, I set out by looking at the books and curriculum outcomes." (PST2)

"I used the question-answer technique while expressing goals in the introduction course." (PST3)

"My topic (base stations) was not included in the MNE textbook. I set my outcomes and goals from papers and scientific reports. I reduced them to students' understanding level." (PST1)

As a result of the micro-teaching practices, we should highlight that the pre-service science teachers did not have a single traditional orientation. They adopted multiple student-centered orientations, and they performed teaching based on these orientations. The findings from different data collection tools showed similarity to each other in that the pre-service teachers reflected their "technology-supported, argumentation-based and question-answer" orientations on SSI-teaching in action and on their own expression in the theoretical sense. For example, it was observed that the pre-service science teachers (PST1, PST4, and PST6) used the "argumentation-based" orientation in their practices in the real classroom environment. They also stated verbally in the card-sorting activity that the "*argumentation-based*" orientation reflected their teaching. Therefore, we may infer that the pre-service science teachers on different PCK levels reflected the change in science teaching orientations on their teaching after argumentation-based teaching.

Additionally, the pre-service science teachers were asked to make a self-assessment in terms of the effect of teaching practices on development of science orientations. The NVivo-12 analysis model of the data was as Figure 1.

In the self-assessment model, it was understood that the pre-service science teachers stated that their science teaching orientations showed positive development in various sub-themes. Examples of direct quotations from the participants' self-assessment views were as follows.

"The knowledge of why a topic should be taught is a factor in planning career. The things we can use in daily life are important. I understood how I could attract students' attention." (PST4)

"It helped me determine the appropriate method in this regard." (PST2)

"It guided me to prepare the lesson plan." (PST5)

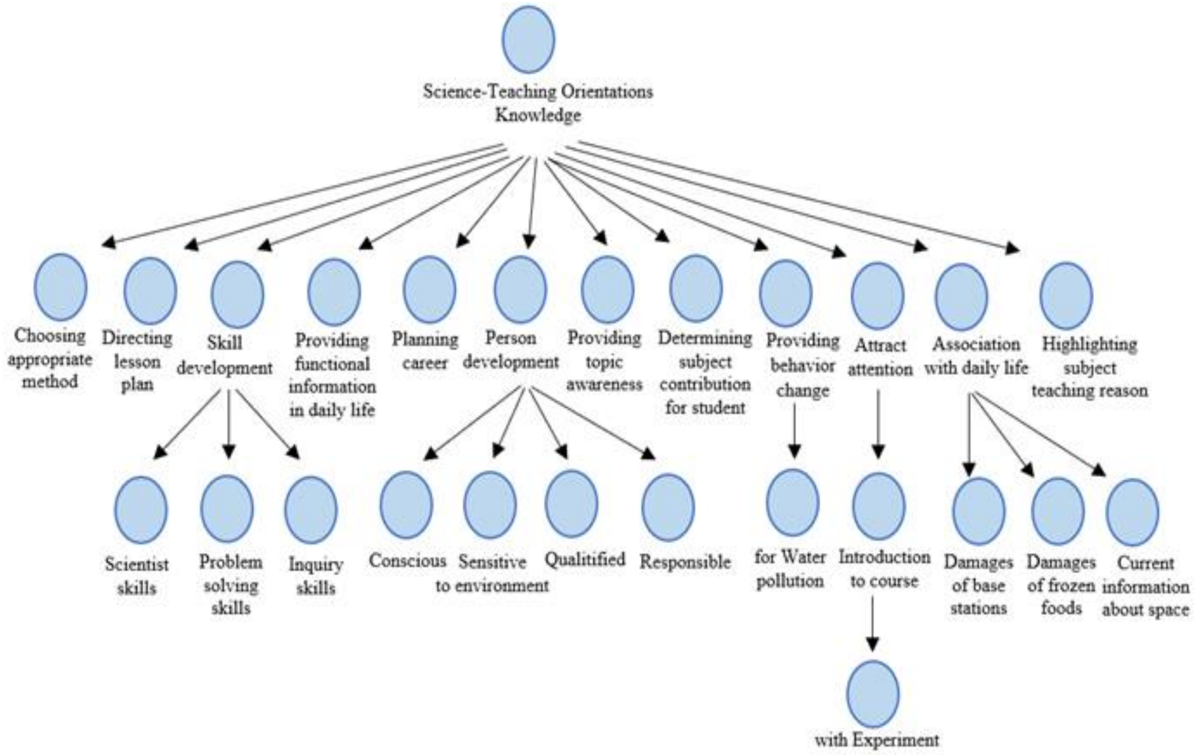

Figure 1. Self-assessment on development of science teaching orientation knowledge

DISCUSSION

In this study, we developed various SSI-specific data collection tools (card sorting activity, lesson plan, observation, and interview forms) to determine and explain pre-service science teachers' teaching orientations in theoretical sense and in action. We also prepared argumentation-based teaching modules compatible with the nature of SSIs and PCK. So, we recommend these different tools and teaching modules to identify topic-specific science teaching goals-objectives, teaching experiences and needs for lifelong professional development of pre-service teachers in argumentation-based learning environments.

In the research's experimental design, it was remarkable that the "*inquiry, argumentation-based, technology-supported*" orientations were most preferred, and the preference of the "*STEM, project-based*" orientations increased substantially in the posttest. We think the reason for this result arose from realization of argumentation-based 'mobile and QR code technology' applied in SSI-teaching with an interdisciplinary approach. Views with a more alternative and constructivist approach were also achieved following the teaching process. Based on these results, it was understood that argumentation-based teaching practices had a positive effect on the change of SSI-specific science orientations. In this context, there are research results in the literature that various practices (*teacher training and vocational development programs, method lessons, peer discussions, etc.)* contribute to development of science orientations (Aydeniz & Gürçay, 2018; Campbell et al., 2013; Faikhamta et al., 2009; Sahingoz & Cobern, 2020).

In the research's case study design, it was observed that the pre-service science teachers with different PCK levels used the "*argumentation-based and technology-supported*" orientations, which they stated in the card sorting activity. We would like to draw attention to the finding that they reflected their orientations on their teaching in the real classroom. So, it was concluded that argumentation-based teaching was effective in the science teaching orientations in action. It is possible to reach research results which are contrary to these results. For example, it was observed that teachers who preferred the inquiry-based orientation in the card sorting activity taught via the teacher-centered orientations in practice (Alkış Küçükaydın, 2017; Monet, 2006). In the literature, the relativity of orientation knowledge specific to the "variables of experience, time, material, issue type" was emphasized due to differences between the ideal and actual orientations (Akın & Uzuntiryaki-Kondakci, 2018; Şahingöz & Cobern, 2018). In this context, because of the similarity of these variables, we may understand that the preferred and observed science teaching orientations were consistent with each other in our study.

Another remarkable result was that the pre-service science teachers performed teaching based on multiple student-centered orientations. They associated themselves with more than one constructivist SSI-teaching orientation. These orientations had the common characteristics of "*research-inquiry, scientific discussion, setting problem, generating solutions*." In fact, the student-centered orientations were mostly explained by constructivist learning concepts in science teaching (Adibelli Şahin et al., 2016). In the literature, a thesis study (Özcan, 2013) where pre-service teachers used different student-centered orientations in teaching, the nature of science was similar to the result of this study. Moreover, a study indicated that pre-service teachers gain more reform-based orientations after reflective teaching (Demirdöğen & Uzuntiryaki-Kondakçı, 2016). Such a finding was also reported as that prospective teachers had various orientations at the same time (Güven, et al. 2019; Yılmaz Ergül & Taşar, 2020). Similarly, it was determined that mathematics teachers used different representation methods, and their pedagogical content knowledge was not limited to certain orientations (Gökkurt Özdemir & Soylu, 2017).

In our study, it was found that the pre-service science teachers obtained a lower score from the lesson plans in comparison to the observation scores. So, we concluded that they reached higher scores in their observation process due to the flexible practice of their lesson plan. According to the lesson plans, it was determined that they stated the teaching objectives under the sub-headings of "*daily life, scientific process skills, discussion* and *science-technology-society-environment*" in a more reform-based approach (Luft & Roehrig, 2007; Roberts, 2007). It was noteworthy that SSI-specific goals and dimensions (*economic, controversial, environment*) took place among the SSI-teaching objectives which they planned. In a similar study (Lee & Witz, 2009), it was pointed out that science teachers deal with SSIs with their "environmental and social" dimensions. It was also seen that a pre-service teacher on the medium level (PST4) received full points from the observation and lesson plan in our study. In this context, we may infer that there was no direct relationship between the PCK levels and science teaching orientation scores. Unlike this result, it is possible to reach a study that determined a relationship between the PCK levels and reform-based science orientations of teachers (Park et al., 2011).

Considering the micro-teaching practices, the pre-service science teachers frequently emphasized science teaching orientations in accordance with the "*argumentation-based and problem-based"* teaching methods. Thus, we were able to demonstrate that their science teaching orientation mostly interacted with the teaching strategy knowledge. In the literature, there are conclusions that science teaching orientations and beliefs often interact with knowledge of teaching strategies (Demirdöğen, 2016; Suh & Park, 2017). According to the micro-teaching focus group discussion, it was determined that the pre-service teachers stated issue-specific goals. In terms of the effect of argumentation-based teaching, they assessed that their orientation knowledge showed a positive development in various sub-themes.

Conclusions, Limitations and Pedagogical Implications

In our study, we developed argumentation-based teaching modules and multiple-measurement tools in addition to the card sorting activity including innovative teaching practices in SSIs to determine the change of science orientations. Our main findings pointed out that the pre-service science teachers' SSI-specific science orientations improved during argumentation-based teaching. The findings also highlighted that this development was on both a theoretical and practical level. At the same time, each of them had more than one reform-based SSI-teaching type. Our other remarkable conclusion was that the pre-service science teachers' reform-based goals and purposes of their teaching included various SSI dimensions. It should also be noted that their orientations were more compatible with "knowledge of teaching strategies" in comparison to other PCK components. In summary, we undoubtedly see an opportunity of this research for contributing to the literature in terms of determination of development in science orientations concretely through various evaluation tools and teaching modules prepared in the context of SSI-specific PCK.

Considering the specific results of our research, despite SSI-specific teaching practices, STEM and project-based orientations were found among the orientations that a few students were not sure in reflecting their teaching goals. Thus, activities where STEM and project-based orientations are more actively reflected in SSI-teaching may be developed and implemented. To assess these orientations predictively, additional data collection tools such as "CoRe, PaP-eRs, diary and mind maps" may be used. Additionally, the "social, ethical and political" dimensions of SSIs, which were not addressed by the pre-service teachers, may be introduced more with teaching scenarios. In our research, the pre-service teachers performed micro-teaching for SSI regarding different learning contexts, which are mostly included in the primary and secondary school science curriculum. New studies may be repeated for "global and regional SSIs" comparatively. This comparative study may be also carried out for a sample of different countries. So, it will be possible to discuss science orientations internationally in terms of education practically. It was also noteworthy that there was no relationship between the PCK levels and science teaching orientations of the pre-service teachers in our research. Departing from this, we recommend that the reasons for this phenomenon may be investigated through action research in an in-depth sense. Besides, we suggest that comparative studies examining the effects of positive or negative factors (*different learning domains of SSIs, self-efficacy and pedagogical reasoning, etc.)* on the orientations of pre-service teachers may be carried out.

This study had a few limitations. The first limitation was that the change in the SSI-specific science teaching orientations was examined through a single group. This limitation may be eliminated by performing similar studies with a control group. Another limitation was that the SSI-specific orientations were examined at the beginning of the course. In new studies, this process may be extended to all micro-teaching processes, and the orientation knowledge may be examined in a holistic approach with different PCK components.

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