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Heeding the Voices of Pre-Service Early Childhood Education Teachers: Their Beliefs about Early Childhood Science Education and Self-Efficacy for Teaching Science

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Abstract: This cross-sectional survey study aimed to explore pre-service early childhood education teachers' (PTs) beliefs about (a) the aims and scope of early childhood science education and (b) their self-efficacy beliefs in teaching science to preschool children. A survey consisting of open-ended questions was applied to PTs (N = 130). According to the results, PTs were aware of the importance of science education in early childhood. They mainly focused on the roles of early childhood science education in satisfying curiosity, developing questioning skills, and facilitating understanding of the environment and life. However, most PTs associated science education in early childhood with only natural sciences-related activities and concepts. Moreover, PTs reported low self-efficacy beliefs in teaching science to preschool children due to their lack of experience and theoretical knowledge. This study has some implications for PTs to view science education in early childhood from a comprehensive perspective and improve their self-efficacy.

Keywords: Early Childhood Science Education, Pre-Service Teachers, Self-Efficacy Beliefs, Survey Research, Teacher Education

Okul Öncesi Öğretmen Adaylarına Kulak Vermek: Okul Öncesi Dönem Fen Eğitimine İlişkin İnançları ve Fen Öğretimine Yönelik Öz-Yeterlikleri

Öz: Bu kesitsel tarama araştırması okul öncesi öğretmen adaylarının (a) okul öncesi dönem fen eğitiminin amaçları ve kapsamına ve (b) okul öncesi dönem çocuklarına fen öğretimi konusundaki öz-yeterlik inançlarına ilişkin inançlarını ortaya çıkarmayı amaçlamıştır. Veriler öğretmen adaylarından (N = 130), araştırmacılar tarafından hazırlanan ve açık uçlu sorulardan oluşan bir form aracılığıyla toplanmıştır. Sonuçlar, öğretmen adaylarının okul öncesi dönem fen eğitiminin öneminin farkında olduklarını ve fen eğitiminin merakı giderme, sorgulama becerilerini geliştirme, çevreyi ve yaşamı anlamayı kolaylaştırma gibi rollerine odaklandıklarını göstermiştir. Ancak öğretmen adaylarının çoğu, okul öncesi dönemde fen eğitimini yalnızca doğa bilimleriyle ilgili etkinlik ve kavramlarla ilişkilendirmiştir. Öğretmen adayları ayrıca deneyim ve teorik bilgi eksiklikleri nedeniyle okul öncesi dönem çocuklarına fen öğretimi konusunda öz-yeterlik inançlarının düşük olduğunu bildirmişlerdir. Çalışma, öğretmen adaylarının okul öncesi dönem fen eğitimine yönelik kapsamlı bir bakış açısı kazanmaları ve fen öğretimi konusundaki öz yeterlik inançlarını geliştirmelerine ilişkin bazı çıkarımlar sunmaktadır.

Anahtar Sözcükler: Okul Öncesi Dönem Fen Eğitimi, Öğretmen Adayları, Öz-Yeterlik İnançları, Tarama Araştırması, Öğretmen Eğitimi

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The innate curiosity and eagerness of children to explore the world make the early childhood years (between 0-8 years) the ideal time to start science education (Brunton & Thornton, 2010; National Research Council [NRC], 2012). Science education is an opportunity to satisfy children's curiosity and encourage these natural characteristics by helping them find answers to "how" and "why" questions and better understand the world around them. Besides, attitudes, knowledge, and skills about science begin to shape during the early years of life. Early childhood science education introduces scientific methods and concepts (e.g., living things and habitats, the structure of the human body, healthy life, force, sound, light, color, and shadow) to young children in an age-appropriate way. It helps them develop their knowledge and skills in science (Campbell & Howitt, 2018).

Children need child-centered and hands-on learning experiences in early childhood to think and act like scientists and build hypotheses and theories rather than rote learning (Loxley et al., 2017; Martin et al., 2014). Therefore, children's learning experiences in early childhood education (ECE) should be developmentally appropriate, enjoyable, inquiry-based, and support natural curiosity toward science (Campbell & Howitt, 2018; MacDonald et al., 2020). Thus, children can think like a scientist, develop an understanding of science concepts, and improve their science process skills (SPS) (e.g., observation, asking questions, predicting) (NRC, 2012).

ECE teachers play a crucial role in maintaining children's interest and curiosity toward inquiry and exploration, developing positive attitudes toward science, and establishing the foundations of science literacy (Olgan et al., 2014; Özsoy & Ahi, 2014). Therefore, in early childhood science education, children need to be guided by adults with comprehensive knowledge about the scope and application of science education in early childhood. In addition, teachers' beliefs about science are of great importance in their classroom practices and thus for children to acquire science literacy, which will be vital for them in the future (Reinoso et al., 2019). On the other hand, teachers' ability to effectively reflect their beliefs about early childhood science education into their practices is closely related to the extent to which they see themselves as competent in teaching science to children (Bandura, 1997; Oppermann et al., 2021). Thus, PTs' self-efficacy beliefs are another significant concern in early childhood science education. This study investigates PTs' beliefs about and self-efficacy in early childhood science education to understand their needs and expectations and provide implications to contribute to their still-developing beliefs in their professional preparation process (Wu et al., 2021).

Theoretical Background

As Pajares (1992) states, beliefs are the most fundamental determinant of decisions based on one's experiences, and teachers' beliefs affect their decisions in the classroom and the educational process. Hence, teachers' beliefs have been the research subject for many years in science education. These studies have mainly focused on teachers' beliefs and views on teaching science, features of effective science teachers, and the integration of science with other disciplines (e.g., Buldur, 2017; Zhan et al., 2020). However, a limited number of studies have investigated the beliefs of in-service and pre-service ECE teachers in science-specific content (e.g., Günşen & Uyanık, 2020; Leuchter et al., 2020; Uçar et al., 2023). In parallel with Pajare's (1992) views, the studies have revealed that ECE teachers' beliefs regarding science education shape their teaching practices (Bell & Clair, 2015; Wu et al., 2021).

ECE Teachers' Beliefs about Early Childhood Science Education

This study focuses on PTs' beliefs about the purpose and scope of science education in early childhood. Science education aims to help children develop their knowledge of the world around them, thus contributing to their ability to make sense of the world's mysteries (Brunton & Thornton, 2010; Hong & Diamond, 2012). Science education also aims to contribute to children developing positive attitudes toward science, better interpretation of science-related concepts in future science-related learning, and reason scientifically, and provide children with opportunities for developing their innate abilities (e.g., curiosity, reasoning, observing, exploring) through planned learning activities (Eshach & Fried, 2005).

The scope of early childhood science education may be considered under three all-around titles:

concepts, skills, and the role of stakeholders. A wide variety of concepts may be included in early childhood science learning: the life sciences, such as animals, nature, and insects; physical sciences, such as gravity, matter, and electricity; and earth and space sciences, such as planets, earth, and moon (Charlesworth, 2016; Martin et al., 2014; Piasta et al., 2015). Science education in early childhood aims to lay the foundations of children's understanding of these concepts and provide them with learning opportunities to experience science process skills (Paños et al., 2022; Worth, 2010).

Since people's beliefs have a determining role in perceptions (Pajares, 1992), PTs' beliefs about the purposes and scope of early childhood science education may influence their perceptions of science-related learning opportunities in and out of school. When ECE teachers do not perceive science as an essential component of the curriculum, they may prefer science activities less than other activities to apply in educational settings (Pendergast et al., 2017). Similarly, teachers' beliefs about science teaching opportunities in children's daily lives may also guide their science education practices (Edwards & Loveridge, 2011). Awareness of opportunities for science learning in the classroom or any environment is associated with the frequency and quality of science-related experiences provided by teachers and children's engagement with science (Saçkes et al., 2013). It means that although teachers experience the same environment, they may practice differently from each other because of their different perceptions of the affordance of education environment for science learning.

The role of stakeholders is another critical subject for science education in early childhood. Parents are more associated with the informal ways of experiencing science, such as reading science-related books, visiting a museum, practicing science experiments, watching science-related products, and visiting science fairs or festivals (Gilligan et al., 2020; Junge et al., 2021). Parents can also support their children's science education by providing opportunities in informal learning environments and participating in school activities (Ata-Aktürk & Demircan, 2021; Junge et al., 2021). ECE teachers are expected to provide an exciting and rich education environment with full opportunities to observe, sense, and construct knowledge cooperatively with the teacher and peers (Charlesworth, 2016). They play the role of a source of scientific knowledge and skills, encourage children to ask questions and engage in discussions, serve as role models about the science processes skills, document children's learning, and create time for children to engage in scientific experiences (Brunton & Thornton, 2010). ECE teachers can provide opportunities for science education through play and conversations to make science more meaningful for children (Gerde et al., 2018) and guide children's scientific inquiry with their pedagogical knowledge to make concepts noticeable and clear (Worth, 2010).

Research revealed that teachers' beliefs about the role of children and teachers in science education might affect their science-related practices. For example, some teachers may believe that the involvement of teachers in children's science-related experiences may inhibit the active explorer nature of children (Sundberg & Ottander, 2013). These types of concerns may cause teachers to abandon science education practices altogether. Similarly, suppose a teacher thinks that children cannot learn science concepts. In that case, s/he either does not offer any science activities, or even if s/he does, s/he offers simple and superficial activities that do not satisfy curiosity and exploration. If teachers do not trust children's abilities, they may see direct instruction and experiments as the best way to teach children science (Karademir et al., 2020). Conversely, when teachers see children as active participants in learning and capable of learning science, they plan their educational activities according to this child's perspective on education and give them more opportunities to make observations and explorations (Blake & Howitt, 2018).

ECE Teachers' Self-Efficacy Beliefs in Early Childhood Science Education

Bandura (1997, p. 3) defines self-efficacy as "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments." Prior studies have indicated that ECE teachers' self-efficacy beliefs were significantly associated with their frequency of engaging young children in science (Chen et al., 2022; Gerde et al., 2018) and the extent to which ECE teachers provide opportunities for children to be actively involved in science activities (Gürler-Ağaçkıran & Aslan, 2023). ECE teachers' self-efficacy beliefs in science also mediate the relationship between their professional development and science practices

(Oppermann et al., 2021).

The literature also revealed that ECE teachers might avoid providing science-related learning experiences for young children and perform fewer science practices in education than in other fields, such as art, math, and literacy (Doğanay-Koç, 2023; Gerde et al., 2018; Gropen et al., 2017; Oppermann et al., 2019). Several other reasons might be behind this avoidance, but the most important is the weak self-efficacy beliefs in teaching science to young children (Oppermann et al., 2021). Although ECE teachers consider science education necessary for children, they may have low self-efficacy in teaching science-related subjects (e.g., Okur-Akçay, 2016). There are similar results for PTs (e.g., Sundberg & Ottander, 2013; Torquati et al., 2013). ECE teachers' science teaching efficacy beliefs during higher education may remain permanent after graduation and starting their careers (Deehan et al., 2020). Besides, as Bandura (1997) stressed, previous experiences can affect self-efficacy beliefs. Thus, PTs' current experiences in science teaching may play a decisive role in their future science-teaching efficacy beliefs (Barenthien et al., 2020; Chen et al., 2022; Uludag-Baustista & Boone, 2015). In this context, professional development for pre-service ECE teachers encompasses acquiring new competencies and knowledge and cultivating a sense of self-efficacy, which is pivotal in fostering innovation and enhancing productivity (Bandura, 1997; Saçkes et al., 2012). Therefore, in this study, PTs' beliefs about the aims and scope of science education in early childhood and their self-efficacy beliefs were considered worth investigating.

The Current Study

This study focused on examining the beliefs of PTs multidimensionally in the context of the purpose and scope of science education in early childhood and their self-efficacy beliefs in teaching science to preschool children. Such an exploration will provide a picture of their evaluations of already implemented science education in ECE classrooms and what is going on with science education in their minds, beginning from their education for early childhood science education to their science-related practices. For these purposes, answers to the following research questions will be addressed within the scope of this study:

1. What are the beliefs of PTs about the aims and scope of early childhood science education?
2. What are the self-efficacy beliefs of PTs regarding teaching science to preschool children?

Method

Research Design

This study is designed as a cross-sectional survey that allows researchers to collect data from a large sample at a specific time and determine the participants' current descriptive characteristics, views, attitudes, and beliefs on a topic (Fraenkel et al., 2012; Rea & Parker, 2014).

Participants

The participants were 130 PTs. They were enrolled in the third year of the ECE program of a public university in Türkiye and had completed science education and school experience courses. Participants consisted of 97 female (74.61%) and 33 male (25.38%) PTs, and their mean age was 21.

Early Childhood Teacher Education Program in Türkiye

The ECE program aims to prepare PTs for their careers during the 4-year education to guide the development and education of children from 0-6 years old. In this program, science education and school experience courses are included in the fall semester of the third year. The science education course focuses on the importance of science and nature, science education in early childhood, teaching methods in main science concepts and process skills, preparing and practicing curriculum, and instructional tools. The school experience course focuses on observing children and classroom practices (e.g., curriculum, teaching methods, assessment strategies) in a natural classroom environment PTs (Council of Higher Education, 2007). This study was carried out in the spring semester with third-year PTs who completed both courses because of the theoretical knowledge and practical experiences offered to PTs. These two lessons may be efficacious for

shaping their beliefs about science education in early childhood (Olgan, 2015). Indeed, PTs are exposed to the broadest science and early childhood science education content through the science education course. Similarly, it was found necessary that PTs complete the school experience course because this course allows them to observe how science is practiced with preschoolers in natural educational settings.

Data Collection

Data were collected through a survey created by the researchers. The survey consisted of 7 open-ended questions expected to be answered in writing. The use of open-ended questions in collecting data allowed the researchers to obtain more individualized and in-depth responses on the topic and not limit the participants to predetermined responses (Rea & Parker, 2014).

Besides the demographic questions (e.g., gender, age), the survey questions were constructed around two themes: science education in early childhood (importance, aims, scope, roles of the participators) and self-efficacy in teaching science. After the initial survey draft was prepared, expert opinion was consulted. The expert evaluated the questions regarding clarity and suitability for the research and revised them in line with the expert's suggestions (e.g., The question of how science education should be in early childhood can be organized under sub-headings. For example, what should the role of the child be? What should the role of the teacher be?). The first author applied the survey (see Table 1) on the same day in four sessions (approximately 33 students per session). It took about half an hour for the PTs to answer the questions.

Table 1. Survey questions used in data collection

Themes	Questions	
Science education in early childhood	1) Do you think science education is necessary for preschoolers? Why is that?	
	2) Which concepts do you think "science education in early childhood" should include?	
	3) Which activities do you think "science in early childhood" should include? Please explain briefly with an example activity.	
	4) When you consider the science education practices provided in ECE institutions based on your observations during your school experience course;	a) What do you find correct? b) What do you find wrong/missing? What do you think can be done to correct these mistakes/deficiencies?
	5) In your opinion, in an effective early childhood science education;	a) What should be the role of the child? b) What should be the role of the teacher? c) What should be the role of the parents? d) What should be the role of the education program (curriculum)?
Self-efficacy in science teaching	6) Do you think that the science education course you take during your undergraduate program provides you with the knowledge and skills required to teach science to preschoolers?	
	7) Do you feel confident in teaching science education to preschoolers?	• If yes, what made you feel confident? • If no, what can be done to make you feel more confident?

Data Analysis

The data were analyzed using content analysis. Within the context of survey research, content analysis allows the coding of written responses given by participants to open-ended questions into a meaningful set of themes/categories to perform further quantitative analysis (Lavrakas, 2008). Accordingly, two general themes (i.e., science education in early childhood and self-efficacy in science teaching) referring to what PTs think about early childhood science education and their beliefs in their capacity to provide science experiences to young children were determined. Then, codes were generated from the PTs' statements on related questions asked based on the predetermined themes, and emerging codes were assigned to the themes and categories.

As the first step, the authors conducted a preliminary read-through of data to discover the data, and memos were taken. In the second step, the answers given by a randomly selected sample of the participants (n = 20; 15%) were coded independently by both authors into various themes determined in line with the survey questions (Merriam & Tisdell, 2016). The coders compared their coding and then discussed the points of disagreement by conducting online meetings. They re-coded the data until they reached an inter-rater agreement rate higher than .80 percent. At the end of this process, the inter-rater agreement between the two

coders was found to be .93 (Miles et al., 2013). Then, the first author continued to code the remaining data. In the final step, the frequency of the codes (how many participants included the relevant code in their answers) was counted, and the qualitative data were converted into quantitative data (percentages) (Creswell, 2012). One participant's response to a survey question may contain multiple codes.

Ethical Considerations

Before data collection, necessary permission was obtained from the Kastamonu University Social Sciences and Humanities Research and Publication Ethics Board decision dated 01.06.2021 and numbered 14 to conduct the study. Consent of the participants was obtained with a voluntary participation form. It was announced to the prospective teachers that their personal information would be kept confidential (using nicknames) and not shared with anyone other than the research team. PTs were also informed that their participation in the study was based solely on volunteering. They could leave the classroom at the beginning of the process if they wanted or stop answering questions while the process was continuing (Creswell, 2012). All PTs volunteered to stay in the classroom and answer the questions.

Results

PTs' Beliefs regarding the Purposes and Scope of Science Education in Early Childhood

The first aim of this study was to explore PTs' beliefs about science education in early childhood. All PTs reported that science education is necessary in early childhood years. According to most PTs, the aims of science education in early childhood are to satisfy innate curiosity, develop questioning skills, and have the ability to understand the environment and daily life. They believe that preschoolers' curiosity and eagerness to research are the main advantages of starting science education in early childhood (see Table 2). Below are some quotes from PTs regarding the importance of science education for children and the advantages of starting science education in early childhood;

> "Since we are in the age of technology, children are interested in mobile phones, computers, and tablets. They can access information whenever they want. Sometimes, this information may not be accurate. Through science, we can teach them to make decisions about the accuracy of the information they access." PT102

> "Science education in early childhood is necessary because children learn best by doing and exploring in the early childhood period. Science gives children the opportunity to learn by doing." PT17

Table 2. Science education in early childhood – contributions

Categories	Codes	f	%
Importance for children	Satisfying innate curiosity	26	18.84
	Developing questioning skills	24	17.39
	Ability to understand the environment and daily life	23	16.67
	The basis for future learning	16	11.59
	Motivation for science as a profession	11	7.97
	Positive attitude towards science	10	7.25
	Increasing interest and curiosity towards science	8	5.80
	Discovering abilities for science	8	5.80
	Science and technology literacy skills	7	5.07
	Developing problem-solving skills	5	3.62
	Total	138	100
Advantages of early childhood	Curiosity and desire to do research	27	62.79
	Learning by doing	7	16.28
	Being eager to learn	4	9.30
	Rapid cognitive development	3	6.98
	Imagination and creativity	2	4.65
	Total	43	100

PTs believed that the early childhood science education content should include experiences for SPS (e.g., experimentation, observation, research, testing, reasoning, and prediction). PTs also suggested specific science

concepts from different fields of natural sciences. These are biology (e.g., nature, ecology, living creatures, human body), earth and space sciences (e.g., planets, earth, moon, universe, space, climate, wind), physics (e.g., gravity, force, electricity), and chemistry (e.g., matter, change of state). Some PTs considered science from an interdisciplinary perspective and reported that engineering and technology (e.g., technology, engineering, inventions, and robotics) and mathematics (e.g., weight, measurement, addition, and subtraction) could also be subjects of science (see Table 3). For example;

> … Children can observe about what the magnet attracts or does not attract… PT48
>
> Nature, animals, humans, space, planets, and technology. PT112
>
> Science education in ECE should include experiment, observation, research, and reasoning. PT107

Table 3. Science education in early childhood – concepts

Categories	Codes	f	%
Science process skills (SPS)	Experiment	30	30.61
	Observation	25	25.51
	Research	23	23.47
	Others	20	20.41
	Total	98	100
Natural sciences	Biology	101	42.61
	Earth and space sciences	75	31.64
	Physics	45	18.98
	Chemistry	16	6.75
	Total	237	100
Mathematics, Engineering, and Technology	Engineering and technology	20	60.6
	Mathematics	13	5.82
	Total	33	100

When they were asked to give examples of science activities that can be implemented in ECE settings, more than half of the PTs provided examples of activities for natural sciences. Some PTs provided a wealth of integrated activities in which science is presented via integration into other activities, such as art, engineering, literacy, play, and drama; however, some could not suggest an activity.

PTs were also asked to evaluate science activities and implementation processes aligned with their ECE classroom observations and science education course. Most PTs reported the necessity of children's active participation in science education. According to PTs, children should be allowed to be involved as much as possible in science activities by giving them responsibility, creating opportunities for learning by doing, allowing them to practice what they know and demonstrate this learning, and encouraging research. PTs also reported that teachers should develop themselves to provide satisfying and proper answers to children's questions, ask probing questions, prepare science activities, give effective feedback, and have scientific knowledge. PTs also pointed out the necessity of a more diverse range of science-related activities (e.g., activities related to daily life, field trips, observations in nature, play activities) instead of just making experiments, art activities, or instructions. Their evaluations for the science course in the university also revealed similar considerations to science practices in ECE classrooms. Most PTs believed they should be provided more opportunities in the science course to gain experience in science activities (e.g., planning developmentally appropriate activities for young children and sharing diverse science activities instead of just doing experiments). They also reported their wishes to have more science-related courses during their undergraduate years and to enhance their abilities to teach science concepts without causing misconceptions (e.g., how-to guide children and what teaching methods they can use) (see Table 4). For example;

> Just doing experiments is not enough for science education. It is also ineffective because teachers only do experiments by showing them to children. Children with the necessary safety precautions should carry out experiments. In addition, they should be allowed to do research. PT92
>
> I believe we need more practical than theoretical knowledge to provide more effective science experiences for young children. PT88

Table 4. Science education in early childhood - considerations

Categories	Codes	f	%
Practice	Active involvement of children	21	22.58
	Teacher education	19	20.44
	More science activities	16	17.20
	Diversifying science activities	14	15.05
	Concrete explanation of concepts	8	8.60
	Rich environment	7	7.53
	Child characteristics	4	4.30
	Parent involvement	4	4.30
	Total	93	100
Science education course	Experiencing more science-related activities	49	45.79
	Teaching science	25	23.36
	Appropriate activities	18	16.82
	Theoretical knowledge	15	14.01
	Total	107	100

According to most PTs, children have roles in science education, such as active participation, research, curiosity, and asking questions. Nonetheless, some PTs noted that children have no part because of their ages. Parents and teachers were attributed to similar roles at varying proportions. PTs reported that teachers and parents should guide children by supporting them wherever they need assistance by asking questions, giving clues, and answering children's questions. In addition, according to the PTs, parents and teachers should encourage children to research, ask questions, observe and learn, and support their curiosity, interests, investigation, and independence. PTs also reported that they see teachers and parents as responsible for providing learning opportunities for children and preparing learning environments. Besides, according to PTs, parents should participate actively and provide opportunities to be involved in informal learning environments. PTs also expressed that the ECE program should be teachers' primary source of knowledge in science education. Specifically, it should have science-related content, be sensitive to the contemporary developments in science and technology, be current, and be comprehensive. Most importantly, it should include additional objectives regarding scientific processes. PTs also reported that the program should be sensitive to children's developmental characteristics, age, culture, needs and interests, and individual differences and encourage research, discovery, curiosity, and creativity (see Table 5). Sample quotations from PTs were presented below;

> Children should be active explorers in science activities who ask questions and research concepts. PT79

> ECE teachers should guide the children and help them understand the concepts. ECE teachers should support children when they need support. PT14

> …. Parents should always support the child and prepare the environment at home for him/her to explore science concepts. PT81

> ECE program should include goals and objectives to support children's curiosity and allow children to research. PT38

Table 5. Roles of participants of science education in early childhood

Categories	Codes	f	%
Child	Active participator	83	26.94
	Making research	48	15.58
	Having curiosity	46	14.93
	Asking questions	36	11.68
	No role (because of age)	34	11.03
	Learning by doing	25	8.11
	Discovering	22	7.14
	Making observations	14	4.54
	Total	308	100
Teacher	Guidance	107	43.49
	Encouragement or support	46	18.69
	Preparing learning opportunities	36	14.63

	Source of information	20	8.13
	Observing	15	6.10
	Passive	11	4.47
	Learner	11	4.47
	Total	246	100
Parents	Encouragement or support	57	28.21
	Education at home (parallel with school)	43	21.28
	Active participation	34	16.83
	Providing learning opportunities	23	11.38
	Collaboration with teacher	18	8.91
	Guidance	15	7.42
	Source of information	7	3.46
	Observing	5	2.47
	Total	202	100
Program	Knowledge source	69	53.48
	Responsiveness to child characteristics	38	29.45
	Encouragement	22	17.05
	Total	129	100

PTs' Self-Efficacy Beliefs in Early Childhood Science Education

Many PTs reported low self-efficacy beliefs in teaching science to preschoolers (n = 91; 70%). However, less than one-third of the PTs (n = 39; 30%) reported high science education self-efficacy. PTs who saw themselves as competent mainly attributed this to the experiences and knowledge they gained during undergraduate years (e.g., courses, practice, and observations) and feeling confident about teaching skills (e.g., knowing how to teach, ability to draw children's attention, planning activities for young children, asking practical questions). Most PTs with low self-efficacy beliefs attributed this to a lack of experience and theoretical knowledge regarding science education. PTs reported that doing more research about teaching science to young children and developing themselves in effective science teaching (e.g., explaining science concepts in a way that the child can understand, appealing to children's imaginations and curiosities, and creativity) can increase their self-efficacy (see Table 6). For instance;

> …I am good at communicating with children. I think I have had practical experience planning and implementing science activities. I believe I am good at answering children's questions… PT40

> I believe I need to improve myself in science education. I need to improve myself in helping children understand science concepts. In addition, I must improve myself in science activities to arouse children's curiosity, support children's imagination, and guide children on how to access correct information. PT26

Table 6. Self-efficacy beliefs for science

Categories	Sub-categories	Codes	n	%
Self-efficacy beliefs		Experience and knowledge in university	21	53.84
		Confidence in teaching abilities	9	23.07
		Knowledge about science	7	17.94
		Positive attitude to science	2	5.12
		Total	39	100
Lack of self-efficacy beliefs	Sources	Lack of experience	16	17.58
		Lack of theoretical knowledge	14	15.38
		How to teach science	13	14.28
		Ineffective education in the university	10	10.98
		Other/Unspecified	38	41.75
		Total	91	100
	Solutions	Making research	31	34.06
		Professional development	24	26.37
		More education	20	21.97
		More experience	11	12.08
		Others	5	5.49
		Total	91	100

Discussion

Results indicated that PTs' beliefs on the aims of early childhood science education mainly focus on creating opportunities for children to develop SPS (e.g., making observations, experiments, predicting, and testing) through learning activities planned around scientific concepts from different fields of science, such as biology, physics, and chemistry. More specifically, PTs perceive science education as mainly children's effort rather than instructing children. This definition aligns with the 21st-century science education perspective, which argues that science can be learned by "doing" rather than transferring scientific concepts to children (Loxley et al., 2017; Schwarz et al., 2017). Science education introduces children to these concepts through learning activities in which children actively do science and integrate their science-related knowledge and skills (e.g., Paul, 2018). Furthermore, children possess the capacity to learn science and the right to comprehend their world through the lens of scientific learning (Larimore, 2020).

PTs mainly reported that early childhood science education content should include concepts related to natural sciences (e.g., biology, physics, earth, and space sciences) and SPS. Some PTs viewed science education from an interdisciplinary perspective and mentioned that science education might include concepts related to different subject areas such as engineering, technology, and mathematics. However, their numbers were low, and most PTs focused primarily on natural science concepts, as reported in similar research studies (Charlesworth, 2016; Piasta et al., 2015; Thulin & Redfors, 2017). Similarly, when PTs were asked to give examples of science activities that can be applied in ECE, most gave examples of natural sciences. Although there are examples of activities for integrating science with other content areas, this number is limited. Even more interesting, some PTs could not give examples of science activities. These findings point out that most PTs referred to the concepts only in natural sciences rather than focusing on the interdisciplinary nature of science, and some had a limited activity repertoire for early childhood science education. As Kennedy and Odell (2014) stressed, adopting an interdisciplinary approach in science education focuses on designing innovative solutions to complex problems that require knowledge and skills in different disciplines rather than providing children with isolated learning experiences in various subject areas. Such an approach allows children to discover the connections between disciplines and be encouraged to make new and valuable connections (NRC, 2012). Therefore, it is crucial for PTs, who will design and implement activities for preschoolers in the future, to be aware of learning opportunities where science content is integrated with other disciplines and that children are supported in many areas at the same time (Çiftçi et al., 2022).

In parallel with the literature, PTs reported numerous early childhood science education contributions to children (e.g., Brunton & Thornton, 2010). Significantly, there was an emphasis on contributions regarding children's active involvement and independence, such as developing questioning and problem-solving skills and discovering their skills and abilities for making science. PTs also focused on future contributions to science education, such as being the basis for future learning and developing motivation for science as a career. These findings indicate that PTs are also aware of the contribution of science education to children's future academic or professional success. More interestingly, PTs also saw some developmental characteristics of children as factors creating an advantage for science education, such as innate curiosity, desire for research, and creativity and imagination, which were also documented in the literature as the natural characteristics of young children (NRC, 2012; Raven & Wenner, 2023).

The results regarding considerations of PTs signified that PTs were aware of how science education should be in the early years. PTs importantly focused on the active involvement of children, which was also emphasized in previous studies reporting that the active participation of children enhances the quality of science education (e.g., Karademir et al., 2020). The answers of PTs may also reveal that there should be a balance between the roles of teacher, parent, and children. That is to say, they attributed mainly roles for children coherent with their nature, such as curious, question-asker, and researcher. They attributed teachers and parents as information sources, observers, guides, and enhancers. This is a way of maximizing the effectiveness of science education (Nayfeld et al., 2011). PTs also noted the need for daily life-related and integrated science activities in ECE classrooms. Children's daily lives may be a "laboratory" in which children can make sense of scientific skills more effectively. As future teachers, it is a significant finding that PTs are

aware of the opportunities in children's daily lives, whether in school or out of school, to make science education more meaningful (Gomes & Fleer, 2020).

As in some previous studies (e.g., Babaroğlu & Okur-Matwalley, 2018; Gerde et al., 2018), most PTs believed that the scope of the science education course in their undergraduate education was insufficient. According to them, this course can be a practical science education course that allows PTs to experience a more significant number and variety of activity examples and enables them to develop knowledge and skills in guiding preschoolers' science learning and preparing developmentally appropriate activities. Similarly, Saçkes et al. (2012) draw attention the need for a science education course that is planned and implemented in a way that provides teacher candidates with knowledge, skills, and experience on how science-related content can be integrated into the curriculum through developmentally appropriate methods (e.g., play, music, drama) and approaches (e.g., project approach). Also, PTs pointed out that they needed more courses regarding science education in their undergraduate education. It is promising for PTs to be aware of the need for more comprehensive content for science education and to seek diversity in science activities because research findings reflect that ECE teachers provide limited activities for science (Doğanay-Koç, 2023; Lippard et al., 2018) or only specific types of science education such as more life sciences, and less earth and space science (Saçkes, 2014).

Finally, although most PTs thought parents had roles in their preschoolers' science education, only a few PTs have included parent involvement as a feature of effective science education in early childhood. Previous studies have revealed that PTs have high self-efficacy beliefs in parental involvement. However, they have high perceived barriers (e.g., parents who are inadequate to support their children academically and parents who do not want to participate in activities in the school setting) (Alaçam & Olgan, 2019). This finding may be related to limited knowledge of PTs about how parents can be involved in their preschoolers' science education in formal and informal settings and their perceived barriers to parental involvement in science education (e.g., Başkan & Kutluca, 2020).

Results also revealed that almost three-fourths of PTs have low self-efficacy in teaching science to children. This result is consistent with previous studies (e.g., Aslan et al., 2016; Olgan, 2015; Oppermann et al., 2021; Pendergast et al., 2017). There might be many reasons for this lack of self-efficacy. Perhaps the most significant contribution of the current study is to enable PTs to reflect on their self-evaluation about science teaching and find solutions to what they can do to improve their possible self-efficacy. According to the results, the responsible factor for having or not having efficacy beliefs about themselves is whether they have experience with science education practices with young children in preschool settings—a common problem influencing the quality of science education in preschools. Moreover, PTs reported the insufficiency of their theoretical science knowledge, not having teaching skills in science, and the insufficiency of the science education course in their undergraduate education as the other determining factors for their low self-efficacy beliefs. In parallel to this finding, a wealth of research studies reported that one of the pre-and in-service teachers' problems is related to experience in science teaching and pedagogical content knowledge (Oon et al., 2019; Thulin & Redfors, 2017).

PTs' solution ideas to enhance their self-efficacy beliefs in science teaching were collected under three themes: conducting research on early childhood science education, gaining more experience with young children, and having more education. Similarly, in the literature, in-service ECE teachers touched on similar needs in some subjects such as science-related content knowledge, science education-related resources, developing materials and planning and implementing science activities, and science teaching methods in ECE (Babaroğlu & Okur-Metwalley, 2018; Oon et al., 2019). More professional education may create opportunities for PTs to have knowledge and experience in early childhood science education. Research revealed that professional development in science education provided through educational programs provides PTs with more comprehensive and positive beliefs about science (Thulin & Redfors, 2017) and is associated with the frequency of implementing science activities in educational settings (Piasta et al., 2015).

Conclusions and Educational Implications

This study aimed to walk in PTs' shoes and explore science education in early childhood through their eyes. In light of the results and limitations of the study, it is possible to make many implications for teacher education programs, ECE program developers, and future researchers.

First, this study revealed that most PTs comprehensively perceive early childhood science education. However, many PTs associate science with natural sciences and do not focus on the concepts related to other disciplines (e.g., engineering, technology, math, arts, history) that can be integrated into science activities. This situation also manifested in their examples of activities related to early childhood science education. This study suggests broadening PTs' perceptions of science education in early childhood by making science courses in teacher education programs more practice-oriented and interdisciplinary. In such a course, through the micro-teaching practices, PTs can also explore and experience the integration of STEM, an approach to integrating disciplines and daily life, into ECE classrooms through developmentally appropriate and hands-on activities. As suggested by PTs in this study, they can be encouraged to practice these activities with children in ECE classrooms and gain more experience in providing science education to children; thus, their self-efficacy beliefs in science education can be supported. Moreover, opportunities to see and experience practices where such activities are conducted with parental involvement can reduce PTs' potential perceived barriers to parental involvement in early childhood science education.

The second implication is for the Turkish ECE program. This study revealed that PTs need more guidance and examples of activities in integrated science education, providing daily life connections in science education, and parent involvement in science education. The ECE program, the central resource for pre-service and in-service ECE teachers in Türkiye, can be revised to meet these needs. Thus, PTs' repertoire of activities in science education can be expanded. It can be ensured that they see alternative practices for supporting science education in the context of home, community, and daily life.

The final implications are for future studies. Participants of the current study were limited to third-year students of the ECE program in a university. In future studies, data can be collected from different samples, and the study findings can be compared with the results of this study. Thus, making more comprehensive and generalizable comments on the subject under investigation may be possible. Besides, in this study, collecting data through an open-ended survey made it possible to reach many participants. However, it also caused limitations (e.g., missing data and short answers like yes/no). In future studies, focus group discussions may be held with some participants to examine the PTs' beliefs in more deeply.

Declarations

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