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Research Article

Preservice early childhood teachers' science conceptual changes with STEM-based science activities

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Abstract

Developing positive attitudes towards science and scientific process skills at an early age enables children to become more successful in the fields of science. However, in order to provide this education in early years, it is necessary to use scientific concepts correctly and appropriately by teachers and parents. This study investigated the effects of STEM-based science education practices on the science conceptual changes of preservice teachers. One-phase experimental embedded pattern design, one of the mixed-method research, was used in the study. The study group consisted of 20 (16 women, 4 men) preservice teachers (PST) who were enrolled in an undergraduate course titled Science Activities for Preschoolers. In addition, data were collected from the Science Concepts Form, STEM-based science activities plans, and application videos. The study results showed that STEM-based science activities positively impacted the science-related conceptual changes of preservice teachers. Especially, preservice teachers' conceptual changes were increased in stone and soil, living and non-living thnigs, and force, motion and balances concepts. Furthermore, it has been determined that this program supported teachers in correcting misconceptions in different science subjects (ex. Earth and space science, life science, physical science) and using concepts correctly. The study results suggested that STEM-based science education practicess are important for teacher's science understanding and using in classroom.

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Introduction

In recent years, educators across the globe have emphasized the importance of teaching STEM (science, technology, engineering, and mathematics) related subjects to children across all grade levels (Breiner, Harkness, Johnson, & Koehler,

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2012; Bybee, 2013; English, 2016). While STEM reform efforts were initially aimed at older students at the elementary, middle, and high school levels, the emphasis has now been expanded to include younger students, including those attending preschool or kindergarten (McLure et al., 2017). This shift in emphasizing STEM education in early childhood was, to a certain extent, a consequence of the publication of two policy reports in the United States (US) by the National Science Foundation (NSF). The "Early STEM Matters: Providing high-quality STEM experiences for all young learners" (Early Childhood STEM Working Group, 2017) and "STEM Starts Early: Grounding Science, Technology, Engineering, and Math Education in Early Childhood" (McClure et al., 2017) stressed the importance of beginning STEM education at an early age. These reports also included recommendations for policy, research, and practices designed to enhance early childhood STEM education.

According to the Early Childhood STEM Working Group (2017), four basic principles should be adhered to in order for early childhood STEM education to be effective: i) children need adults to develop their natural STEM inclinations; ii) representation and communication are central to demonstrating STEM learning; iii) Adults' beliefs and attitudes about STEM education affect children's beliefs and attitudes about STEM; iv) STEM education is not culturally neutral. An earlier report (National Research Council [NRC], 2011) maintained that preschool teachers should have a solid understanding of STEM education. This, they claim, is necessary to design appropriate learning experiences to help students actively participate in STEM education. Nevertheless, according to Park and colleagues (2017), even though preschool teachers are aware of STEM education's importance, many reports challenges when it comes to teaching STEM in the classroom. These challenges include a lack of time as well as a lack of knowledge about STEM topics. This situation is partly due to inadequate professional development and support within preschool teacher education programs. Thus, the Early Childhood STEM Working Group (2017) recommendation was that preschool teachers should be prepared both pedagogically and professionally regarding the related subject matter. In sum, preschool teachers' ability to effectively apply STEM teaching practices relies upon their understanding of STEM pedagogy and the relevant subject matter, including science conceptual understanding.

This study aimed to investigate the effects of STEM-based science education practices on the development of preservice early childhood teachers' science conceptual understanding. In the following section, we outline the importance of STEM education and science education for young children. Then we discuss the preparation of early childhood teachers to provide them with more science experiences to improve their science conceptual understanding.

Importance of STEM Education

It is maintained (e.g., Jones, Lake, & Dagli, 2005; Seffeldt, Galper, & Jones, 2011) that using a STEM approach can support critical developmental skills in young children, such as critical thinking, problem-solving, and executive thinking. Beyond these more general skills, STEM teaching and learning can help children acquire scientific process skills and positive attitudes towards science (Furtak, Seidel, Iverson & Briggs, 2012; Leuchter, Saalbach & Hardy, 2014; Trundle & Saçkes, 2012). However, according to Çorlu and colleagues (2014), STEM education's effectiveness relied on a theoretically grounded infrastructure and determined at the application level. For example, in a study of STEM education, Strong (2013) found that children developed basic science skills such as observation, experimenting, and the ability to identify different variables. However, supporting developing such skills in young children is only possible if the teacher has relevant professional training. Beyond training, having an appropriate STEM curriculum as well as the support of parents and families is also essential (Uyanık-Balat & Günşen, 2017).

Science Education

For a preschool teacher to deliver lessons that include well-designed science activities for young children, she should have a good understanding of science concepts. Carrier (2013) noted that "Teachers must have a clear understanding of science vocabulary in order to communicate and evaluate these understandings with students" (p.405). Carrier (2013) also concluded that the extent to which preservice teachers use science vocabulary in a lesson is related to their background and experience. Indeed, several reports (e.g., NRC, 2003) suggested a need for teacher preparation programs to improve preservice teachers' science content knowledge and pedagogical teaching strategies. It follows that preservice

teacher education programs that focus on STEM-based science education should positively influence preservice teachers' use and application of science concepts and their attitudes toward science.

This perspective is supported by Starr and colleagues (Starr, Hunter, Dunkin, Honig, Palomino, & Leaper, 2020), who noted that "STEM courses are often the gatekeepers to STEM careers" (p. 3). Thus, a STEM emphasis in early childhood teacher education would lead to young children engaging in developmentally appropriate STEM activities in the classroom. Also, using science practices in the classroom can help build future teachers' self-efficacy beliefs about science and scientific knowledge (Starr et al., 2020). This is important given that, according to the literature, it is well established that the majority of preschool teachers hold negative attitudes towards science and thus use fewer science activities in the classroom (Eshach, 2003; Gelman & Brenneman, 2012; Greenfield et al., 2009; Kildan & Pektas, 2009). In addition, most preservice and in-service preschool teachers feel uncomfortable teaching science in early childhood classrooms due to their lack of knowledge about science concepts. Therefore, a promising approach and to overcome this obstacle to effective science teaching is to provide preservice teachers with classroom teaching experiences. Therefore, in the current study, drawing on the work of Carrier (2013) and Putman (2012), classroom teaching experience is considered as a potentially effective way to improve prospective teachers' science teaching skills in the broad science categories of earth and space science, life science, and physical science.

Earth and Space Science

Typically, in early childhood, the topic of earth and space science draws on children's natural interest in object and events in the world around them, such as soil, rocks, rain, snow, clouds, rainbows, the sun, moon, and stars (NRC, 1996). In addition, according to the NRC (1996), children must understand the properties of materials, objects in the sky, and changes in the earth and sky (NRC, 1996). Although such topics can be considered complex or challenging, according to Lind (2010), early introduction of such content is essential for children to learn about their world and prepare for their future understanding. The challenge for preschool teachers is to prepare developmentally appropriate activities to support children's understanding of these concepts. Beyond hands-on activities, they should also encourage children to talk about what they observe and be curious about pattern changes.

Life Science

Life science is a popular topic in early childhood that provides children with opportunities to build on their knowledge of animals, plants, life cycles, and habitats. According to Charlesworth and Lind (2010), "Children display an eagerness to learn about the living things around them" (p. 508). Therefore, preschool teachers need to support the development of children's understanding of life science concepts. This entails planning appropriate classroom activities and developing questions and evaluation strategies (Charlesworth & Lind, 2010). Nevertheless, the extent to which preschool teachers can do this depends on their understanding of these concepts.

Physical Science

Children seem to be interested in physical science (Simsar, 2018), possibly because physical science experiences are often fun and exciting for them (Charlesworth & Lind, 2010). According to the NRC, this broad category includes (1996) topics such as the properties, position, and motion of objects, light, heat, electricity, and magnetism. Teaching such topics to young children should rely on first-hand experiences using natural objects and visual materials. For preschool teachers to plan appropriate activities, they would first need to "brainstorm strategies to prepare children to understand physical science topics such as magnets, light, and electricity" (Charlesworth & Lind, 2010, p. 523). Preschool teachers' understanding of science concepts, such as the states and shape of matter, light and shadows, force, motion and balance, blocks, magnets, and simple machines, shapes can significantly influence this process.

Preparing Preservice Early Childhood Teachers

Given the recent increased emphasis on improving STEM education, it is necessary to increase early childhood teaching and learn in the relevant disciplines such as science. This can be challenging because, according to recent research, most early childhood teachers feel less confident and prepared to teach science content (Barenthien, Oppermann, Anders, & Steffensky, 2020; Banilower et al., 2013; Early et al., 2010; Greenfield et al., 2009). As a result, science is not frequently

taught in early childhood classrooms. For example, in a national sample of K-3 teachers, 41% of participants reported not teaching science every week (Banilower et al., 2013). Likewise, Tu (2006) worked with early childhood teachers and noted that most participants (86.8 % of participants) did not provide time for science activities. Greenfiel et al. (2009) described it as particularly problematic in preschool classrooms, which can only be remedied by providing professional development (Gerde et al., 2018; Gropen, Kook, Hoisington, & Clark-Chiarelli, 2017). Such training should be designed to help teachers develop their abilities to plan and deliver appropriate science activities. Such skills, however, are rooted in preservice teachers understanding of basic science concepts. Indeed, it is maintained that "a critical focus of preparing ECE teachers to teach science must be to help them understand what constitutes science and strategies for teaching it." (Barenthien et al., 2020, p. 208). This focus is also crucial because early childhood teachers' science background experiences can significantly impact their science teaching self-efficacy beliefs.

While there are various approaches to preparing early childhood teachers to teach science, researchers maintain that it should be practice-based and emphasizing the development of pedagogical knowledge. For example, in a recent study, Carrier and Grifenhagen (2019) designed a science methods course that focused on science vocabulary instruction strategies and science lessons taught to peers. As a result, the researchers concluded that preservice teachers' science vocabulary knowledge had increased by the end of the semester but that there were some inconsistencies regarding their science vocabulary experiences (Carrier & Grifenhagen, 2019). Likewise, teachers' instructional strategies are another factor that can impact students' science vocabulary learning.

The Current Study

The importance of teacher education and training in STEM-related disciplines has been highlighted in recent research studies (Çolakoglu & Gökben, 2017; Dilet et al., 2020; Furtak et al., 2012; Leuchter, Saalbach & Hardy, 2014; Uyanık-Balat & Günşen, 2017. Preschool teacher education in STEM teaching, for example, is associated with more positive attitudes toward the fields of science, mathematics, engineering, and technology (Furtak et al., 2012; Leuchter, Saalbach & Hardy, 2014; Uyanık-Balat & Günşen, 2017). Yet, other research studies reveal some shortcomings and challenges concerning the preparation of preservice teachers in STEM teaching and learning in Turkey (Çolakoglu & Gökben, 2017). One crucial challenge is that preschool teachers tend to have negative attitudes toward science and related fields, and consequently, they use fewer science activities in the classroom (Eshach, 2003; Gelman & Brenneman, 2012; Greenfield et al., 2009; Kildan & Pektas, 2009). However, supporting the development of efficacy beliefs cannot be done in isolation. There also has to be an emphasis on relevant content as well as practical experiences. For example, researchers in one study found that teachers were uncertain about supporting students who had difficulties understanding science concepts (Seah, 2016). Therefore, researchers stated that preservice teachers need science method courses that will support them in order to be able to help children's understanding and learning of science concepts (Carrier & Grifenhagen, 2019).

Problem of Study

Therefore, the current study sought to document preservice teachers' conceptual understanding following their engagement in a STEM based teacher education program. Guiding the study was the following overarching research question:

- What is the effect of a STEM education program on preservice teachers' understanding of earth and space, life, and physical science concepts?

Method

Research Model

The study was designed as a one-phase experimental embedded design which, according to Creswell (2012), is an approach that is used to "collect quantitative and qualitative data simultaneously or sequentially but to have one form of data play a supportive role to other forms of data" (p. 544). Moreover, in such studies, qualitative data can be collected before and after the experiment (Creswell & Plano Clark, 2007). In the current study, quantitative data were collected

before and after the participants engaged in classroom-based STEM activities, and qualitative data were collected during the treatment phase. Such an approach meant that the qualitative data were embedded in the design (Creswell, 2012) and that both data types could be independently analyzed. A visual schema of the design is illustrated in Figure 1.

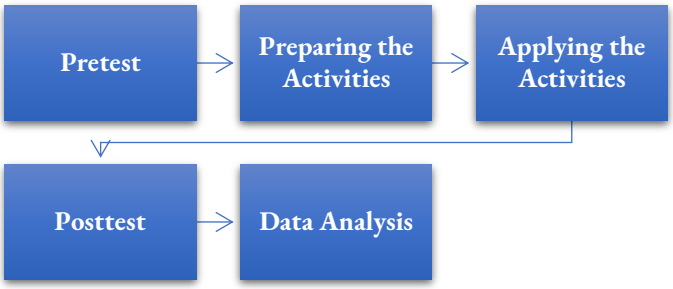


Figure 1

Schematic Representation of the Research Process

Participants

A stratified purposeful sampling approach was used to select the study participants. According to Suri (2011), such an approach is "useful for examining the variations in the manifestation of a phenomenon as any key factor associated with the phenomenon is varied" (p. 70). The study group consisted of 20 (16 women, 4 men) preservice teachers (PST) who were enrolled in an undergraduate course titled "*Science Activities for Preschoolers."*This four-credit course was a mandatory course for undergraduate students who were majoring in early childhood education. The two critical components of the class were two hours of instruction addressing theoretical aspects and two hours engaging in practical science activities. Thus, the course's emphasis was on conceptual understanding and the design of developmentally appropriate STEM-based science activities for young children.

Although 38 students were enrolled in the course, there were several with incomplete data, and therefore they were not included in the study sample. Thus, the 20 PST who participated in the study were those who had completed all of the relevant activities and the video recordings. All of the participants had previously taken early childhood science-related courses. In addition, most (80%) had participated in some type of classroom-based teaching experience. Relatedly, they reported that they had some experience in planning science activities for preschool-aged students. Nevertheless, according to the participants, their knowledge of STEM education in early childhood education was quite limited.

Instruments

Use of Science Concepts

For this study, an instrument titled "Use of Science Concepts" was created. This consisted of 19 questions in three categories: earth and space science, life science, and physical science. First, the earth and space category consisted of 6 questions addressing concepts concerning *Natural Phenomena, Planets, Weather Phenomena, Stone and Earth, Gravity, and the Night-Day Cycle.* Then, there were seven questions in the life science category addressing *Food Chain, Animals, Plants, Living and Non-living things, Body Organs and Their Functioning, Different Habitats, and Different Senses.* The final six questions addressed concepts concerning the *States of Matter, the Shape of Matter, Light and Shadows, Force, Motion and Balance, Blocks, Magnets and Simple Machines, and Kitchen Activities*.

The following are examples of individual items:

- That are the first five (5) concepts/words that you would think of if you were engaged in preschool science activities concerning *Natural Phenomena?*'
- What are the first five (5) concepts/words that you would think of if you were engaged in preschool science activities concerning the *States of Matter*?
- What are the first five (5) concepts/words you would think of if you were engaged in preschool science activities concerning *Light and Shadows.*'

Instrument validity was established by having three educators, each with expertise in preschool education, science education, measurement and evaluation, review of the questions.After the final version of the instrument were used in the study after fixing the unclear sentences. The instrument was administered on two occasions during the semester; once at the beginning of the semester and then during the final week of the semester.

Procedures

All of the participants participated in a ten week-long course on science-based STEM education for early childhood teachers. The class was organized around both traditional classroom teaching as well as classroom-based practical activities. The content focused on the topics of earth and space science, life science, and physical science. During the first class session, the participants were administered an instrument titled "Use of Science Concepts". For the practical application part of the program, the participants engaged in a series of 6-7 hands-on science-based STEM activities.

Given that the participants were all in an early childhood preservice teacher education program, the focus of the class activities was on activities that could be used with either preschoolers or kindergartners. However, during the class sessions, the PST's also developed their STEM activities that would be appropriate for teaching young children in preschool or kindergarten. Each of the preservice teachers developed a total of 19 different STEM activities. Of these, six were based on earth and space science, seven were on topics related to life science, and the last six activities centred on physical science. Video recordings of the students demonstrating the activities were subsequently analyzed to identify how they had interpreted and applied different science or STEM-related concepts.

Data Analyses

In this research, the extent to which preservice teachers were able to specify different science concepts was identified based on their responses to the "Use of Science Concepts" instrument. This instrument allowed the researchers to identify the concepts that the PST's were able to identify concerning each overarching theme. Then, the concepts noted by each PST were used as codes in analyzing the video recordings of the science-based STEM activities. For example, if a PST had written "earthquake", "soil", "sun", etc., in response to the prompt "natural phenomena", these were then used as codes in analyzing the activity plans and video recordings. This approach allowed the researchers to determine the extent to which the PST's had applied the concepts in each of the 19 activities. Then, by using both pre and post data from the use of concepts instruments, changes in the extent to which the PST's understood and applied the various concepts could be determined.

Results

The current study sought to document changes in PST's knowledge and application of STEM/science-based concepts. First, the participants' various terms identified in the pre and post-tests were organized around relevant themes, sub-themes, and concepts. These are reported in a series of tables. Also included in the tables are the total number of times the concepts had been identified and the number of times the related codes were applied when analyzing the participant's activity plans. In addition, six randomly selected activities from the application videos are shared under each theme to illustrate how the relevant concepts and terms were used. These results are organized around several overarching concepts, including earth and space science, life science, and physical science.

Theme 1. Earth and Space Science

Conceptual changes in preservice preschool teachers towards STEM-based science education to teach the theme of Earth and Space Science are reported in Table 1.

Table 1

Conceptual Changes of Pre-service Teachers on the Theme of Earth and Space Science

Theme	Sub-Themes	Pre-Test			Post-Test		
		Science Concepts	**Codes**	**f**	**Science Concepts**	**Codes**	**f**
Theme 1. Earth and Space Science	**Natural Phenomena**	Earthquake (10), Soil (9), Volcano Eruption (8), Tsunami (6), Erosion (5), Flood (4), Hair Dryer (3), Landslide (3), Plants (2), Earth (2), Sun (2), Landslide (2), First aid kit (2), Wind (2), Shake (2), Water (2), Earth (2).	**17**	**66**	Landslide (9), Rocking (7), Water (7), Volcano and Volcano eruption (6), Protection of Soil and Soil (5), Erosion (4), Flood (4), Earthquake (3), Lava (3)), Hose (3), Tree and Afforestation (2), Fire (2), Importance of Plant Growing (2), Wave (2), Sea (2), Natural Disaster (2), Sky (2), First Aid Kit (2), Sand (2), Sugar Cube (2), Temperature (2), Exercise (2), Life Triangle (2).	**23**	**77**
	The Planets	Sun (15), Moon (11), Stars (11), Earth (9), Space (8), Astronaut (3), Names of Planets (2), Spacecraft (2), Space Shuttle (2), Mars (2).	**11**	**65**	Sun (11), Earth (10), Planets (9), Space (8), Stars (8), Astronaut (6), Moon (4), Jupiter (4), Rocket (4), Spacecraft (4) , Sky (2), Venus (2), Mars (2), Light Sources (2), Solar System (2).	**16**	**78**
	Weather Phenomena	Wind (11), Rain (11), Snow (10), Cloud (4), Storm (4), Cold (4), Water (4), Hot (3), Steam (2), Hairdryer (2) The Sky (2), The Snowman (2), The Umbrella (2).	**13**	**61**	Rain (11), Snow (9), Sun (7), Cloud (6), Wind (6), Storm (5), Steam (4), Hair Dryer (3), Weather (3), Water (3) , Full (2), Weather (2), Partly cloudy (2), Boralies (2), Fog (2), Cold-hot (2), Umbrella (2).	**17**	**71**
	Stone and Soil	Sand (8), Pebble (7), Rocks (6), Red Soil (5), Clay (5), Brown Soil (4), Soil (4), Growing of Plants (2), Different kinds of stones (2) .	**9**	**43**	Soil and soil types (10), Pebble (9), Stone (8), Sand (5), Rock (4), Red soil (4), Sea shell (3), Clay (3), Hard-soft stones (3), Abrasion (2), Hot-Cold (2), Large-small (2), Desert (2), Limestone (2), Fragmentation (2), Rough-smooth (2), Colored stones (2).	**17**	**65**
	Gravity	Falling(12), Magnet(4), Gravity of Earth(4), Flying(3), Earth(2), Apple(2), Air(2), Ball throw(2), Space(2).	**10**	**33**	Falling (9), Magnet (6), Gravity (5), Space (4), Force (3), Weight (2), Earth (2), Force (2), Airspace (2), Newton (2), Flying (2), Ground (2), Gravity (2), Jumping (2), Astronaut suits (2), Balloon (2), Feather(2), Stone(2).	**18**	**52**
	Day-Night Cycle	Light-Dark (23), Sun (11), Moon (8), Earth (6), Light (6), Night-Day (5), Stars (4), Evening (2), Shadow (2), Sight (2), Getting up (2), Sleeping (2).	**12**	**72**	Light-Dark (18), Night-Day (14), Sun (12), Moon (8), Earth (7), Stars (5), Day (3), Light and light sources (3), Evening (2), Flashlight (2), Breakfast (2), Time (2), Morning (2), Sleep (2), Orbit (2).	**15**	**84**

Table 1 shows the PST's conceptual changes for six different sub-themes related to the theme of earth and space science. It is evident that 'earthquake' (10) was initially the most commonly used concept for the sub-theme, natural phenomena. However, most participants identified the concept 'landslide' (9) after completing the classroom activities. Then, for the sub-theme, planets, the most commonly identified concept was 'the sun' (15). There was, however, no pre- to post-test change for this concept. For the sub-theme, weather phenomena, the most commonly used concepts were 'wind' (11) and 'rain' (11), with "rain" also being the most commonly identified concept after completing the classroom activities. Then, when considering the sub-theme of stone and soil, the concept 'sand' (8) was initially

identified, while "soil and soil types" was the most common concepts at the post-test stage (10). For the sub-theme, gravity, the PST's identified the concept 'to fall' (12) both before and after (9) completing the class activities. Finally, when considering the sub-theme, the day-night cycle, the concept of 'light-dark (23) was most frequently identified.

The PST's earth and space activity plans were analyzed using the previously identified codes. A total of 120 activity plans were examined, and the findings are reported in Table 2. As shown in Table 2, most of the PST's activity plans were centred around two overarching concepts: 'the sun' (93.5%) and 'light & dark' (74.19%).

A sample of videos of the PST's teaching the planned activities was also examined. This in-depth analysis allowed the researchers to document how the PST's used the concepts and vocabulary (see Tables 1 & 2) when teaching activates concerning the theme of earth and space. Natural Phenomena Activity: The children and the practice teacher go to the school's sandbox and start to make a mountain by bringing the sand together.

> PT8: Kids, now everyone will make a mountain with their group. Let's start.
> PT8: Guys, let's plant these branches in the mountains we have built.
> C1: Miss, why are we planting branches?
> PT8: Let these branches be the trees on your mountain.
> C5: Miss, can I put leaves in the tree?
> C7: Miss, can I put flowers?
> PT8: You can decorate with any material you want, but I want you to decorate only one side. On the other side, there should be no trees, flowers or grass because we will use these two parts for the next experiment... (PT8 - Natural Phenomena Activity Video).

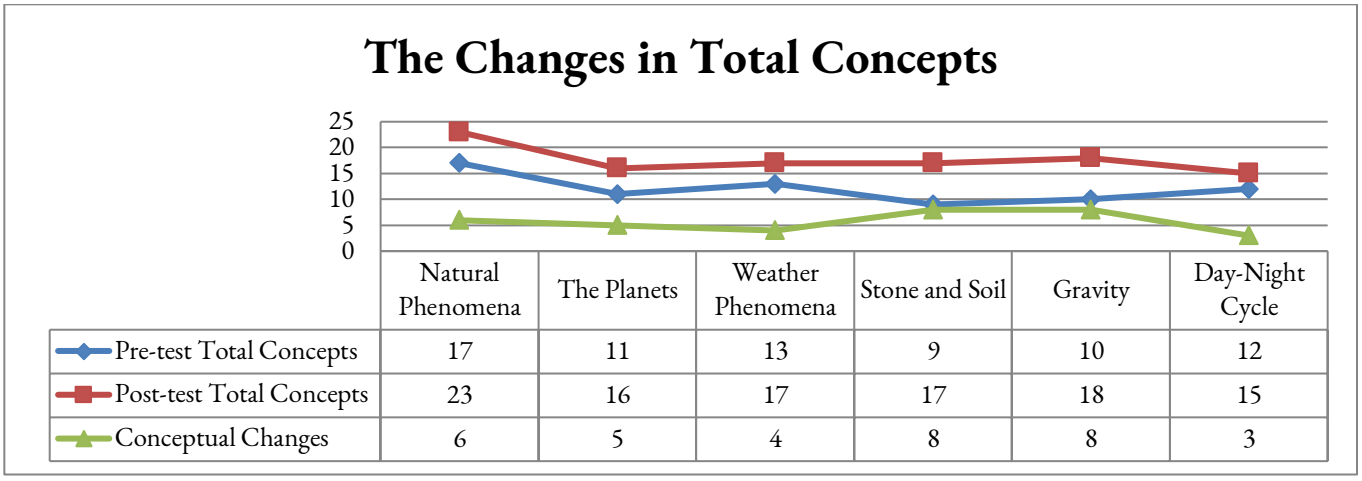
Here, the teacher tells the children about erosion and landslides and then asks them to observe what kind of landslide occurs after the rain in the mountains they have built. Children are asked open-ended questions and the reasons for their answers. In addition, it is seen that the teacher used some concepts and words related to the sub-theme, 'natural phenomena', mentioned in Table 1 during the education process.

Weather Phenomena Activity: Children sit in U shape in the classroom.

> PT3: What is the wind?
> C4: Miss, the wind is the air.
> C7: Miss, the wind shakes the branches of the trees.
> PT3: When does the wind come out? How do tree branches move when the wind blows? How does the wind whistle?
> C5: When it gets cold.
> C13: In the evening...
> PT3: Have you ever seen a windmill?
> All Children: Noooo!.
> PT3: Let's make a windmill together now. Then let's examine how they move outside (PT3 - Weather Phenomena Activity Video).

At the end of the activity, the children observe the windmills outside and talk about the effect of the wind on other objects. Here, it was found that the teacher also mentioned several concepts and words on the theme of 'weather phenomena'.

Detailed analysis of the changes in the total concepts and codes in Table 1 is given in Figure 2 and Figure 3.

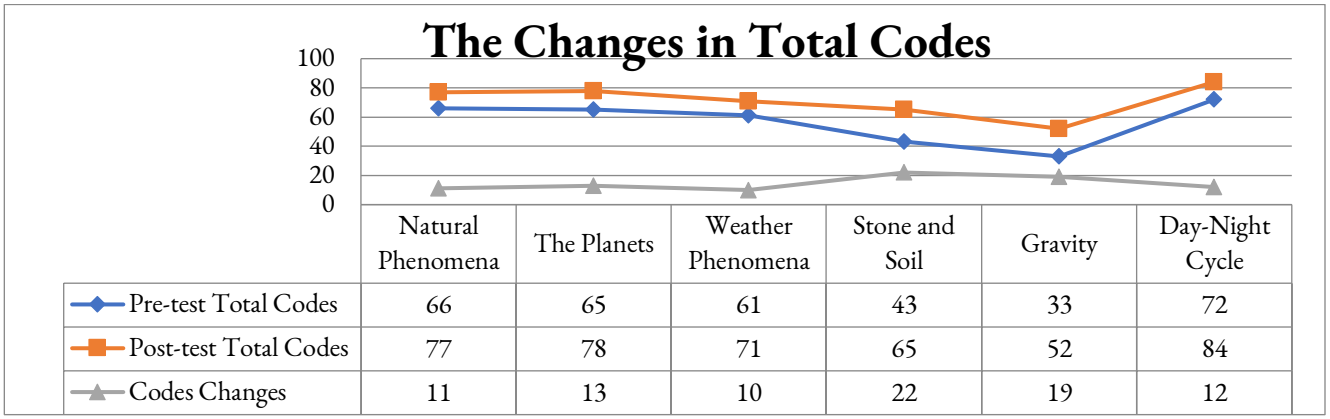


	Natural Phenomena	The Planets	Weather Phenomena	Stone and Soil	Gravity	Day-Night Cycle
Pre-test Total Concepts	17	11	13	9	10	12
Post-test Total Concepts	23	16	17	17	18	15
Conceptual Changes	6	5	4	8	8	3

Figure 2

Pre-test and Post-test Results of Teacher Candidates' Conceptual Changes Related to Earth and Space Science Theme

The science-related conceptual changes in preservice teachers towards the theme of earth and space science are shown in Figure 2. In Figure 2, when the conceptual changes regarding the theme of earth and space science are examined, it is observed that the most changes occur in the sub-themes of gravity (8) and stone and soil (8), while minor changes occur in the sub-theme of the day-night cycle (3).



	Natural Phenomena	The Planets	Weather Phenomena	Stone and Soil	Gravity	Day-Night Cycle
Pre-test Total Codes	66	65	61	43	33	72
Post-test Total Codes	77	78	71	65	52	84
Codes Changes	11	13	10	22	19	12

Figure 3

Pre-test and Post-test Results of Pre-service Teachers' Codes Changes Related to of Earth and Space Science Theme

The changes in total code that occurred in the preservice teachers regarding the theme of earth and space science are illustrated in Figure 3. The figure shows that for the sub-theme of earth and space science, the most changes in total code occurred in the sub-theme of stones and soil (22), while the least changes occurred about weather phenomena (10) and natural phenomena (11). In general, the data analyses suggested that the STEM-based science activities positively affected the PST's understanding of the theme of earth and space science.

Theme 2. Life Science

The PST's conceptual changes that relate to the overarching theme of life science are reported in Table 3.

Table 3

Conceptual Changes of Pre-service Teachers on the Theme of Life Science

Theme	Sub-Themes	Pre-Test			Post-Test		
		Science Concepts	Codes	f	Science Concepts	Codes	f
Theme 2. Life Science	Food Chain	Nutrition of people (9), Plants (4), Animal nutrition (4), Animals (4), Meat (3), Carnivorous (3), Healthy nutrition (3), Water (3), Cow (2), Fruit (2), Herb (2), Herbivorous (2), Milk (2),	13	43	Feeding of humans (5), Herbivores (5), Animals (4), Snake-mouse (4), Lion (3), Food types (3), Plants (3), Cow-bait (3), Food (3) , Grasshopper-leaf (2), Natural events (2), Meat eaters (2), Mouse-cheese (2), Tiger (2), Goat-grass (2), Life (2).	16	47
	Animals	Land inhabitants (10), Floating animals (6), Air inhabitants (5), Water inhabitants (5), Floating animals (4), Fish (3), Sea inhabitants (3), Pets (3), Birds (3)), Creatures (2), Animal kingdom (2), Dog (2), Reptiles (2).	13	50	Land inhabitants (9), Aquatic inhabitants (6), Fish (5), Airborne animals (5), Marine inhabitants (4), Animals' habitats (4), Flying animals (4), Pets (3), Birds (3), Creatures (2), Hazelnut (2), Animal nutrition (2), Mammals (2), Forest animals (2), Reptiles (2), Animals living under the ground (2), Eggs (2) .	17	59
	Plants	Flowers (11), Plant growing (10), Fruits (9), Trees (6), Vegetables (6), Seeds (6), Thorns (2), Photosynthesis (2), Sun-water benefit to plants (2), Colors (2).	10	58	Plants (11), Trees (10), Fruits (9), Flowers (8), Seeds (6), Thorn (5), Vegetables (5), Germination (4), Water (4), Leaves (3), Photosynthesis (2), Sun (2), Soil (2), Foliage (2).	14	73
	Living and Non-Living Beings	Living Beings (5), Moving-immobile (5), People (5), Breathing (5), Animals (4), Nutrition (3), Plants (3), Traveling (3), Life (3), Food (3), Growth (2), Speaking and non-speaking (2).	12	43	Living and inanimate (13), Breathing (9), Movement (7), Animals (7), Plants (5), People (5), Feeding (4), Growing (4), Table (3), Dying (3), Pen (2), Speaking (2), Respiration (2), Stone (2).	15	68
	Body Organs and Functioning	Lung (5), Vision and eye (5), Heart and heartbeat (5), Vessels (3), Circulatory system (3), Sensory organs (3), Digestive system (3), Mouth (2), Urinary system (2), Nose (2), Bean-Kidney like metaphors (2), Health (2), Walking (2).	13	36	Eyes and eyes (8), Heart (8), Lung (6), Respiratory system (4), Brain (3), Touch (3), Hearing (3), Stomach (3), Organ pictures (3), Tasting (3), Intestines (2), Nose (2), Movement of joints (2), Function of the ear (2), Breathing (2).	17	55
	Different Habitats	Sea creatures (7), Forest and forest creatures (7), Cities (5), Homes (4), On land (4), Living (4), Village / town (3), Lake creatures (3), Water inhabitants (3), Creatures (2), Sky (2), Airborne inhabitants (2), School (2), Earth (2).	14	48	Animal habitat (6), Humans and habitat (6), Land inhabitants (5), Plants habitat (4), Water inhabitants (4), Sea creatures (3), Pets (3), Fish (2) , Living in the air (2), Birds' habitat (2), Forest (2), Soils (2), Living space (2).	14	44
	Different Senses	Touching (7), Seeing (5), Sniffing (5), Bitter-sweet-sour (4), Sour (4), Smell Experiments (4), Tongue (3), Sweet-salty (3), Tasting (3), Salted (3), Soft-hard (3), Friends Recognition Experiments (2), Spices (2), Nose (2), Objects in Various Tissues (2), Skin (2), Ear (2) , Fruit (tasting) (2), Hard (2), Sound (hearing) (2), Taste Tests (2).	19	62	Sour (9), Bitter (7), Sniffing-nose (7), Taste (7), Dessert (7), Salty (6), Touching (4) Seeing (4), Nose (3), Tongue (3)), Hearing-ear (3), Smell (3), Hard objects (for touch) (3), Sweet foods (3), Soft and hard tissues (3), Mouth (2), Sour food (2), Hand (2), Thin (2), Ear (2).	21	84

The most common concept for the sub-theme of the food chain was 'nutrition of people' (9), while 'nutrition of people' (5) and 'herbivores' (5) were the most commonly used concepts after the activities. When the sub-theme of animals was examined, the most commonly used concept was 'terrestrial animals' (10), which remained the same (11) after the activities. When the responses to the sub-theme of plants were observed, the most commonly used concept was initially stated as 'flower' (11), but later it turned out to be "plants" (11) after the activities. The most emphasized concept for the sub-theme of living and non-living beings was 'living beings' (5), but later it turned out to be "living and non-living beings" (13). In terms of the sub-theme of body organs and functioning, the most frequently mentioned concept by preservice teachers was initially "lung" (5), but later it turned out to be "vision and eye" (8). When the responses to the sub-theme of different habitats were examined, the most commonly used concept was initially stated as 'living organisms living in the sea' (7), but later it turned out to be 'habitat of animals' (6). Finally, the responses to the sub-theme of different senses revealed that the most commonly used concept was 'tactility' (7), but it turned out to be 'sour' (9).

Table 4

The Concepts in the Learning Plans of the Pre-service Teachers' About the Theme of Life Science

Theme	Codes	f	%
Theme 2. Life Science	Bitter-Sweet-Sour	23	60.53
	See	19	50.00
	Fruits	19	50.00
	Trees	18	47.37
	Sniffing	17	44.74
	Flowers	15	39.47
	Land Lives	15	39.47
	Heart	13	34.21
	Animals	12	31.58
	Seeds	12	31.58
	People	11	28.95
	Plant Growing	10	26.32
	Moving-Nonmoving	9	23.68
	Aquatic Inhabitants	9	23.68
	Living Things	7	18.42
	Taste	7	18.42
	Dessert	7	18.42
	Lungs	6	15.79
	Vegetation	6	15.79
	Animals' Habitat	6	15.79
	Vegetables	6	15.79
	Salty	6	15.79
	Living in the Air	5	13.16
	Breathing	5	13.16
	Habitat of Plants	4	10.53
	Touching	4	10.53
	The Respiratory System	4	10.53
	Food Types	3	7.89
	Nutrition	3	7.89
	Veins	3	7.89
	Sea Creatures	3	7.89
	The Circulatory System	3	7.89
	Our Sensory Organs	3	7.89
	Meat	3	7.89
	Carnivorous	3	7.89
	Pets	3	7.89
	Birds	3	7.89
	Healthy Eating	3	7.89

One hundred and forty activity plans prepared by preservice teachers for the theme of life science were examined with the thematic coding method, and the results are shown in Table 4. Table 4 demonstrates that the most common concept used by preservice teachers was 'bitter, sweet and sour (60.53%) at first, but later it turned out to be 'to see' (50.00%) and 'fruits' (50.00%). When these findings were compared with Table 3, it was thought that the preservice teachers paid more attention to "bitter, sweet and sour" concepts because they frequently used these concepts in the sub-themes of different senses. In addition, this situation helped ensure the validity of the concepts written in the science concepts form.

The randomly chosen activity videos of the preservice teachers about the theme of life science were examined, according to which the examples of how the concepts and vocabulary were used in Tables 3 and 4 are given below.

Activity on Plants:

PT12: Guys, can you tell me what plants you see around you?
C1: Flowers
C2: Roses
C7: Red roses
C11: Violets
PT12: OK, where do you think they grow?
C3: In the garden.
C6: In the forest
C5: In the soil
PT12: Now, everyone, some plants also grow in pots. I brought you some plant seeds and some soil today. Everyone will grow them in their pots... (PT12 - Plants Activity Video).

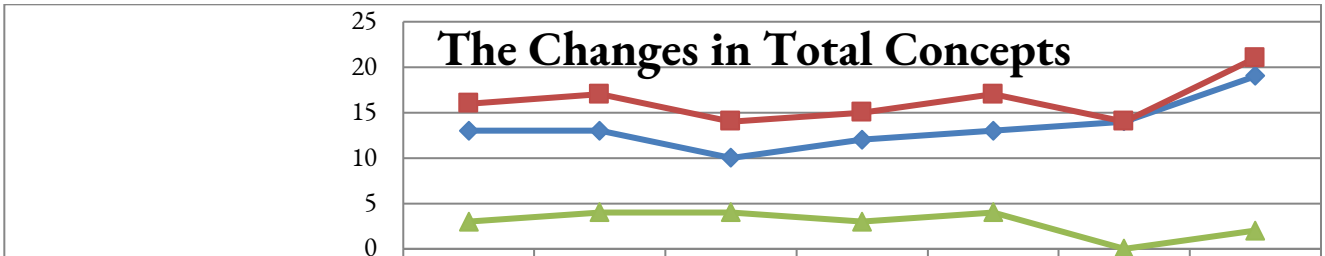
Here, the teacher makes the planting science activity after getting the preliminary information about the plants from the children. Here, chatting with children about plants will help them develop their skills in growing plants. Furthermore, when the concepts and vocabulary used are examined, it is seen that those mentioned in the theme of plants are used.

Different Habitats Activity: Children sit U-shaped, and the teacher chats with children asking questions.

PT8: Kids, where do people live?
C3: At homes
C5: In villages
C11: In apartments
PT8: OK, everyone, where do animals live?
C4: In the forest, but some live in the sea.
PT8: So, why do you think they want to live here?
C7: Because the forest is beautiful. Our house is in the woods as well.
C8: I went swimming once. Maybe they like to swim in the sea.
PT8: So, where do you think worms live?
C9: Under the ground.
PT8: Well done. It is great. How would you like it if you wanted to create a new living space for yourself? ... (PT8 - Different Habitats Activity Video).

In the first part of the activity, the preservice teachers help the children participate in the lesson by asking them the questions included in the activity plan to attract their attention to different habitats. In addition, the preservice teachers reinforce children's pre-knowledge by asking them open-ended questions about the living spaces that children will prepare. Here, it is observed that some concepts and vocabulary, which have been previously covered in the sub-theme of Different Habitats, are also mentioned.

Detailed analysis of the changes that occurred in the total concepts and codes in Table 3 is given in Figure 4 and Figure 5.

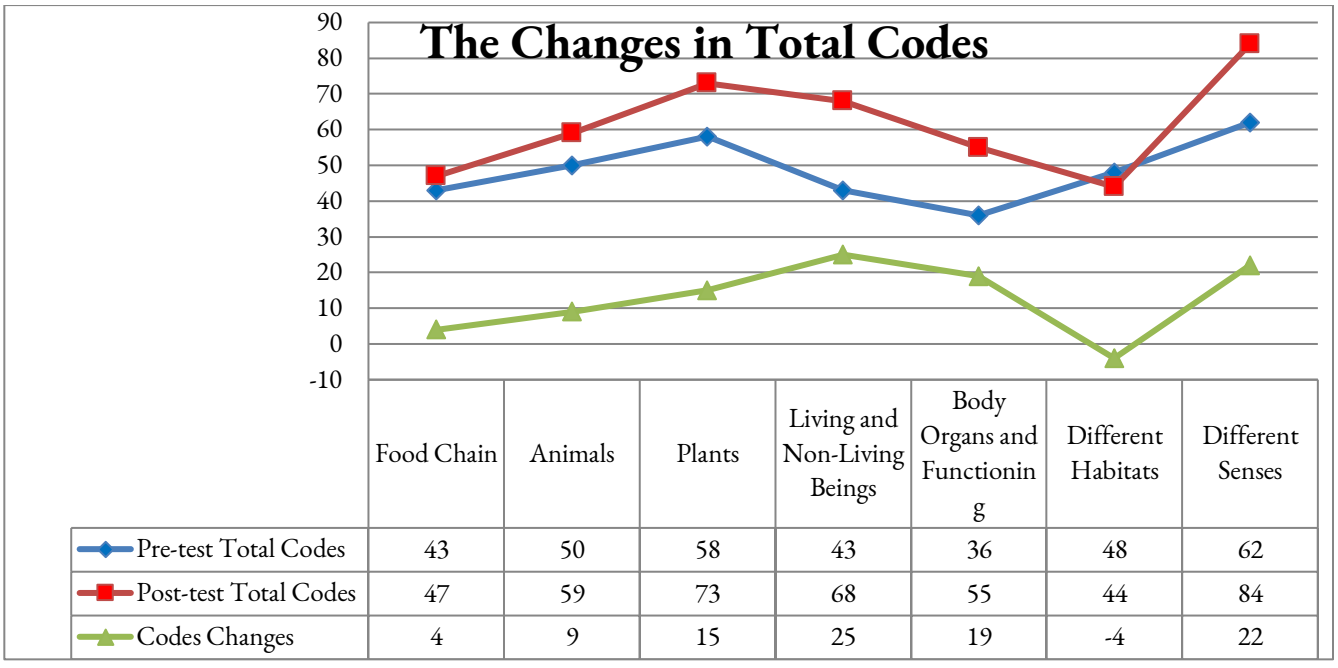


	Food Chain	Animals	Plants	Living and Non-Living Beings	Body Organs and Functioning	Different Habitats	Different Senses
Pre-test Total Concepts	13	13	10	12	13	14	19
Post-test Total Concepts	16	17	14	15	17	14	21
Conceptual Changes	3	4	4	3	4	0	2

Figure 4

Pre-test and Post-test Results of Pre-service Teachers' Conceptual Changes Related to Life Science Theme

The conceptual changes that occurred in the preservice teachers towards Life Science are shown in Figure 4. Figure 4 reveals that there is not much change in the sub-themes when the conceptual changes in the preservice teachers regarding the theme of life science are examined. Looking at the figure, the most commonly used concepts are in the sub-themes of animals (4), plants (4), and body organs and functioning (4), while the least common is in the sub-theme of different senses (2). Interestingly, it is also observed that while conceptual changes do not change numerically in the sub-theme of different habitats (0), different concepts are observed to emerge.



	Food Chain	Animals	Plants	Living and Non-Living Beings	Body Organs and Functioning	Different Habitats	Different Senses
Pre-test Total Codes	43	50	58	43	36	48	62
Post-test Total Codes	47	59	73	68	55	44	84
Codes Changes	4	9	15	25	19	-4	22

Figure 5

Pre-test and Post-test Results of Pre-service Teachers' Codes Changes Related to Life Science Theme

Total code changes in the preservice teachers regarding the theme of life science are given in Figure 5. When the total code changes for the theme of life science is examined, it is observed that the most changes occurred in the sub-theme of living and non-living beings (25), and the minor change is observed in different habitats (-4). In general, it was determined in the light of data analysis that STEM-based science activities positively affected preservice teachers regarding the theme of life science. However, as a surprising result, it was observed that the conceptual changes that occurred in preservice teachers did not change numerically in the sub-theme of different habitats. This situation is thought to be due to the fact that preservice teachers do not have sufficient knowledge on this subject.

Theme 3. Physical Science

Table 5 presents the science content knowledge of preservice preschool teachers for six different sub-themes related to the Physical Science theme.

Table 5

Conceptual Changes of Pre-service Teachers on the Theme of Physical Science

Theme	Sub-Themes	Pre-Test			Post-Test		
		Science Concepts	Codes	f	Science Concepts	Codes	f
Theme 3. Physical Science	States of Matter	Gas (7), Solid (7), Liquid (7), Water (6), Evaporation (5), Ice (5), Hardness-softness (4), Stone (3), Viscosity (2), Freezing (2) Melting (2), Weather Events (2), Condensation (2).	16	57	Liquid objects (11), Water (11), Vapor-Evaporation (8), Solid (8), Ice (6), Hard materials (4), Freezing (3), Gas (3), Balloon (2), Natural gas (2), Melting (2), Air (2), Snowflake (2), Boiling (2), Softness (2).	29	60
	Shape of Matter	Heavy-Light(14), Cold-Warm(9), Color(8), Long-Short(8), Geometric shapes(5), Soft-Hard(4), Step(2), Straight(2), Rough –smooth(2), Length(2).	10	56	Heavy-Light (14), Cold-Hot (9), Color (8), Long-Short (8), Geometric shapes (5), Soft-Hard (4), Step (2), Flat (2), Rough - Smooth (2), Length (2) Thick-Thin (2), Height (2), Heat (2) Thermometer (2).	14	62
	Light and Shadow	Flashlight (14), Sun (11), Shadow (10), Darkness (7), Moon (4), Light (4), Day and night (4), Light (4), Lamp (2), Lunchtime (2)	10	62	Light-light sources (12), Shadow (11), Daylight (9), Flashlight (5), Light (4), Darkness (3), Transparency (3), Long-Short (3), Moon (2) , Daylight (2), Lamp (2), Transparent paper (2).	12	58
	Force, Motion, and Balance	Weight (7), Balance Board (7), Strong-Weak (5), Running (5), Scales (3), Jumping (3), Pull-Push (2), Lightness (2), Moving-Still (2)), Fast-slow (2), Strong (2).	11	40	Pushing (9), Pulling (8), Moving-Still (7), Power (6), Balance board (4), Weight (3), Rope (3), Force (3), Seesaw (3), Scales (3), Standing objects (2), Fall (2), Stand on one leg (2), Height (2).	14	57
	Blocks, Magnets and Simple Machines	Magnet (5), Gravity (4), Building (4), Wooden Blocks (3), Pull-Push (3), Reel (3), Catapult (3), Electric Current (2), Thrust (2) , Legos (2).	10	46	Magnet (9), Pull-push (7), Gravity (5), Blocks (4), Building (4), Metal and non-metal objects (4), Catapult (3), Contrast (3), Similarity (2), Iron (2), Motion (2), Pole (2), Magnets (2), Board (2), Seesaw (2), Scales (2).	16	55
	Kitchen Activities	Making Dough (13), Making Cakes (7), Making Cookies (6), Ice Cream Making (5), Dish Washing (4), Pickle Making (4), Yoghurt Ferment (4), Cooking (2), Milk (2)), Dessert (2), Cleaning (2), Flour (2), Kneading (2).	13	55	Making cookies (6), Flour (6), Dough kneading (5), Popcorn (5), Ice cream (4), Cake making (4), Fruit (4), Yoghurt making (3), Dish-washing (2) , Baking powder (2), Mixing (2), Fermentation (2), Cheese fermentation (2), Baking (2), Pudding (2), Temperature (2), Sugar (2), Pickles (2), Vanilla (2), Cooking (2).	20	61

When Table 5 is examined, the most commonly used concepts for the sub-theme of states of matter are 'gas' (7), 'solid' (7) and 'liquid' (7), whereas they turned out to be 'liquid objects' (11) and 'water' (11) after the activities. When the sub-theme of the shape of the matter was examined, the most commonly used concept was observed as 'heavy-light (14), and later it turned out to be 'hot-cold (12). When the sub-theme of light and shadow was considered, the most commonly used concept or word was stated as 'torch' (14), but later it turned out to be light and light sources (12). The most emphasized concepts or words related to the sub-theme of force, motion, the balance were noted as 'weight' (7) and 'balance board' (7), but later it turned out to be 'pushing' (9). For the sub-theme of blocks, magnets and simple machines, preservice teachers stated that the concept or word they referred to most was 'magnet' (5), and it later remained the same (9). Finally, when the answers given to the sub-theme of kitchen activities were examined, the most commonly used concept or term was 'making dough' (13), but later turned out to be 'making cookies' (6) and 'flour' (6).

Table 6

Concepts Used in the Learning Plans of the Pre-service Teachers About the Theme of Physical Science

Theme	Codes	f	%
Theme 3. Physical Science	Heavy-Light	25	64.10
	Pull-Push	20	51.28
	Shadow	20	51.28
	Cold Hot	20	51.28
	Making Dough	18	46.15
	Long Short	16	41.03
	Solid	15	38.46
	Soft-Hard	13	33.33
	Light-Light Sources	12	30.77
	Sun	11	28.21
	Weight	10	25.64
	Ice	10	25.64
	Balance Board	10	25.64
	Gas	10	25.64
	Cake Making	10	25.64
	Day	9	23.08
	Color	8	20.51
	Movable - Stationary	7	17.95
	Dark	7	17.95
	Liquid	7	17.95
	Power	6	15.38
	Making Cookies	6	15.38
	That	6	15.38
	Fame	6	15.38
	Evaporation	5	12.82
	Ice Cream Making	5	12.82
	Geometrical Shapes	5	12.82
	Magnet	5	12.82
	Popcorn	5	12.82
	Moon	4	10.26
	Bright	4	10.26
	Washing Dishes	4	10.26
	Gravitational Force	4	10.26
	Ice Cream	4	10.26
	Build	4	10.26
	Wood Blocks	3	7.69
	Freezing	3	7.69
	Mixing	2	5.13
	Leavening	2	5.13

Prepared by preservice teachers for the theme of physical science, 120 activity plans were examined with a thematic coding method, and the findings are shown in Table 6. The table reveals that the most used concepts were 'heavy-light (64.10%), then 'pull-push (51.28%), 'shadow' (51.28%) and 'cold-hot (51.28%), respectively. When these findings were compared with the findings in Table 5, it was observed that the reason why the preservice teachers included the most commonly used concepts in different sub-themes as well (states of matter, force, motion and balance, blocks, magnets and simple machines) was that such concepts were the most encountered ones in the activities.

By examining the selected activity application videos of the preservice teachers about the theme of physical science, the examples of how the concepts and vocabulary in Table 5 were used are given below.

Light and Shadow Activity: "Children are in the school garden in sunny weather with their backs to the sun.

PT12: “Guys, what do you think is on the floor now?
C5: Our shadows, Miss.
C3: Miss, it always follows me.
PT12: Yes, guys, that is our shadow. Is everyone's shadow the same?

C3: Yesss!
C4: Nooo!
PT12: So why do you think everyone's shadow is different or the same?
C8: Miss, I am a girl, and my shadow is like a girl. A boy's shadow is like a boy.
C13: Miss, my shadow's hair and Ayşen's shadow are different. There are circles in her shadow. (PT12 - Light and Shadow Activity Video).

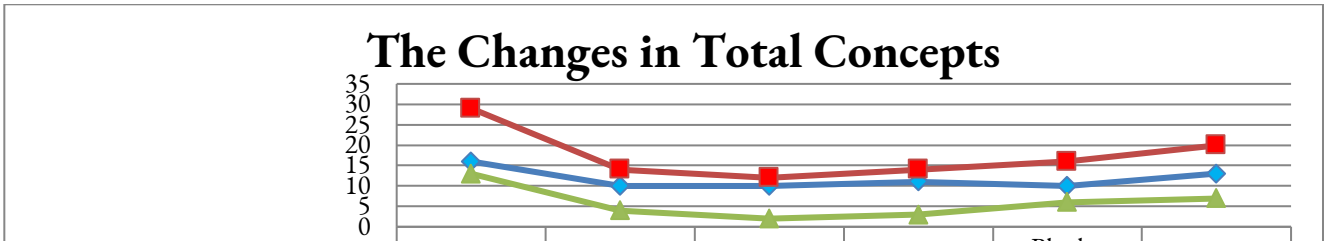
Here, it is thought that the preservice teachers' organizing a garden activity with children on the theme of light and shadow and practising the children's views on this theme will increase the efficiency of the activity. In addition, it is observed in the application videos that the preservice teachers mentioned some concepts and words under this theme.

Force, Motion and Balance Activity:

"PT19: Guys, what do you think it takes to move the ball?
C8: We need to hit the ball.
C12: We need wind.
PT19: So, guys, how does the ball move? Can we move balls and other objects by applying force or pushing and pulling?
C3: Miss, balls roll.
C1: Miss, balls spin.
C5: We need to push them, teacher.
PT19: Do you think the situation is the same when riding a bicycle? What do we need when pedalling the bicycle?
C7:We need to push them, Miss.
C2: We need to apply force, Miss. We cannot go unless we step on the pedal." (PT19: Force, Motion and Balance Activity Video).

The preservice teacher comes to the classroom with a ball in hand and gets the preliminary information about the sub-themes 'force, motion and balance' from the children; they carry out the push and pull forces experiment with moving objects (toy car, 3-wheel bike). The children are then asked to make wheeled vehicles using bottle caps, and a race is held using the pushing force of the balloon. Here, it is seen that the preservice teachers mentioned different concepts and vocabulary seen in Table 5 during the application and experiment process.

Detailed analysis of the changes that occurred in the total concepts and codes in Table 5 is given in Figure 6 and Figure 7.

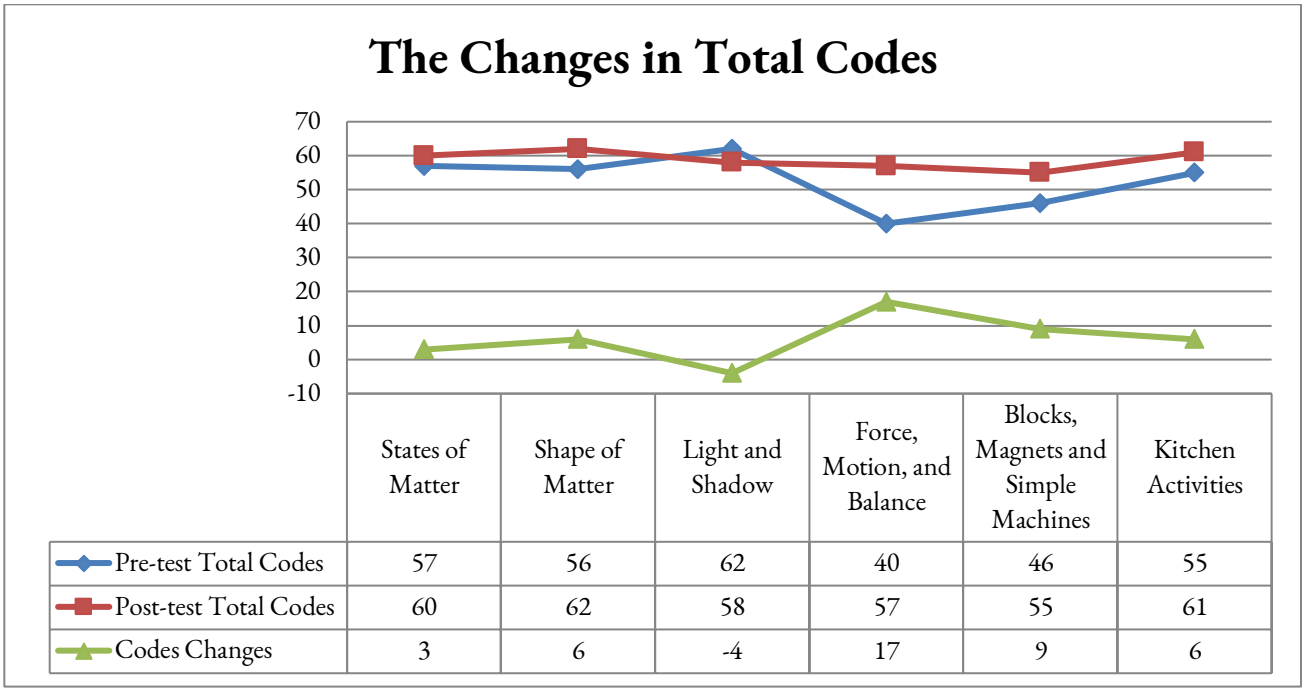


	States of Matter	Shape of Matter	Light and Shadow	Force, Motion, and Balance	Blocks, Magnets and Simple Machines	Kitchen Activities
Pre-test Total Concepts	16	10	10	11	10	13
Post-test Total Concepts	29	14	12	14	16	20
Conceptual Changes	13	4	2	3	6	7

Figure 6

Pre-test and Post-test Results of the Pre-service Teachers' Conceptual Changes Related to Physical Science Theme

The changes in the science content knowledge of the preservice teachers towards the theme of physical science are shown in Figure 6. The figure shows that when the conceptual changes regarding the theme of physical science are examined, it is observed that the most numerical change occurs in the sub-theme of the states of matter (13), whereas the least is observed in the sub-theme of light and shadow (2).



	States of Matter	Shape of Matter	Light and Shadow	Force, Motion, and Balance	Blocks, Magnets and Simple Machines	Kitchen Activities
Pre-test Total Codes	57	56	62	40	46	55
Post-test Total Codes	60	62	58	57	55	61
Codes Changes	3	6	-4	17	9	6

Figure 7

Pre-test and Post-test Results of the Total Code Changes for the Pre-service Teachers' Physical Science Theme

Total code changes in the preservice teachers regarding the theme of Physical Science are given in Figure 7. When the total code changes for the theme of physical science are examined in the figure, it is observed that the most change occurred in the sub-theme of force, motion and balance (17), whereas the minor change occurred in the sub-theme of light and shadow (-4). In general, it was found that STEM-based science activities positively affected preservice teachers regarding their understanding of the theme of physical science in the light of data analysis.

Discussion

The study revealed that STEM-based science activities conducted by preservice preschool teachers had a positive effect on their understanding of the science concepts. The findings of the study are discussed below.

Conceptual Changes in Science Concepts

In particular, preschool children should be taught many scientific concepts such as science, mathematics, technology, and engineering (Ayvacı, 2010). Therefore, researchers emphasize that STEM-based education should start early (Allen, 2016; Torres-Crospe, Kraatz & Pallansch, 2014). This study used the STEM-based science education model to develop themselves to work with preschool children towards science concepts. The study's findings revealed an increase in the science content knowledge of the preservice teachers regarding science concepts through the use of a STEM model.

Similarly, Carrier (2013) observed that science education course made a significant difference in the post-test results of preservice elementary teachers. The author stated that the main reason for the significant difference in the scientific vocabulary used by preservice teachers stems from the applications from which the preservice teachers try to use the words and suggest that there should be applications for science education courses. In another study, Santau, Maerten-Rivera, Bovis, and Orend (2014) emphasized that science concepts can be developed in preservice teachers using the 5E Teaching Model in science education. In addition, Pecore, Kirchgessner and Carruth (2013) conducted zoo-based science training with preservice teachers during the science education course and found that preservice science teachers' knowledge of science concepts developed, but no positive attitude towards science was formed. Similarly, in this study, it was found that STEM-based science education preparation and application processes carried out by preservice teachers create conceptual changes towards science concepts.

Rowe and Goldin-Meadow (2009) stated that vocabulary knowledge is an essential factor for school success, while weak vocabulary also adversely affects science teaching (Harmon, Hedrick, & Wood, 2005). In addition, Fisher and Frey (2014) stated that science vocabulary is necessary for children to understand science and scientific processes.

Nonetheless, interpreting the concepts of science will improve people's decision-making skills (Carrier, 2013). There appear apparent differences between the concepts stated by preservice teachers in pre-tests and post-tests through STEM-based science activities can be regarded as a significant factor to improve the science content knowledge of preservice science teachers. In addition, the event that a concept can be used in different areas, i.e. the concept of 'sun' used in sub-themes such as planets, light and shadow, day and night cycle, shows how preservice teachers have mastered this concept. This will only occur through the support of applied science education.

Many other studies have indicated that conceptual changes in science concepts increase in parallel with the learning levels of preservice teachers (Ültay & Ültay, 2009; Ünal, Çalık, Ayas, & Coll, 2006). So much so that teachers generally do not feel sufficient in terms of science concepts, and they, therefore, spend less time in science education (Adamson, Santau, & Lee, 2013; Griffith & Scharmann, 2008; McMurrer, 2008; Trygstad, 2013), and as a result, children's capability to develop the understanding of science concepts was negatively affected (Nilsson& Van Driel, 2010). This study found that the science content knowledge of preservice teachers could be improved with STEM-based science activities. Similarly, it can also be assumed that preschool teachers can help develop science concepts in children by including STEM-based science activities in their classrooms.

Conceptual changes are seen as one of the main factors for good science education (Duit & Treagust, 2003). Moreover, self-reflection about emotion-related behaviour is essential for scientific inquiry and to learning more broadly in science education (Kayumova and Tippins, 2016). Researchers also stated that these could be both students and their teachers' hands-on learning in science (Garner, Gabitova, Gupta, & Wood, 2018). When the findings of the study were examined, positive conceptual changes were observed in different sub-themes, such as states of matter (13), stone and soil (8), and gravity (8). This situation is thought to be important for preschool teacher candidates to provide good science education in the future.

Similarly, in the study conducted by Ültay and Ültay (2015), preservice preschool teachers who took a science education course differed according to the level of science content knowledge of preservice teachers who were teaching preservice teachers did not take this course. In fact, in a recent study, Carrier and Grifenhagen (2019) have suggested that science teaching methodology should be practised to improve the science vocabulary knowledge of preservice teachers. The researchers stated that with the practical lessons, the preservice teachers would acquire the skills to apply the words they knew and teach concepts. Similarly, it was observed in this study that the conceptual perceptions of preservice teachers about the sub-themes related to Earth and Space Science, Life Science, and Physical Science themes changed.

Earth and Space Science

In terms of Earth and Space Science, conceptual changes that occurred in preschool teachers regarding the sub-themes of gravity (8) and stone and soil (8) were found to be highest, while it was the least regarding the day and night cycle (3). In a similar study conducted by Carrier (2013), it was seen that preservice teachers used very few words (tornado) about weather events. However, in the study conducted by Harman and Çökelez (2017), it was found that preservice preschool teachers formed minor metaphors about planets (1). It is thought that this situation may be caused by the lack of sufficient conceptual skills of preservice teachers in science education about the science of earth and space.

Life Science

Food chain, animals, plants, different habitats could be assumed to be the most common topics in terms of life science concepts taught in the preschool period. The study conducted by Carrier (2013) revealed that preservice teachers' most frequently mentioned concepts were the food chain in the sea and ecosystems in the forest. In addition, it was stated that preservice teachers frequently talked about seed growing. Similarly, the study conducted by Harman and Çökelez (2017) demonstrated that the concepts that preservice preschool teachers mentioned most were found as living things (27) and then as plants (14) people (14) and animals (13). In addition, the preservice teachers were found to mention little about habitats. This study found that preservice teachers mostly mentioned food chain, different habitats, and body organs. The lack of an increase in the conceptual perceptions of preservice teachers regarding different habitats emerges as an

unexpected result in this study. This situation is thought to be due to the fact that preservice teachers consider themselves inadequate about the topic of habitats. In a study by Ültay, Can, and Ültay (2014), the authors stated that the level of content knowledge of preservice teachers, studying preschool teaching at the third grade, about the theme of 'heat temperature, was low and that in this case, preservice teachers could improve themselves through the lessons they would take for science education and their applications. Likewise, in this study, it is considered that more applied studies on different habitats will contribute positively to the conceptual changes to occur in preservice teachers in this sub-theme.

Physical Science

Carrier (2013) stated that preservice teachers mentioned enough topics such as solid / liquid, liquids and sound. In the study conducted by Harman and Çökelez (2017), it was observed that the most frequently mentioned subjects by preservice teachers were simple machines, force-motion and speed-acceleration. In this study, it was seen that preservice teachers' knowledge on the subject of states of matter and force and motion improved. In addition, it was found that the science content knowledge of preservice teachers increased about kitchen activities, which are frequently used in preschool education. In the study conducted by Ültay and Ültay (2015), it was found that preservice preschool teachers had low level of conceptual knowledge about “electricity”, “heat-temperature”, “acid-base”, “matter” and “water”. The main reason for this situation is thought to be negative attitudes of preservice teachers towards science education (Ültay and Ültay, 2015). In another study by Dönmez, Usta and Ültay (2015), the authors stated that the preservice teachers' perception of science as abstract and complex affected the situation. There are more differences in the perceptions of the concepts related to concrete themes such as states of matter (13) than other themes that showed similarity to those findings in other studies in the literature. This situation is that ought to be due to the fact that the concepts regarding the states of matter are the most frequently mentioned concepts in the process of teaching practice by preservice teachers.

Conclusion and Recommendations

This paper aimed to show relationships between STEM-based science activities and conceptual changes of preservice early childhood teachers. As a result, STEM-based science education has been found to increase the science content knowledge of preservice teachers, and it is suggested that this model can be used for a science education course in teacher training programs. In addition, in-depth conceptual analyses should be conducted by examining the preservice teachers' attitudes towards different science subjects. It is also suggested that the most frequently mentioned science themes in preschool education and the level of content knowledge of teachers who use such themes should be investigated.

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