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The Effect of STEM Education on the Hypothetical-Creative Reasoning Skills of the Pre-school Pre-service Teachers

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Abstract
The study aims to explore the effect of STEM education on the hypothetical-creative reasoning skills of the pre-school pre-service teachers. The pre-school pre-service teachers were educated with STEM education for 14 weeks within the scope of the study. A mixed-method was employed in the study. The quantitative data were collected with the "Hypothetical-creative Reasoning Skills Inventory" in the study. The hypothetical-creative reasoning Inventory was applied to the pre-school pre-service teachers as a pre-test before the STEM education and a post-test after the STEM education. The qualitative data were obtained with a semi-structured interview form applied to the pre-school pre-service teachers. At the end of the study, it was found that STEM education developed the pre-school pre-service teachers' hypothetical-creative reasoning skills. The qualitative data also supported this result. The pre-school pre-service teachers claimed that they used the steps of determining the situation, collecting necessary data, suggesting solutions, doing research, analysing data, evaluating, that is, scientific problem solving during STEM education.

Keywords: Hypothetical-creative Reasoning Skills, STEM, Pre-school, Pre-service Teachers

Introductıon
Hypothetical thinking is a way that is used for the process of reasoning, hypothesising, and making decisions about current situations (Amsel, 2010; Lawson, 2002). Hypothetical thinking is an important cognitive reasoning skill that includes making predictions within certain contexts based on assumptions (Evans, Over & Handley, 2003). In this respect, hypothetical thinking is considered as a scientific thinking skill. Because this reasoning skill is one of the reasoning skill ways that is used in testing by separating the knowledge into

theory or hypothesis and observables in scientific processes through making experiments and observations in scientific processes (Amsel, Trionfi and Campbell, 2005; Ju, and Choi, 2018). That is, it is an argumentation process that consists of posing a problem with more than one result, producing possible solutions, and predicting the possible results of the experiment by experimenting to prove the accuracy of the solutions (Lawson, 2003). This way of thinking that was put forth by Lawson (1995), was shaped consisting of a structure with interrelated aspects that includes processes such as proportional thinking, determining and defining variables, probabilistic thinking, thinking with combinations, and correlational thinking. In addition, the Hypothetical-Creative Thinking, which was raised by Lawson (2000), can be defined as the transformation of the data obtained by the individual and the related news (information) into argumentation as an assumption conjecture, inference or determination, estimation process (doxa); processing, becoming knowledge after or together with the dimensions of hypothetical thinking, proportional thinking, probabilistic thinking, correlational thinking; determining and defining variables, combined thinking; processing this information in the dimensions of analogical thinking, metaphorical thinking, vertical thinking, lateral thinking, divergent and convergent creative thinking (Duran, 2014). Hypothetical-creative thinking skill is a mental process that is used in the abstract operational period and can be developed (Evans and Kakas, 1992; Gelen, Duran and Özer, 2016). The development of these mental functions of individuals, especially students who are in the abstract operational stage and teachers has great significance. Because teachers can identify their students' thinking and form a regular system in identifying, classifying and naming students' thinking items with the hypothetical learning (Sztajn et al., 2012). Teachers, who have advanced hypothetical thinking skills, are very good at seeing details (Confrey et al., 2017; Lizardi and Kalhil, 2012). In addition, they have a greater performance in focusing on students' thoughts and determining appropriate learning goals, interpreting students' mathematical thinking and giving them appropriate instructions (Ivars et al., 2018).

Several factors influence hypothetical-creative thinking; more precisely, it is thought that these factors that influence creativity will influence hypothetical-creative thinking, which is based on creativity, albeit a little (Duran, 2014). Some of the factors that influence creativity are the organic and chemical structure of the brain, emotions, nutrition, stress, lifestyle, social status, family economic status, education, culture, social factors (Öncü, 2003; Piffer, 2012). In this study, considering the education factor, which is defined as a factor affecting hypothetical-creative thinking, the effect of STEM education, which is a new and different form of education, on the hypothetical-creative thinking skills of pre-school pre-service teachers was tried to be examined. That the mental process can be developed particularly in the pre-school period is of great significance for teachers of this age group to acquire different ways of thinking (Gökalp, 2016; Sternberg and Zhang, 2001; Zhu and Zhang, 2011). Accordingly, the focus group was the pre-school pre-service teachers in this study considering that mental development would have a very critical effect on understanding the significance of thinking differently, providing students with different thinking skills and preparing an educational environment for them.

STEM is an education movement based on integrating the disciplines of science, technology, engineering and mathematics (Kuenzi, 2008). It is not the education approach that provides to transfer information directly but an activity-based education approach in which knowledge is created by doing and living in an individual's mind in line with one's own learning experience (Wai et al., 2010). Individuals make analyses, synthesises and evaluate the information in their mind for the design they will create at the end of the education (McDonald, 2016). If their current knowledge is sufficient, they will learn how to use this knowledge; what they can do by using them or how they can integrate this knowledge into different situations, how they can use them to produce something, how to integrate them with other disciplines; above all, how to use them in everyday life (Chen, 2009; Çakır and Yalçın 2020). If their current knowledge is not sufficient, they learn how to research to obtain new information and thus to do research and to learn by doing research; that is, they gain the ability to learn by themselves, to be responsible for their learning (Watkins and Mazur, 2013). Individuals encounter with several problems during STEM education. These problems emerge primarily with a process consisting of a situation, a problem or a scenario and last until the end of the design. In this process, the individual collects information related to the current process, hypothesises, tests, proves, designs, produces and creates a unique product (Becker and Park, 2011). In this process, the individual gains a lot of knowledge, skill and experience. These skills include mental skills as well as physical skills. It has been concluded that the studies suggest that the STEM education develops several ways of thinking such as the advanced thinking skills (Baharin, Kamarudin and Manaf 2018; Subia et al. 2020), critical thinking (Elliot et al. 2001; Evcim and Topsakal, 2019; Gandi, Haryani and Setiawan, 2019), problem solving (Crippen and Antonenko, 2018; Özkızılcık and Betül Cebesoy, 2020; Öztürk and Yalçın, 2020), metacognition (Çevik and Abdioğlu, 2018), creativity (Çakır, Yalçın and Yalçın, 2019; Güldemir and Çınar, 2021), scientific creativity (Gülhan and Şahin, 2018; Uğraş, 2018;

Yılmaz Baltabıyık and Duru, 2021), scientific process skills (Gökbayrak, and Karışan, 2017; Sullivan, 2008), epistemological belief (Akpınar and Altun Yalçın 2021), motivation (Çakır and Ozan, 2018; Meyrick, 2011), cognitive risk-taking (Akkoyun, 2019), inquiry learning (Çetin, 2021; Mirici et al. 2020), reflective thinking (Hasançebi, et al 2021; Samur and Yalçın 2021) etc. This study aims to explore the effect of STEM education on Hypothetical-creative reasoning skills which is a different way of thinking.

Research Model

An explanatory design, which is among the mixed method types, was used in the study. The mixed-method research is a research type in which researchers apply both the qualitative and quantitative methods together to investigate a topic deeper and reveal the reasons, relationships more clearly (Creswell, 2003). Primarily the quantitative data are collected and analysed in the explanatory design. Then, the qualitative data are collected to understand the results obtained from the quantitative data (Johnson and Christensen, 2004). As the study group model, a single-group pre-test model was applied. This group model enables to compare of the effect of the application for a group with the pre-and post-test scores (Cohen, Manion and Morrison, 2007).

Research Universe and Sample

Among the convenience sampling types, volunteer sampling was used in the research. Volunteer sampling is a way of selecting sample that is both reachable and volunteers to participate in the study (Teddlie and Yu 2007). The research sample consisted of 22 pre-school pre-service teachers who were studying at the pre-school teaching department of a faculty of education in a state university in the 2020-2021 academic year. The pre-service teachers participated in the study voluntarily. Then, a STEM education was given to them for 14 weeks. The materials that is used in STEM education can be described as simple materials such as carton boxes, empty bottles and caps, used CDs, straws, skewers etc. It was ensured that these materials were made up of materials that everyone could reach easily in daily life, and that could even be considered as waste. Thus, the teachers were asked to make things like machines, vehicles, cars that they encounter in daily life by using simple materials for different purposes.

Data Collection Tools

To measure the hypothetical-creative reasoning skills of the pre-school pre-service teachers, the "Hypothetical-Creative Reasoning Skills Inventory", which was developed by Duran (2014) was used. The Cronbach Alpha inner consistency coefficient of the scale was calculated as 0,950. The scale is in 5-points Likert-type and consists of 23 items in total and five sub-dimensions. These sub-dimensions are hypothetical thinking and creativity, proportional thinking, separating variables and thinking in combinations, correlational thinking and probabilistic thinking.

The semi-structured interview form consisted of 5 open-ended questions. The items of the scale were taken into consideration for the content and face validity of these questions. The questions were prepared in parallel with these items, and their relevance was analysed by 4 academicians, two of whom were at the science education department and two at the mathematics education department. For the face validity, it was decided that the questions would serve the specified purposes in line with the feedback from the experts.

The content analysis was used in the analysis of the qualitative data. First, the interviews were transcribed, and different codes and categories were created for each question in the study. The stages in the content analysis are orderly as coding the data, identifying categories, arranging-defining the codes and themes, interpreting the findings (Yıldırım and Şimşek, 2008). The codes and categories specified independently by the two researchers in the content analysis to provide the reliability of the qualitative measurement tools were compared with the researchers' codes and categories. The reliability of the research was ensured by determining the numbers of consensus and disagreement. For this, the reliability coefficient was determined based on the formula (Reliability=Consensus/Consensus+Disagreement) developed by Miles and Huberman (1994) (Miles and Huberman, 1994). The reliability coefficient was calculated as 91% in this research.

Data Analyses

As the sample size was over 30, the quantitative data obtained in the study were subjected to the Kolmogorov–Smirnov normality test before the statistical analyses; it was determined that the data demonstrated normal distribution as the p significance value was found as over 0,05 (Can, 2016). With the normal distribution of the data, the correlated sample t-test, which is the parametric test, was used to determine whether a difference was observed between the scores.

The purpose of this test is to compare the pre-and post-test average scores on the same group.

The content analysis was applied to the qualitative data. For this, different codes and categories are created for each question by gathering the interviews together firstly. The stages in the content analyses are orderly as coding data, determining categories, arranging and identifying codes and themes (Yıldırım and Şimşek, 2008). The codes and categories created during the validity and reliability stages of the data analyses were presented to 3 different experts and the results were combined. The qualitative data analysis reliability value was found as 90%. That the reliability value between the coders is over 70% demonstrates that it is reliable (Arastaman, Öztürk Fidan and Fidan, 2018).

Process

Before the application process of the research, necessary researches and literature reviews were held related to including the features of STEM education and including the level of excitement for the characteristics that are required to be measured in pre-school pre-service teachers can create new designs by using their field knowledge. In addition, it was taken into consideration that the pre-service teachers be qualified to solve the problems they would encounter in the activities with the experience and knowledge they had gained from the previous activity and that they were at a level that they would use in their professional life and personal development throughout their lives. The materials in the activities consisted of the simple materials that can be found in each area of daily life and appropriate in terms of cost (such as pet bottle-cups and lids, straws, cardboard boxes, insulating cables, tin cans). The STEM applications that continued for 14 weeks in total, 2 hours per week were held with the 22 pre-school pre-service teachers under the guidance of an experts in the field. In this process, it was tried to help the pre-service teachers to remove their prejudices towards the solution of the problem they encounter in daily life, to develop their hypothetical thinking and creativity skills, to gain different perspectives, to connect the information they had learned with their daily life situations, and to provide the self-confidence that they can design their products. Before starting these applications, the theoric information about the STEM education was presented to the pre-service teachers in presentations. Then, they were asked to create groups consisting of four participants most to perform the activities that had already been prepared. The pre-service teachers were asked to prepare the activity by giving the theoric information (such as science and mathematics information that were necessary, visualisation of the activity that would be applied by drawing) about the problem situation and how to do the last week's activity. As an example of those made

with simple materials, in the activity named “Painter robot”, a circuit institution from the candidates, engineering design, using mathematical measurements to keep balance and a robot using daily materials such as colored pencils and pet glasses has been asked to design. In addition, the originality in the activities was taken as the base; that is, it was ensured that the pre-service teachers consulted with the group to produce a solution to the given problem and design the appropriate product not about being put into a certain mould and everyone creating the same product.
Below are the problem situations given for 14 weeks:

Table 1.
STEM education application with Simple Materials

STAGE	ACTIVITY	DURATION
Pre-Test Practice	-	2 lessons
Problem case 1:	Catapult construction	2 lessons
Problem case 2:	Shipbuilding	2 lessons
Problem case 3:	Giraffe making	2 lessons
Problem case 4:	Traffic light	2 lessons
Problem case 5:	Motor car	2 lessons
Problem case 6:	CD that doesn't roll over	2 lessons
Problem case 7:	Remote controlled snake	2 lessons
Problem case 8:	Making a car with a mousetrap	2 lessons
Problem case 9:	Piggy bank that swallows money	2 lessons
Problem case 10:		2 lessons
Problem case 11:	Caterpillar making	2 lessons
Problem case 12:	Shaky robot construction	2 lessons
Problem case 13:		

Problem case 14:	Boxer robot build Making a dancing robot Painter robot	2 lessons
Post-test application:	-	2 lessons

Ethical Information

The ethical permission was taken from the Erzincan Binali Yıldırım University Human Rights Ethics Committee dated 01.09.2020 and numbered 07/06. The voluntary individuals selected to collect data from the sample group were informed about the issue by signing the consent form. No action was taken related to the Scientific Research and Publication Ethics and all the rules in the Higher Education Institutions Scientific Research and Publication Ethics Directive were complied with.

Finding

The Analyses of the Hypothetical-Creative Thinking Skills Scale

As the hypothetical-creative thinking skill inventory normality test consisted of 22 participants (Shavelson, 2016, if the number of participants is below 30) the Shapiro-Wilk test was applied and it was found that the life pre-test sig. =,212; post-test sig. =,013. It demonstrates normal distribution in these values.
In the hypothetical-creative thinking pre-test, the mean was found as =89,04; median=90 mode=90: S.deviation=9,915; skewness =-0,881; kurtosis=,705.
In the hypothetical-creative thinking post-test, the mean was found as=97,86; median=102; mode=102; S.deviation=12,885; skewness=-,792; kurtosis=-,503.
All these values indicate that it demonstrates normal distribution. There are the normality results related to the sub-dimensions of life dimension below.

Table 2.
Findings for descriptive statistics of the hypothetical thinking skills pre-test scores

Pre-tests	Average	Median	Mode	Std. Deviation	Skewness	Kurtosis
1st sub-dimensi	20,27	20	24	3,180	-,254	-,891

on						
2nd sub-dimension	18,78	19	20	2,762	-,673	,388
3rd sub-dimension	23,43	24	24	3,087	-,916	,225
4th sub-dimension	15,52	15	15	2,271	,348	,321
5th sub-dimension	11,39	11	12	1,437	,138	-,692

1st sub-dimension: hypothetical thinking and creativity, **2nd sub-dimension**: proportional thinking, **3rd sub-dimension**: separating variables and thinking in combinations, **4th sub-dimension**: Correlational thinking, **5th sub-dimension**: proportional thinking

The normality Shapiro-Wilk values related to the sub-dimensions are orderly as: 1st dimension =,298; 2nd sub-dimension =,624; 3rd sub-dimension =,073; 4th sub-dimension =,122 and 5th sub-dimension =,303. Those which did not demonstrate normality were interpreted by considering the descriptive statistics above.

Considering the descriptive statistics results of the pre-test scores related to the sub-dimensions of the hypothetical-creative thinking skill inventory (Table 2), it is seen that the mean, median and mode values of the scores in all of them are very close to each other, and the kurtosis and skewness values are in the range of -2 to +2. That the skewness and kurtosis values were found between the mentioned values indicated that the data of this research demonstrated normal distribution (George and Mallery; 2001). For this reason, it is assumed that the hypothetical-creative thinking skill inventory and its sub-dimensions demonstrated normal distribution. In addition, since the significance value used in checking the normality assumption was found above,05, it demonstrated normal distribution. (Can, 2016).

Table 3.
Descriptive statistics findings for the hypothetic thinking skills post-test scores

Post-tests	**Mean**	**Median**	**Mode**	**Std. Deviation**	**Skewness**	**Kurtosis**
1st sub-dimension	20,68	21	25	3,956	-,750	,063
2nd sub-dimension	21,59	22,5	24	2,702	,-731	-,132
3rd sub-dimension	26,09	27	23	3,624	-1,150	1,192
4th sub-dimension	17	17	17	2,563	-,858	,386
5th sub-dimension	12,72	13	15	1,931	-,185	-1,546

***1st sub-dimension**: hypothetical thinking and creativity, **2nd sub-dimension**: proportional thinking, **3rd sub-dimension**: separating variables and thinking in combinations, **4th sub-dimension**: Correlational thinking, **5th sub-dimension**: proportional thinking*

The pre-test Shapiro-Wilk values related to the sub-dimensions are orderly as 1st dimension =,052; 2nd dimension=,059; 3rd dimension =,009; 4th dimension ,045 and 5th dimension =,007. Those which did not demonstrate normality here were interpreted by considering the descriptive statistics above.

Considering the descriptive statistics applied for the post-test scores related to the sub-dimensions of the hypothetical-creative thinking skills inventory (Table 3), it is seen that the score mean, median, mode values are close to each other in each; their skewness and kurtosis values are in the range of -2 and +2. That the skewness and kurtosis values are in the specified value ranges indicates that the research data demonstrate normal distribution (George and Mallery; 2001). Therefore, it was considered that the hypothetical-creative thinking skills scale and its sub-dimensions demonstrated normal distribution.

Table 4.

Paired samples t-test results for the hypothetical thinking skills inventory

Measurements	**N**	**$\bar{X}$**	**S**	**T**	**sd**	**p**
Pre-test	22	89,00	10,14	-3,084	21	,006
Post-test	22	97,86	12,88			

p<0,05

The paired samples t-test results reached between the pre-test and post-test scores to determine the effect of STEM educations with simple materials for the pre-school pre-service teachers' hypothetical thinking skills are presented in Table 4. In the results of the test, a significant difference was found between the pre-application score average (pre-test=89,00) and post-application score average (post-test=97,86) (t21: -3,084; p< 0.05).

Table 5.

Paired samples t-test results for the sub-dimensions of the hypothetical thinking skills inventory

Measurements	**N**	**$\bar{X}$**	**S**	**t**	**Sd**	**p**
1st sub-dimension pre-	21	20,28	3,257	-,208	20	,838
1st sub-dimension post-	21	20,47	3,932			
2nd sub-dimension pre-	22	18,72	2,814	-4,144	21	,000
2nd sub-dimension post-	22	21,59	2,702			
3rd sub-dimension pre-	22	23,40	3,157	-2,946	21	,008
3rd sub-dimension post-	22	26,09	3,624			
4th sub-dimension pre-	20	15,55	2,327	-1,813	19	,086
4th sub-dimension post-	20	17,00	2,695			
5th sub-dimension pre-	22	11,36	1,465	-2,859	21	,009
5th sub-dimension post-	22	12,72	1,931			

1st sub-dimension: hypothetical thinking and creativity, **2nd sub-dimension**: proportional thinking, **3rd sub-dimension**: separating variables and thinking in combinations, **4th sub-dimension**: Correlational thinking, **5th sub-dimension**: proportional thinking

The paired samples t-test results between the pre-test and post-test scores to determine the effect related to the STEM educations with simple materials for the pre-school pre-service teachers' hypothetical thinking skills inventory and its sub-dimensions are presented in Table 5. In the test results, no significant difference was found between the pre-application of the score average of the 1st sub-dimension (pre-test=20,28) and its post-application

score average (post-test=20,47) (t20: -,208; p> 0.05). A significant difference was found between the pre-application score average of the 2nd sub-dimension (pre-test=18,72) and its post-application score average (post-test=21,59) (t20: -,208; p> 0.05). A significant difference was found between the pre-application score average of the 3rd sub-dimension (pre-test=23,40) and its post-application score average (post-test=26,09) (t21: -2,946; p< 0.05). No significant difference was found between the pre-application of the score average of the 4th sub-dimension (pre-test =15,55) and its post-application score average (post-test=17,00) (t19: -1,813; p>0.05). A significant difference was found between the pre-application score average of the 5th sub-dimension (pre-test =11,36) and its post-application score average (post-test=12,72) (t21: -2,859; p< 0.05).

Qualitative Data Analysis Results
Table 6.

The opinions of pre-school pre-service teachers before and after the STEM education with simple materials

			After the Education		
Category	**Code**	**Frequency**	**Category**	**Code**	**Frequency**
Affective	Bias	8	Affective	Produce	1
	Not	1		Interest	2

	interested				
	Like	1		Ability to make	
	Be bored	2		Fun	
	Want	2			
	Hate	2			
	Fear	1			
Cognitive	Have no knowledge	2	Cognitive	Analytical thinking	8
	Theoric	1		Problem-solving	6
	Recycle	1		Useful	31
	Attention	2		Product	6
				Research	2
				Critical thinking	2
				Point of view	3
				Application	3
				Active	3
			Other	Activity	2
				Education	4

When Table 6 is examined, it is realised that the answers of the pre-school pre-service teachers before and after the STEM education create two categories as affective and cognitive. In the affective category, the pre-school pre-service teachers stated that the STEM education would not contribute to their fields and personal developments; that they got bored to make products; that they worried about choosing the course; that they would not make projects and materials or love the STEM education; thought that it was not necessary and did not want to get it as they hated science courses. On the other hand, some of the pre-school pre-service teachers claimed that they wanted to get the course and insisted on their friends getting the course; they found the name of the course very interesting. In the category of cognitive, there are the opinions that they had no information related to the course; that they thought the course was theoretical; that they could not build machines with waste materials and that they found the name of the course very interesting. The answers of the pre-school pre-service teachers after the STEM education created 3 categories as affective, cognitive and other. The affective category consists of the pre-school pre-service teachers' thoughts referring that teaching with the STEM education was fun, that they realised that science courses could be taught with fun, that it was very entertaining, interesting and different from usual courses, that they noticed that they could make it easier, that the emerging product gave pleasure and that their thinking about product development improved, their interest increased and they began to like it.

The category of cognitive consisted of the pre-school pre-service teachers' thoughts as that the course was very useful, that they experienced a great difference, that it developed them, gained a different point of view, that it developed the students' and their analytical thinking, critical thinking, problem-solving and researching skills, that are based on practice and provided their active participation.

The category of cognitive consisted of the teachers' thoughts that they learned new activities and reached the competence to design their activities, that the activities were not difficult, that they could easily do it using simple materials, that it was economical and attractive. Also, in the category of other, they claimed that it was an important course and that they wanted to take this course to offer a better education, and receive advanced education, that they completed the education with pleasure and willingness, and looked at the materials from a different point of view. Some opinions are given below.

"...Before taking STEM, I thought that I would not be able to reconcile this education with daily life. But then, I think it is directly compatible with the fields of science, mathematics and engineering and contributes to our personal development."

"...Before receiving the training, I thought it would not contribute, but after the training, I think my ability to produce solutions and practical thinking skills have increased."

Table 7.

Opinions of pre-school pre-service teachers for the effect of STEM education on their problem-solving strategies

Category	Code	Frequency
	Brain Storming	2
	Trial-error	3
	Permanent learnings	2
Affective	Creative	3
	Logical thinking	2
	Practical thinking	2
	solution	13

	Interest	2
	Fun	3

When the opinions of the pre-school pre-service teachers, in Table 7, related to the effect of STEM education on their problem-solving strategies are examined, the cognitive and affective categories emerge. In the category of cognitive, the pre-school pre-service teachers stated that they did the research for the origin of the problems that they encountered during the activities, checked them again and again; that it was necessary to look from different aspects and think about the problem to produce different ways of solution as these problems had more than one solution; thus they developed their skills of problem-solving by themselves, thinking differently and practically, and generating smart solutions. They also claimed that they gave a different meaning to all the things around them, they looked at the materials, that is, they saw all the materials around them from a different point of view, such as waste, dairy, and simple. They referred that "I wonder how I can use it, that is, how can I do something different from this material, what can I do with these materials, what material (waste, simple, daily material) I can use for my problem."

In addition, they also expressed that they thought the activities were based on practice, that different styles of activities contributed a lot to them and they needed to follow the stages while doing these activities, they thought logically, brainstorming, trial and error and permanent learning. In the category of affective, they claimed that they thought the activities would attract the children's attention and the *children would have fun during these activities.*

"...I was very surprised when I saw the activities before I received my training. I didn't know how it worked. But now I can generate ideas from many materials. I can repair broken circuits.."

"..After taking this course, I learned how to solve the problem we will encounter. It enabled us to apply our theoretical knowledge in practice. While it provided more permanent learning, it also enabled us to
approach problems in a solution-oriented manner."

Table 8.
The opinions of pre-school pre-service teachers related to the effect of STEM education with simple materials on their process of researching and reaching conclusions.

Category	Code	Frequency
	Solution	8

Researching	Researching	7
	Problem	6
Other	Material	5
	Saving	4
	Personal development	3
	Activity	3

When Table 8, which indicates the opinions of pre-school pre-service teachers related to the effect of STEM education with simple materials on their process of researching and reaching conclusions, are examined, it is seen that 2 categories and 7 codes emerge. The category of researching consists of the pre-school pre-service teachers' thoughts that they did research from different researches thanks to the STEM education and they did it continuously; thus they learned what they should do while researching. In addition, they claimed that their multi-dimensional thinking skills were developed to produce practical solutions, find different alternatives to reach more data, research, analyse and evaluate the ways followed, and find out how to reach the things that were wanted to be obtained. Moreover, they stated that their skills of recognising problems faster, reaching a solution in a shorter time, establishing a cause-effect relationship between events, thinking faster and finding solutions, thinking about all kinds of possibilities, and evaluating. The category of other consists of t pre-school pre-service teachers' thoughts that, their research skills were developed, they learned where the materials would be used thanks to the research they had done during STEM education, and thus they saved time and effort, and their research contributed to their personal development. They expressed that they attached a different meaning to all the items around; they thought "how can I use it, that is, how can I do something different from this material, what can I do with these materials, what material (waste, simple, daily material) I can use in my environment." Moreover, they stated that they had fun while researching, they had the opportunity to go beyond the usual subjects and activities, and they had a very effective and productive time.

"...As the training process progressed, I started to solve the problems that emerged faster. This saved time and provided self-confidence."

"...I started to establish a cause and effect relationship. It also contributed to my personal development."

Table 9.
The opinions of the pre-school pre-service teachers related to the effect of the STEM education with simple materials on the students

Category	Code	Frequency
Cognitive	Thinking	9
	Problem-solving	5
	By doing and living	6
	Research	3
	Learning	6
	Creativity	4
	Inquiry and criticism	1
	Cooperative learning	1
Affective	Motivation	7
	Fun	1
	Personal development	6
Other	Physical development	5
	Producing	3
	Life	3

When Table 9, which indicates the opinions of the pre-school pre-service teachers related to the effect of the STEM education with simple materials on the students, is examined, it includes 3 categories and 12 codes. In the category of cognitive, it was determined that the pre-school pre-service teachers thought that the students' skills of different and lateral thinking, observing, criticising, questioning, researching and discovering would be developed and that they would participate effectively through learning by doing thanks to these activities. In addition, they also claimed that their understanding skills would be developed and they would realise active, permanent and effective learning, and many mental skills such as problem-solving, creativity and cooperative learning skills would develop. In the category of affective, they expressed that the students would have fun thanks to the STEM activities, that the activities would attract their attention and increase their interests and curiosity, and motivate them. Furthermore, they claimed that it would contribute to their personal development, increase their patience, respect for others' skills and self-confidence. In the category of other, they stated that the STEM education would provide students with many advantages such as physical development, gaining the ability to produce and willingness to continue production, and using what they learned in their lives.

"…It will broaden students' horizons, expand their imagination and increase their self-confidence through their work."
"…I think students' creativity will improve as a result of such activities. Being related to daily life will ensure permanent and fun learning."

Table 10.
The opinions of the pre-school pre-service teachers related to the problems that the students may encounter during STEM education with simple materials

Category	Code	Frequency
Material	Deficiency	5
	Its form and dimension	2
	Appropriate to the purpose	4
	Careful selection	2
	Storing	2
Classroom	Crowded	2
	Dominance	3
	Danger	2
	Economical	2
	Safety	1
Educative	Deficiency	1
	Education	1
Students	Appropriate	3
	Interesting	1
	Attention	2
	Difficulty	4
	Unhappy	1
Product	Study	1
	Having no pretty look	2
	Aesthetic	2
	Complicated	2
	Failure in the circuit	1

When Table 10 indicates the opinions of the pre-school pre-service teachers related to the problems that the students may encounter during the STEM education with simple materials is examined, it is seen that it consists of 5 categories and 22 codes. The category of the material consists of the opinions of the pre-school pre-service teachers referring that there might be a material deficiency, that the materials had to be chosen according to the purpose and carefully, that its form and dimension was important. In addition, they also claimed that the storage and protection of the materials were also important. The category of classroom consisted of the opinions that it would be difficult to establish classroom dominance during STEM Activities in crowded classrooms, dangerous events might occur while doing the activities, and that it was necessary to pay attention to security measures. Besides, they stated that the activities should be economical. In the category of educative, there are the thoughts that the number of teachers who will give STEM Education is low because the number of teachers and pre-service teachers who have received this education is limited. In the category of student, there are thoughts of the pre-school pre-service teachers referring that the activities should be suitable for the muscle structures and readiness levels of the students. Moreover, they stated that the activities may not attract their attention, that they may not find it interesting and do not want to do it, have difficulty, struggle while doing it, and therefore they may feel unhappy. In the category of product, there are the thoughts of the pre-school pre-service teachers referring that the products made by the students might not be sturdy and the circuits might fail in activities containing circuits, the activities might seem complicated and the products might not have a pretty look because they would not have aesthetic concerns.

“..At this stage, if students fail to do something, their motivation may decrease.”

“...So sometimes, when doing a project, materials may not be available. Otherwise, there may not be enough time or there may be mistakes while doing the project..."

Discussion

At the end of the study, it was found that STEM education had a positive effect on the pre-school pre-service teachers' hypothetical-creative reasoning skills, in other words, developed. Positively and statistically significant developments were observed in the skills of proportional thinking, separating variables and thinking with combinations, probabilistic thinking, that are the sub-dimensions of hypothetical-creative reasoning. Although there was no statistically significant development in the sub-dimensions of correlational thinking, hypothetical thinking and creativity, it was determined that they developed positively. Even though several studies examined the effect of STEM education on the cognitive development of an individual, no studies have been encountered on the hypothetical-creative reasoning skill in the literature. In the study conducted by De Oliveira, and Ferreira, (2021), the hypothetical learning trajectory is a significant way in terms of educating pre-service teachers, for it has a characteristic that is instrumental, flexible, interactive, predictable and dynamic. This result, which has been reached from the quantitative data of the research, overlaps with the quantitative data of the study. It was determined that the pre-school pre-service teachers did research to get to the source of the problems they encountered and they checked them over and over during the STEM education, and thought that since these problems had more than one solution, it was necessary to produce different solutions, to look at the events from a different perspective and to think about the problem, thus self-solving problems, different and practical thinking and developed their ability to obtain creative and rational solutions. This situation exactly coincides with hypothetical thinking, which is the sub-dimension of the hypothetical creative reasoning skills inventory. Kılınç, Demirbağ and Yılmaz (2018) claim that the problem is put forward, defined, the steps to be solved are specified, experiments or designs and verifications are made over this, that is, hypothetical thinking is used in the STEM education. One encounters continuously with problems during STEM education and follows a scientific route as a scientist for the solution of this problem (Akpınar and Altun Yalçın, 2021). In the study, it was also determined that the pre-school pre-service teachers did research from different sources, they repeated this constantly during the STEM education; thus, they learned the points that they should while doing research. In addition, it was concluded that they thought their skills of creating practical solutions, finding different alternatives to reach more data, researching the ways followed, thinking faster and finding solutions and thinking all kinds of possibilities were developed. This situation exactly coincides with the probabilistic thinking sub-dimension of the hypothetical creative reasoning skills inventory. Throughout the STEM education, the individuals constantly try to complete the process successfully and struggle to take the necessary precautions, anticipate the obstacles and difficulties that the next step may encounter, and take precautions in advance (Cooper, Heaverlo, 2013; Doğan, Aydın and Kahraman, 2020; Öztürk and Yalçın, 2020). It can be claimed that this situation develops the skills of predicting, calculating and taking precautions in every situation that individuals may encounter during STEM Education, that is, their probabilistic thinking skills. In addition, they also stated that their recognising problems faster, reaching solutions in a shorter time, establishing cause-effect relationships between events, evaluating skills were developed. This situation exactly coincides with the sub-dimension of determining and defining the variables of hypothetical-creative reasoning skills inventory. Individuals try to control and eliminate all factors so that the process can continue without any problems during STEM education (Crippen and Antonenko, 2018; Lin et al. 2015; Topsakal and Altun Yalçın, 2020). It can be stated that this situation provides the development of pre-school pre-service teachers' skills in determining and defining variables. In the study, it was found that the researching skills of the pre-school pre-service teachers developed, that they learned where to use the materials and thus saved time and effort and that their research contributed to their personal development thanks to the research that they did during the STEM education. In addition, it was determined that they thought the STEM education was based on practice, that various styles of the activities contributed much to them and that they needed to follow the stages while doing these activities, that they realised logical thinking, brainstorming, trial and error and permanent learning. This situation exactly coincides with the thinking with combinations sub-dimension of the hypothetical-creative reasoning skills inventory. Thinking with combinations is the skill of considering all the possible theoretical or experimental relationships systematically even if they are uncertain (Lawson, 1995). During STEM education, individuals try to put forth a product design by making the theoretical knowledge they have into experience, that is, by using them (Barak and Assal, 2018). This is the process of applying their knowledge in the process of using, trying, testing and observing for the solution of a situation, an event or the production of something, that is, turning them into practice (Sarıcan, and Akgunduz, 2018; Thurmond, 2011). It can be claimed that turning the pre-school pre-service teachers' knowledge into practice, that is applying them and realising the relationship between them during the STEM education develops their skills of thinking with combinations. At the end of the study, it was determined that the pre-school pre-service teachers thought that there was a great difference in themselves, that they developed themselves, they gained a different perspective, that children and their creativity, analytical thinking, critical thinking, and problem-solving skills developed thanks to the STEM education. It was also concluded that they gave a different meaning to all the things around them; they looked at all materials such as waste, daily, simple, etc. they saw around them from a different perspective. They thought, "I wonder how can I use it, that is, how can I do something different from this material, what can I do with these materials, what material (waste, simple, daily material) I can use in my environment." This situation exactly coincides with the correlational thinking sub-dimension of the hypothetical-creative thinking skills inventory. Correlational thinking is the process of relating a variable object with another variable object (Lawson, 1995).

STEM education is generally realised with simple materials that can be called waste materials such as cartons, paper, plastic bottles etc. that can be found around the individual (Doğru, 2020). This situation provides individuals to constantly think about where and how they can use the objects around them. That is, it enables them to gain the skill, ability and awareness to use the objects outside their existing use. Thus, it can be claimed that looking at objects from a different perspective, attributing different meanings and tasks to the objects around them; that is, relating them to use them instead of real materials, improves the correlational thinking skills of pre-school pre-service teachers. At the end of the study, it was determined that the pre-school pre-service teachers constantly evaluated their current knowledge and new knowledge that they learned by researching and from their friends to solve the problems that they encountered during the STEM education; in this way, they thought they developed their abilities to analyse, evaluate and associate information. This situation exactly coincides with the proportional thinking sub-dimension of the hypothetical-creative thinking skills inventory. Proportional thinking is a mental process that is used to compare the relationships between the variables (Lawson, 1995). An individual has very different experiences while making designs during STEM education. These experiences are, for example, relating and testing many variables with each other and with other variables, such as which material will be more useful how it is used, how it designs, how it forms a whole with other materials (Acar, Tertemiz and Taşdemir, 2019; Gwon- Suk, and Sun Young, 2012; Lou et al., 2011; Saleh, 2016; Şahin, 2021).

Considering the findings of the study, it can be claimed that STEM education develops the hypothetical-creative reasoning skills of the pre-school pre-service teachers. It can be stated that this situation originates from the characteristics of STEM education such as student-centred, effective learning by doing, based on self-learning, constantly encountering problems and following and applying scientific problem-solving steps like a scientist to overcome it. The hypothetical-creative reasoning skills of the pre-school pre-service teachers is of great significance both in terms of the development of their own learning experiences in a more logical framework and the preparation of more scientific and more creative learning and teaching environment for their students. Especially in the pre-school period, which is considered as the most important period in which students' creativity develops and students' curiosity and perspectives towards scientific knowledge develop, giving the necessary education to provide the development of the pre-school pre-service teachers’ hypothetical reasoning skills has great significance.

Suggestions

Applications for STEM education can be raised by organizing in-service training for pre-school teachers to raise awareness. Again, in this period, it is thought that students will have better communication skills in terms of interpersonal harmony and cooperation at a very young age by integrating them into pre-school education due to the conclusion that STEM applications positively improve cooperation and group work.

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