PAPER DETAILS

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AUTHORS: Zehra ÇAKIR,Sema ALTUN YALÇIN

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The Effect of Montessori Approach-based STEM Education on Pre-service Pre-school Teachers' Self-directed Learning

Zehra Çakır (PhD Stud.)
Erzincan Binali Yıldırım University - Turkey
ORCID: 0000-0003-4585-8214
zehracakir.29@hotmail.com

Prof.Dr. Sema Altun Yalçın
Erzincan Binali Yıldırım University - Turkey
ORCID: 0000-0001-6349-2231
sayalcin@erzincan.edu.tr

Abstract
The aim in the research was to investigate the effect of Montessori-based STEM education on the self-directed learning skills of pre-service pre-school teachers. A mixed method was employed in the research. The sample of the research consisted of 53 pre-service teachers enrolled in the Pre-school Teacher Education Programme at a mid-sized state university in northeast Turkey. During the research, Montessori-based STEM education was given to the pre-service teachers for two hours per week over 14 weeks. The Self-directed Learning Skills scale was applied to obtain the quantitative data and the Semi-structured Interview Form was used for the qualitative data in the research. After coding the data in content analysis, the themes of the coded data were written down. In order to contribute to the validity of the research, direct quotations from the participant group were included in the findings section and participant confirmation was carried out. In order to contribute to the reliability of the data analysis, the consistency of the results with each other was checked by five experts during the data analysis. The aim was to contribute to the reliability of the study by explaining the data collection and analysis sections in detail. At the end of the research, it was observed that there was a significant difference between the self-directed learning skills pre-test and post-test scores and that the qualitative analysis results supported this difference in direction with the development. These developments were determined from the statements by the pre-service teachers in their interviews stating that the training contributed greatly to their personal and social development and helped them gain learning and teaching skills about a subject. In line with the results obtained, it can be concluded that pre-school teacher candidates' self-directed learning skills such as self-confidence, perseverance, self-planned learning, and self-assessment were developed by Montessori approach-based STEM education.

Keywords: *Montessori approach, Preschool teacher candidates, Self-direction, STEM*

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INTRODUCTION

Scientific and technological knowledge has become a significant factor in the development and modernisation of societies in our developing world. Scientific and technological knowledge emerges as a product of the individual's sense of curiosity and nature research (Arık & Topçu, 2021). Providing education to individuals from an early age, that is, beginning from the pre-school period, will contribute to the laying of the foundations of scientific and technological progress more sturdily and healthily by enabling individuals to be more attentive and sensitive to their environment and to question nature and events (Çakır & Yalçın, 2021a; Yücesan, 2017). Within this scope, it is seen that individuals' efforts to understand and learn about nature and the world they live in come to the fore (Çetin, 2019). Moreover, learning is one of the most crucial needs of an individual. This need is placed at the highest rank in the "self-actualisation" step of the Maslow hierarchy. It is known that as the needs involving the "self-actualisation" step are satisfied, they increase. That is, this need increases as the individual learns. Therefore, it can be claimed that an individual's learning is a need that continues from birth to death (Walsh, 2011). In today's communities, in which information changes and increases rapidly, meeting the learning needs of individuals cannot be provided by direct transfer of knowledge (Timur & Taşar, 2020; Yıldırım, 1998). Currently, what is important is helping individuals gain the learning to obtain the skills for acquiring knowledge on their own. Thus, it is necessary to educate individuals who can plan, arrange, and manage their learning and who can self-actualise by meeting their own learning needs and responsibilities, and, therefore, learn to learn, be self-directed, and realise lifelong learning (Aspin & Chapman, 2000). The most efficient way to provide this is a quality education that starts from an early age (Uyanık Balat & Günşen, 2017). The number of research studies concerning which educational approaches are effective has increased to develop children's research, design, self-directed learning, 21st century, and reasoning skills in the pre-school period (Keulen, 2018). The significance of the Montessori approach (Çakır, Yalçın & Yalçın, 2020) and STEM education applied during the pre-school period was emphasised in the literature in terms of the children's acquiring the mentioned skills (Uğraş, 2017). STEM education refers to a teaching process based on integration of the disciplines of science, technology, engineering, and mathematics involving interdisciplinary approaches (Erol & İvrendi, 2021). On the other hand, the Montessori approach can be defined as a way of life, a way of being, and walking towards the future (Jara, Zapata & Alcívar, 2021). Bender (2018) defines STEM education as solving real-life problems; Çakır, Yalçın & Yalçın (2019) define it as the common similarity Montessori approach in terms of providing real-life skills and problem-solving skills. A Montessori approach is an alternative approach that has been used in the curricula of foreign countries for many years, has just become widespread in this country recently, and is used in different educational institutions. The purpose of this approach is to support children's physical, personal, and social development in all aspects and to nurture individuals with a responsibility to engage in lifelong self-directed learning (Güney & Öz, 2021). The Montessori approach maintains that education is a natural process and children learn by acting according to their inner voice and individual speed. Thus, it is ensured that the children can monitor themselves and that permanent learning is achieved without any feeling of obligation (Elkin et al., 2014). The materials prepared with the philosophy of the Montessori approach help children gain behaviours and skills consisting of willingness and pleasure to work collaboratively, productivity, concentration, questioning, creativity, self-confidence, analysis, sense of responsibility, how to solve a problem, and respect for self and others. For STEM education, Chesloff (2013) recognises the concepts at the centre of STEM as curiosity, analysis, creativity, collaboration, problem-solving, lifelong learning, responsibility to learn, and critical thinking. In addition, STEM education will contribute to the progress in technology and development in the economy by improving the 21st-century skills of the individual (Wang, 2012). The purpose of Montessori-STEM is to develop the students' STEM thinking and application areas with a series of design activities by considering the basic principles and curriculum of the Montessori philosophy and transferring the science content in an up-to-date way and accurately (Ibes & Ng, 2011). Elkin et al. (2014) claimed that the basic engineering concepts were consistent with the Montessori principles. For instance, the students in Montessori classes are good at using the applied materials on their own, working with groups with different skill levels, and discussing more than one solution related

to the same problem together. Therefore, they stated that they could solve new problems presented with STEM by using elements of the Montessori approach (Szostkowski, 2017). The fact that Montessori is based on personal exploration and goal attainment in a way that is meaningful to every child and STEM enables children meaningful and new ideas to cope with new problems in discovering the content that will be meaningful for them bring the effectiveness of applying the two types of education to the forefront (Elkin et al., 2014).

It is clear that the STEM and Montessori approach aims to provide common skills. Therefore, it is argued that STEM education should be given to children with support from the Montessori approach applied in the pre-school period to provide the individual with these skills from the ground up and to ensure their permanence (Çakır & Yalçın, 2020a). Teacher competencies and skills are significant criteria in nurturing individuals qualified and desired for the future society. For this reason, although studies on the development of pre-service teacher competencies have recently been conducted in this country, there are few studies on the Montessori approach and STEM education competencies that pre-school teachers should have in this technological age. Accordingly, in the present study, the influence of the Montessori approach based on STEM education on pre-service pre-school teachers' self-directed learning skills was explored by considering the significance of the education during the pre-school period. In addition, this education that will be provided to pre-service teachers aims to help them become experts in the field of STEM and Montessori education in their professional lives.

YÖNTEM

An explanatory design, a mixed-method type, was employed in the study. In mixed-method research a researcher or research team combines and blends the qualitative and quantitative research method elements (i.e., using the qualitative and quantitative points of view, data collection, analysis, inference techniques) to investigate a topic broadly and in depth to provide clearer understanding and validation (Johnson, Onwuegbuzie & Turner, 2007). On the other hand, in an explanatory mixed design, the researcher collects and analyses the quantitative data first. Then he/she collects qualitative data to support the quantitative data and associates the results (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz & Demirel, 2016). The explanatory design aims to begin the research problem with the quantitative stage and carry out a qualitative study to explain the quantitative results obtained in the second stage. This research is strengthened by the two easily understood and distinguishable phases of the study that build on each other (Sözbilir, 2017). Since the study included a single group, a pre-test post-test model was created. This group design is applied to compare the effect of the application on a group using the pre- and post-test scores (Cohen, Manion & Marison, 2007).

Research Population

An accessible population and purposive sampling were used in the research. The purposive sampling method helps the researcher reach the significant information sources related to a topic that will be researched, event, or phenomenon, and it enables research of the topic situations in depth (Patton, 2018). The research sample consisted of 53 pre-service teachers enrolled in the pre-school teaching department of a faculty of education in a state university located in eastern Turkey in the 2020-2021 educational year. It was determined that the pre-service teachers participating in the study had not received any education (some of them theoretically had some information due to their departments) related to the STEM and Montessori approach. Then the Montessori approach-based STEM activity was given to the pre-service teachers over 14 weeks for 2 hours per week.

Data Collection Tools

The Self-directed Learning Skills scale developed by Aşkın (2015) was applied to measure the self-directed learning skills of the pre-service pre-school teachers. The Cronbach's alpha inner consistency coefficient of the scale was calculated as 0.895. This reliability was calculated as 0.96 in the present study. In the reliability analysis of the research, the pre-test data applied to the 53 pre-service pre-school teachers in a pilot study were used. The scale consists of 21 items in total with 5-point Likert type of

rating. The dimensions of the self-directed learning scale are motivation (seven items), self-control (seven items), self-monitoring (five items), and self-confidence (four items).

The semi-structured interview form consisted of 12 open-ended questions. The items of the scale used for the content and face validity of these questions were taken into account. Examining these ideas one by one, answers were sought to questions such as the relationship of the Montessori-based STEM education with these items, which features of it, and how it affected it. The questions were prepared by considering the aim of the research and the sub-dimensions of the self-directed learning skills scale. In addition, the qualitative questions of the studies that are relevant to the aim of this research were examined (Elkin et al., 2014; Szostkowski, 2017; Yıldırım, 2021). The questions were prepared in parallel with these items and their purpose suitability was examined by 3 experts, one in mathematics and two in science education, and their approval was obtained. Related to the face validity, it was decided that the questions would serve the determined purposes in line with the feedback from the experts. Some examples of the interview form questions in the semi-structured interview form are presented below.

- Has the Montessori-based STEM education affected determining your learning needs and evaluating your results and contributed to gaining skills? How?
- Has the Montessori-based STEM education contributed to your ability to use different learning strategies? How?
- Has the Montessori-based STEM education contributed to the monitoring and planning of your learning process (planning the time, determining the learning method, etc.)? How?
- Has the Montessori-based STEM education influenced your initiative, self-confidence, and interest in learning and teaching new things? How?
- Has the Montessori-based STEM education contributed to your patience regarding learning (such as perseverance and not giving up)? How?

Data Analyses

Since 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 were normally distributed and the p significance value was above 0.05 (Can, 2016). With the normal distribution of the data, the correlated sample t-test, a 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 of the same group (Can, 2016).

Content analysis was applied to the qualitative data. The consecutive stages in the content analyses are coding data, determining categories, and arranging and identifying codes and themes (Yıldırım & Şimşek, 2008). The interviews with the participants were obtained and transcribed in the study. Codes were created by examining all the answers to each question. Then the codes with the same characteristics were grouped under the categories. The codes and categories created were tabularized and interpreted. The codes and categories created during the validity and reliability stages of the data analyses were presented to 5 different experts and the results were combined. The qualitative data analysis reliability value was 85%. The reliability value between the coders is over 70%, demonstrating that it is reliable (Arastaman, Öztürk Fidan & Fidan, 2018).

Ethical Information

The study was granted permission by the Human Research Ethics Committee of Erzincan Binali Yıldırım University with protocol number 07/15 on 31st May 2020 The volunteers selected from the sample group were informed about the topic and signed the consent form. All the rules in the Higher Education Institutions Scientific Research and Publication Ethics Directive were taken into consideration.

Process

A literature review (Elkin et al., 2014; Ibes and Ng, 2011) was performed related to the activities that would be applied for the Montessori approach-based STEM education practices during the study. In this review, it was ensured that the features that were desired to be measured in the pre-service teachers would include the STEM disciplines and Montessori approach philosophy and that it would create the excitement of designing new products by applying the content knowledge of the pre-service

teachers. In addition, it was considered that the pre-service teachers had the knowledge and experience they had gained from their previous practice for solving the problems they would encounter in practice, offer different fields of application in their professional life, and contribute to their personal development and be at a level that would be used throughout their lives.

The study period lasted 14 weeks in total with 2 hours per week. The applications were constituted with the participation of 53 pre-service pre-school teachers with guidance from an expert in the field. During implementation, the applications were conducted with guidance from an educator in virtual environments via distance education as it coincided with the Covid-19 epidemic. The materials used in the education application consisted of simple materials (such as plastic bottles/cups and lids, straws, cardboard boxes, insulating cables, cans, etc.) that can be easily obtained in daily life, are easy to recycle, and are affordable. Before the applications, the pre-service teachers were informed about the theoretical information related to STEM education and the Montessori approach. Then groups were created, consisting of no more than four students for 14 activities determined by the expert earlier. The participants were asked to perform the activity by giving them theoretical information (required information such as science and mathematics, visualisation of the activity to be done with drawing, etc.) about the problem situation related to the activity in the last week and how they will perform it. In addition, originality was taken as the basis of the activities, that is, a certain mould was not used with everyone creating the same product, but it was ensured that they produced solutions to the given problem and designed an original product in cooperation with the group. During this process, it was aimed to help the pre-service teachers to overcome their prejudices towards the solution of problems they encounter in daily life, to increase their self-directed learning and their sense of achievement, to develop their creative skills, to gain different perspectives, to improve their social communication skills, to establish a connection between the information they have learnt and their daily life situations, and to provide self-confidence for designing their products.

FINDINGS

The quantitative and qualitative findings related to the self-directed learning and its sub-dimensions are presented together with their interpretations in the tables below.

Table 1. *The paired samples t-test results related to the self-directed learning scale*

Measurements	N	$\bar{X}$	SS	t	sd	p
Pre-test	51	85.15	9.72	-9.655	50	.000
Post-test	51	100.21	6.01			

p<0.05

The paired samples t-test results applied between the pre- and post-test scores of the self-directed learning skills of pre-service pre-school teachers are given in Table 1. The paired samples t-test was applied to determine whether there was a significant difference between the pre-test and post-test scores of the effect of the Montessori approach-based STEM education on the pre-service teachers' self-directed learning skills. It was observed from the results of the test that there was a significant difference between the pre-application score average (pre-test = 85.15) and post-application score average (post-test =100.21) (t_{51}: -9.65, p< 0.05). Due to this significant difference, it can be claimed that the education given developed the pre-service teachers' self-directed learning skills.

Table 2. *The paired samples t-test results related to the self-control and self-monitoring sub-dimensions of the self-directed learning scale*

Measurements	N	$\bar{X}$	SS	t	p
Self-direction pre-	51	18.05	3.27	-9.731	.000
Self-direction post-	51	23.31	2.07		
Self-monitoring pre-	51	19.64	2.77	-8.877	.000
Self-monitoring post-	51	23.68	1.71		

The results of the paired samples t-test applied to determine the effect between the Montessori approach-based STEM education of the pre-service pre-school teachers' the pre-and post-test scores in the self-control and self-monitoring sub-dimensions related to the scale determining the self-directed learning are presented in Table 2. In the results of the test, a significant difference was encountered between the pre-application score average (pre-test = 18.05) and the scoring average after the application (post-test =23.31) (t50: -9.731; p=.000< 0.05). In the self-monitoring dimension, a significant difference was found between the scoring average before the application (pre-test = 19.64) and the scoring average after the application (post-test=23.68) (t50: -8.877; p=.000< 0.05). When all these results are taken into consideration, it can be claimed that the Montessori approach based on STEM education has positive effects on the pre-service pre-school teachers' self-control and self-monitoring skills of their self-directed learning.

Table 3. *The Wilcoxon signed ranks test results related to the motivation and self-confidence sub-dimensions of the self-directed learning scale*

Measurements	Ranks	N	Row average	Ranks total	z	p
Motivation post-test - Motivation pre-test	Negative Ranks	4	13.75	55	-5.314	.000
	Positive Ranks	42	24.43	1026		
	No difference	5				
Self-confidence post-test- Self-confidence pre-test	Negative Ranks	9	14.22	128	-4.545	.000
	Positive Ranks	37	25.76	953		
	No difference	5				

The paired samples t-test was applied to determine the effect between the Montessori approach-based STEM education on the pre-service pre-school teachers' self-directed learning scale pre-test and post-test scores in the sub-dimensions of motivation and self-confidence; however, the Wilcoxon signed-rank test, which is the nonparametric equivalent of this test, was used as the post-test–pre-test difference scores were not normally distributed. There was a significant difference between the pre-test and post-test scores of the pre-service teachers in the motivation sub-dimension (Z = -5.314; p=.000 < .05). Based on this difference, it can be claimed that education is related to motivation improvement, which is one of the sub-dimensions of the pre-service teachers' self-directed learning skills.

The qualitative data interview form results prepared based on the sub-dimension items of the self-directed learning scale are interpreted in a table below.

In Table 4, there is one category when the pre-service teachers' answers related to the questions "Did Montessori-based STEM education contribute to determining your learning purpose and have an impact on your ability to identify your own learning needs and evaluate the results? How?" were analysed. *In the category of feeling/thought*, the pre-service teachers expressed that they did not think that it would affect their learning needs before receiving Montessori-based STEM education and that the acquisition of these skills with this education is irrelevant and they cannot be acquired. On the other hand, some pre-service teachers claimed that they could not make any comments because they had no idea about the training to be given.

Seven categories were constituted from the results of the interviews conducted after the education. *In the category of self-directed learning,* there were expressions inferring that the education enabled self-directed learning skills. Due to the content of the education, they claimed that they gained the skills to determine and meet their own learning needs and to evaluate the results by asking the question of what they need to learn. In addition, they stated that they learnt to work regularly and in a planned way, they had knowledge about what is needed to be learnt, and it contributes to effective learning with this education. In addition, they stated some expressions related to their learning the answers to the questions about why the applications were conducted and what the results mean, and this contributed to the formation and clarification of ideas about determining learning goals and that their self-directed learning skills were developed, including that they could develop new learning strategies.

In the category of scientific skill, the pre-service teachers listed the scientific skills that they gained from the education with these codes. The pre-service teachers stated that they improved their ability to

see the events from different perspectives and that they received an active education in the course by improving their creative and assertive skills through the education.

Table 4. *The analysis results of the questions related to the self-control sub-dimension (identifying learning needs, goals, and evaluating learning outcomes)*

Pre-education interview results			**Post-education interview results**		
Category	*Code Name*	*f*	*Category*	*Code Name*	*f*
Feeling/Thought	No idea	5	Self-directed Learning	Learning need (determining/eliminating)	4
	Unable to gain skill	1		What should I learn?	3
	Believing it will have an impact	1		Regular/planned study	1
	Finding irrelevant	1		Effective learning	2
				Gaining skill-developing	5
				Self-development	1
				Evaluating results/contribution	5
				Determining learning tool	10
				Clarifying ideas	1
				Strategies	1
			Scientific Skill	Creativity	2
				Problem-solving	2
				Assertiveness	1
				Active learning	1
				Developing viewpoints	3
			Learning	Purpose of activities	1
				What problems does it solve	1
				Directing the purpose	1
				Topic wanted to be learnt	1
				Reason–result relationship	1
				Concrete understanding	1
			Life-long Learning	Applying the knowledge in life	1
				Gaining knowledge	1
				Continuing the process	1
				Professional life	1
			Learning	By trying/understanding	1
				Doing/living	1
				Eliminating memorising	4
				New methods	1

In the category of learning, the pre-service teachers stated that a contribution and skills were provided in learning analysis, making comments, determining learning goals, and acquiring new learning thanks to the education. The pre-service teachers claimed by maintaining the cause and effect relationship throughout the process that they realised concrete concepts in determining the learning goal in the practices, why the practices were done, which problems they offered solutions to, and what the results obtained meant, they were able to make sense of and interpret it, and that this learning was guiding when determining a goal. The pre-service teachers stated that before the training the learning objectives were only related to learning through memorising, that this purpose was replaced by learning by doing/experiencing and discovering, and that the subjects and strategies used in the training contributed to the creation of new objectives and methods.

In the category of life-long learning, the pre-service teachers claimed that before the education the learning objectives consisted only of acquiring information and memorising it, but now the educational objectives contribute to using the information they learnt in daily life and that the information they gained during this process will continue in their professional lives.

In Table 4, the pre-service teachers' answers to the questions "Did the Montessori approach-based STEM education contribute to your ability to monitor and plan your learning process (planning the time, determining the learning method, etc.) and your ability to use different learning strategies? How?" were analysed and two categories in the pre-education emerged. *In the category of bias*, the pre-service teachers' negative thoughts and biases that they had related to the education given to them were placed. The pre-service teachers stated that they thought that they could not gain different learning strategies over a few educational topics and that they did not think that they would have any benefit in learning.

In addition, it was stated that there were pre-service teachers who studied with the memorization method before receiving the training.

In the category of thought, the pre-service teachers stated that they could not make any comment about the learning skills they would gain, since they did not know the learning environments and educational content before the education. On the other hand, some pre-service teachers stated that they thought that they could contribute to the Montessori approach due to the knowledge because of their departments although they did not know the STEM dimension.

In the category of process, the pre-service teachers claimed that they thought that they would not contribute to planning the time before receiving the education, that they did not have a planned working order before they received the education, and some pre-service teachers stated that the education to be given might affect the planning of learning, but they did not know what kind of contribution it would make.

Six categories were created after the education. *In the category of learning*, the pre-service teachers stated that the education contributed to gaining different learning strategies, provided them with awareness in discovering new methods, and that they acquired methods for solving different problems. Some student answers are presented below.

> *The research should be conducted with the strategy and project method. Thus, children can be more curious and express their thoughts.*
>
> *During this education, the information to be given to the children should be more game-based, and the teacher should be involved in the activities when the children need help. Otherwise, the teacher should observe without interfering, and should allow the children to discover their mistakes themselves during the problem situation.*
>
> *The constructivist, investigative method can be applied, because the student is more active in these methods.*
>
> *There should be experiments and activities because students learn more effectively and permanently by experimenting and understanding.*
>
> *There should be methods that they can learn by discovering themselves, independent of the teacher and suitable for the interests of the students.*
>
> *Defining the problem and analysing it in a cause–effect relationship, suggesting more than one possible solution to the problem and determining the most appropriate one among them.*

In Table 5, they stated that they gained the skill of using different and new learning strategies thanks to the science, mathematics, and technological issues. They claimed that it contributed to their use of learning strategies by experimenting, doing, and associating with life and that they learnt theoretical knowledge from different fields after the education. *In the category of the teaching method strategy,* the pre-service teachers argued about the methods to be applied in the Montessori approach-based STEM education. Some pre-service teachers claimed that to carry out the activity a strategy can be applied in the form of firstly defining a problem and analysing it in a cause–effect relationship, suggesting more than one possible solution to the problem and determining the most appropriate one among them. On the other hand, some participants stated that experimental, research, and project-based methods should be used more for problem-solving. *In the category of time*, the pre-service teachers claimed that the education benefitted them in terms of planning and accurate use of time, saving time, and evaluation. *In the category of self-management*, the pre-service teachers mentioned the self-management skills they acquired from the education. The pre-service teachers stated that they could monitor and plan learning processes thanks to the education, and they noticed progress in using the activities in a planned manner and monitoring the learning processes; while they were learning without planning before the training, they now have the ability to be organized, use time effectively, and observe themselves. In addition, some pre-service teachers stated that they tended to learn through planned learning more than in their previous situations and they spared time for other learning, and they were able to analyse, evaluate, and make comments by asking themselves the question 'how I learnt to learn'. *The category of ways of solution* included the ways that the pre-service teachers applied for the problems that they encountered during the practice education.

Table 5. *Analysis results of the questions related to the self-monitoring sub-dimension (using different learning strategies, monitoring, and planning the learning process)*

Pre-education interview results			**Post-education interview results**		
Category	*Code Name*	*f*	*Category*	*Code Name*	*f*
Bias	Teaching with memorising	1	Learning	Learning by doing/living	1
	Not teaching different strategy	1		Learning by experiment	1
	Not benefitting	1		Learning by associating with life	1
				Theoretical learning	1
Thought	No knowledge	9	Learning Strategy	Problem solution	2
	Education content	4		Different strategy	6
	Having contribution	3		Different problems	1
				New methods	1
				Awareness	1
				Contributing	1
Process	Planning learning	1	Teaching Method/strategy	Constructivist method	1
	Planning time	1		Project method	1
	Plan	1		Research method	2
	Planned studying	1		Analysing	1
				Cause and effect relationship	1
				Identifying the problem	1
				Problem-solving method	3
			Time	Correct use	1
				Saving	1
				Ability to plan	5
			Self Management Skill	Self-observation	1
				Monitoring the learning process	5
				Planning learning process	5
				Taking responsibility	1
				How can I learn?	1
				Sparing time for different learning	1
				Planned studying	5
				Systematic work	1
				Unplanned learning	1
				Compare with the old	1
			Planning the Ways of Solution	Solving step by step	1
				By discussing	2
				Idea presentations	3
				Educator support	1
				Getting to problem root	3
				Not giving up	1
				Trial and error	1
				Literature review	2
				Applying to non-field branches	1
				Using content knowledge	1
				Creating cooperation	3
				Seeking guidance	1

The pre-service teachers stated that they made progress through the construction phases again, step by step, free of errors to solve the problems; that they created a discussion environment within the group by getting to the root of the problem; that everyone stated their opinions related to the problem by doing a literature review; that they put these ideas expressed by the group into practice by trial and error; that they never gave up on finding the result and they patiently continued to try solutions; and that they acquired all these behaviours thanks to the training. In addition, the pre-service teachers claimed that they made progress when faced with a problem by distributing different tasks and giving directions to everyone in cooperation, which they tried to solve by asking and researching their pedagogical content knowledge and non-field STEM integrated discipline information with the support of the trainers. Some teachers' answers are presented below.

> *I had no information about it before the education. However, after the education, I learnt that there were different learning strategies thanks to the strategies that it includes. Then I realised that thanks to the science, mathematics, and technology subjects that it includes, it benefitted me in terms of the skills of using various and new learning strategies.*

Before the education, I learnt by memorising generally as others do. However, after the education, I learnt with learning strategies by conducting the experiment, doing by myself, and associating it with real life.

As I did not know the content of the education, I had no idea about how it would benefit me. The education contributed much. Yes, because other approaches were within a narrower circle of mathematics and science. The environment has become more fun and more inspiring thanks to STEM and science and mathematics applications.

Table 6. *The analysis results related to the motivation sub-dimension (love to learn and not giving up on learning/perseverance in learning)*

Pre-education interview results			**Post-education interview results**		
Category	*Code name*	*f*	*Category*	*Code Name*	*f*
Feeling/Thought	Ineffectiveness	1	Self-directed Learning	Patience	11
	Perseverance	3		Not giving up	4
	Impatience	4		Perseverance	1
	No idea	5		Learning topic	1
				Spreading over time	1
				Helping	1
				Ability to teach	1
			Activities	Product creating	2
				Applications/experiments	3
				Activity process	1
				Performing phase	1
				Education content	1
				Unsuccessful results	1
				Finding correct result	1

When the pre-service teachers' answers related to the question 'Did the Montessori approach-based STEM education contribute to your patience in learning (perseverance, not giving up)? How?' were analysed, one category emerged in the pre-education. *In the category of feeling/thought*, some pre-service teachers expressed that they did not have any ideas as they had no information related to the education; some stated that the education would not influence learning patience and that they did not demonstrate patience and perseverance in learning a subject before the education.

There are two categories in the post-education answers. *In the category of self-directed learning*, there are pre-service teachers' expressions stating that the education provided contributed to patience towards learning via self-directed learning skills. *In the category of activities*, the pre-service teachers stated that they learnt patience and perseverance from the education although they encountered difficulties in finding the result during the stage of creating a product, especially in the applications; and that the subjects in the education would not be learnt all at once and effective learning by spreading it over time would enable them become an individual who has patience in learning, not giving up despite unsuccessful results in the activities, and patiently reviewing their mistakes in the construction stages and making corrections. Some of the pre-service teachers' answers are given below.

After the education, I gained self-confidence acquiring new ideas and finding that complex problems can be taught with simple applications.

Thanks to this education, I gained considerable self-confidence in learning and teaching. I noticed a lot of improvement in my self-confidence thanks to the expansion I experienced in what I learnt and what I could teach in this education.

With more rapid comprehension and understanding of the topic, noticing that I was able to do this with putting it into practice I can say that it both encouraged me and gave me confidence.

While I behaved more diffident in the classroom when I could not solve the problems, I became more sociable after this education and it contributed much to my self-confidence.

Table 7. *Analysis results related to the self-confidence sub-dimension (self-confidence/self-perception, taking responsibility for learning, assertiveness, and independence)*

Pre-education interview results			**Post-education interview results**		
Category	*Code name*	*f*	*Category*	*Code name*	*f*
Thought/Feeling	Not having effect	4	Scientific Process Skill	Sociability	7
	Finding it stable/classic	2		Creativeness	1
	Being limited in learning	1		New points of view	2
	Education content	2		Problem-solving	1
	STEM education	1		Critical thinking	1
	No idea	11		Discussing the ideas	1
	Learning interest	3		Creating synergy	1
	Determination	2			
	Confidence	4			
Knowledge /skill	Learning	2	Feeling/ Thought	Interest	4
	Sociability	2		Spirit of design	3
	New information	1		What can I do?	9
				Observations	1
				Contributing/influencing	4
			Personal Development	Encouragement	1
				Self-confidence	9
				Teaching/learning self-confidence	3
				Professional contribution	2
				Problem-solving	1
				Contributing	1
				Assertiveness	2
				Avoidant behaviours	1
				Learning styles	1
				Learning new things	1
				Change	1
			Self-direction	Tendency to new learning	2
				Being conscious	1
				Being planned/programmed	4
				Contributing	2
				Reinforcing responsibility for learning	7
				Making research	1
				Different viewpoints	1
			Effect on Assertiveness	Team spirit	1
				Socialization	1
				Professional life	1

In Table 7, two categories emerged during the pre-education when the pre-service teachers' answers related to the questions 'Did the Montessori approach-based STEM education contribute to your assertiveness and interest in learning new things, develop your responsibility to learn, and contribute to your self-confidence in learning and teaching and to your belief that you can apply this education in your classroom in the future? How? *In the category of thought/feeling*, the pre-service teachers stated that the activities would be the usual classical ones before the education, that they thought limited learning would be provided, that they could not give any answer to the question as they had no information related to the education; some claimed that it would not have any effect on learning, while some stated that they knew the content of the education in a theoretical sense and that it would not have an effect. The pre-service teachers stated that they were willing to learn even before the education and that they were interested in learning new information and happy to learn new things. *In the category of feeling/thought*, some pre-service teachers claimed that they had no information related to the education before; some stated that they had the self-confidence to be determined to learn and strived to reach the result without giving up, but that they did not have this confidence in teaching, and that they could not give enough confidence to children due to their shy attitudes in their professional lives. Some pre-service teachers stated that they thought that the education to be given would not have any contribution to learning and teaching. *In the category of knowledge/skill,* some pre-service teachers stated that they were assertive towards learning new information even before the education.

In the answers in the post-education, five categories emerged. *In the category of the scientific process,* the pre-service teachers claimed that the education contributed much to their interest in

learning new things and developed their scientific process skills. The pre-service teachers stated that learning new things improved their skills to learn new activities, increased their sense of initiative (especially in teaching children), and increased their initiative towards research in solving the issues they could not understand, and they gained new perspectives with the new information they learnt and they created discussion environments and synergy by presenting different and new ideas in the classroom environment, as well as creativity, critical thinking, and problem solving.

In the category of feeling, the pre-service teachers stated that their interests and assertiveness related to learning new things increased thanks to the new activities and their observations in the applications in education. The pre-service teachers who already had these feelings before the education claimed that it contributed much to this topic. In the light of applications during the education and information given about the various examples of these, they stated that the spirit of design and assertiveness stimulates them and encourages them to question what else they can do.

In the category of benefits of education, the pre-service teachers claimed that it contributed to learning every subject that was not understood and wondered about explained by the educator, to present to the student different application types and the willingness to learn.

In the category of personal development, the pre-service teachers expressed that, thanks to the practices in the education they received, they achieved permanent learning by overcoming the subjects that seem difficult in an enjoyable way; they acquired new activities and information professionally, so they developed different learning styles; and it encouraged them to solve the problem situations in the activities and contributed to their self-confidence to learn and especially to teach. In addition, they stated that while they demonstrated shy behaviours in the classroom as they could not solve a problem before the training, they were more sociable and self-confident after the education.

In the category of self-control, the pre-service teachers stated that the education contributed to their behaviour towards self-directed learning, which was more planned, programmed, responsible, and made them more inclined to learn new things and developed their responsibilities to learn by searching. The pre-service teachers claimed that they had this skill before but they became more conscious of it with this education.

In the category of influence on assertiveness, the pre-service teachers stated that the education would contribute to their professional life by creating a team spirit together with the group, and their study contributed to their socialisation and their acquiring new information. Some of the teachers' answers are presented below.

> *I had no idea about planning or such kind of education before I received the education. But it contributed much to me regarding how, where, and for how long to plan the activities.*
>
> *I wasn't a very planned person before I received the education. At the end of the education, it contributed much in terms of how to follow a path in learning and how to plan with application examples.*
>
> *I didn't think it would help especially with time before I received the education. But, after the education, yes it contributed. While I was learning without previous planning, I solved problems earlier by using my time correctly, observing myself, and thinking practically then.*
>
> *With this education, I was able to save time and allocate more time to other subjects I needed to learn by planning compared to the past. I could solve problems early as I brought my practical thinking to a better level over time in the activities and experiments we did.*

RESULTS AND DISCUSSION

The present study investigated the effect of the Montessori approach based on STEM education on pre-service pre-school teachers' self-directed learning. In addition, within the scope of this purpose, the effects on the dimensions of self-monitoring, self-control, motivation, and self-confidence in learning were investigated separately with both quantitative and qualitative data. Consequently, significant differences were seen between the pre-test and post-test scores of the effects of the applied education on the pre-service pre-school teachers' self-directed learning skills and self-regulation, self-monitoring,

motivation, and self-confidence, which are the sub-dimensions. With this significant difference, it can be claimed that the STEM education integrated with the Montessori approach affects individuals' self-directed learning positively. Moreover, it can be stated according to the observations made and interviews conducted during the process that the pre-service teachers developed these skills.

The results obtained in the qualitative data part of the study were found to support these significant differences. In the qualitative results, the results suggested that the pre-service teachers' self-monitoring, motivation, self-control, and self-confidence skills improved in learning. The pre-service teachers stated that they had learnt different learning strategies and to monitor their learning processes and started to make learning plans. They claimed that their motivation feelings in learning new things were increased, they started to enjoy learning, and learnt to show perseverance and not to quit when solving a problem as a result of the education. These results indicate that the education provided to the pre-service teachers improved their determining their own needs and goals for learning, and self-evaluation of learning results, allowed them to look at the problems they face in their lives in a more solving and idea-generating way, and increased their self-confidence.

They stated that their self-confidence related to learning and teaching increased, their assertiveness levels in the education field rose, they started to present their thoughts independently, and had learning responsibility. Accordingly, supporting the results, Çakır and Yalçın (2020a) found that Montessori-based STEM activities developed pre-service pre-school teachers' self-directed learning skills such as self-confidence, monitoring the learning process, doing analysis/evaluation, and solving daily-life problems. Çakır and Yalçın (2021a), who studied a similar subject, found that the self-confidence of pre-service pre-school teachers, specifically regarding learning and teaching science subjects, increased, they gained learning responsibilities and could apply self-evaluation. Considering the results that are supported with the literature, it can be stated that the study has achieved its purpose and these individuals, who will be the primary education teachers of the future, have developed their self-management skills, which are considered within the scope of 21st-century skills, to a certain extent, with the help of the training provided. Thus, we can claim that it contributed to the self-confidence transfer of what they learnt in educating the productive future generations. In addition, Montessori and STEM education is highly effective in developing these skills that should be obtained in the current age.

Yalçın (2019) reported that STEM applications developed the individual's self-directed learning skills. In the education, the individuals participated in the applications actively and active learning was achieved. Aydede and Kesercioğlu (2012) stated that they found that active applied learning made significant differences to students' self-learning skills. Noyat, Karahan, and Alakuş (2018) claimed that the Montessori approach increased helping among students, that children participated in classes without instructions according to their wishes, and that their creativity developed. In addition, the pre-service teachers stated that the education developed their creativity, critical thinking, cooperation, and problem-solving skills; they gained new knowledge/skills and applied them in designing products; and they acquired new questioning and interpretation skills. In the study by Karataş and Başbay (2014), it was determined that as the pre-service teachers' critical thinking tendencies, academic achievements, and general self-efficacy skills increased, their readiness for self-directed learning also increased. Kabadayı (2019) reported that his robotic applications developed the pre-school children's creativity, algorithmic thinking skills, and their ability to reflect these skills in their designs and to establish relationships between concepts. Şahin Sak (2015) stated that the Montessori approach supported creativity and cooperation. It was reported that the education was appropriate to the Turkish education system; however, only one pre-service teacher claimed that the Montessori approach would not be appropriate as Turkey's education system is a rote-oriented system and would cause a financial burden. Şahin Sak (2015) stated that, among the pre-school pre-service opinions related to the Montessori education, half of the participants claimed that it would not be possible to apply this approach in Turkey; approximately half of them stated that it would be extremely difficult but not impossible.

The pre-service teachers stated that they knew the scientific and technological issues thanks to the education and were directed to research in this field. To support this, Yasin, Prima, and Sholihin (2018) found in their study that STEM learning developed the individual's STEM literacy. In their study,

Bircan and Köksal (2020) suggested that the students' STEM attitude levels were positive in general and that gifted students were interested in the STEM career professions.

In the qualitative results of the research, the pre-service teachers stated that STEM developed the students' critical thinking skills, directed them to produce, presented concrete experiences, and should be included in the curriculum. Supporting the result, Uğraş and Genç (2018) explored the pre-service pre-school teachers' opinions towards STEM. At the end, the pre-service teachers claimed that STEM directed the students to think and apply the information in practice, and they gained the skill to obtain concrete products. Moreover, they stated that teachers from different disciplines should work in cooperation, STEM courses should be included in post-graduate programmes, and teachers should receive STEM education.

In the present study, the pre-service teachers reported that they gained new information and skills with the Montessori approach-based STEM education, which benefitted them in terms of personal, social, and professional development. In addition, they stated that education would have positive effects on the children's development and therefore both types of education should be integrated into the education programme. Oğuz and Köksal Akyol (2012) reported that the Montessori approach supports the child's cognitive, social, and physical development; uncovers creativity; and will be effective if used in child education in today's world. Şahin and Hacıömeroğlu (2021) claimed in their study in which they investigated pre-service pre-school teachers' opinions related to STEM that this education contributed to the development of the students' knowledge and skills; increased the students' awareness related to the science, technology, engineering, and mathematics subjects; and would improve their orientation to these areas in their career choice. Topsakal and Yalçın (2020) found significant differences in the learning climate of the problem-based STEM activities. In addition, they claimed that the activities had positive effects on the feeling, thoughts, and behaviours of the students.

At the end of the research, the pre-service teachers claimed that the education developed their creativity, that they could solve complex problems, that this gave them the sense of success, that they could solve daily life problems, and it increased their self-confidence and eliminated their bias concerning science and mathematics. Tiryaki and Adıgüzel (2021) stated that STEM-based robotic applications increased the students' creativity and affected their attitudes towards science positively, that they enjoyed learning, that they felt like scientists during the applications by using robotics and complex software materials to solve daily life problems, and that it influenced their career choices in the future. Samur and Yalçın (2021) stated that STEM activities developed the pre-service pre-school teachers' reflective thinking skills, that they made a connection with daily life, that the use of many scientific fields together developed the ways of synthesis, and that it led to the formation of new ideas by questioning their opinions, thus improving their multi-dimensional thinking. Lee (2005) claimed that reflective thinking activities affected individuals by having a positive impact on their personal development as well as generating new ideas and that pre-service teachers should be supported with courses to develop their reflective thinking. Accordingly, it was concluded that the Montessori approach-based STEM education provided individuals with self-directed learning, synthesis, generating new ideas, questioning, and personal development with multidimensional thinking.

When the literature was reviewed, it was determined that self-directed learning, which is a fundamental skill that should be gained by pre-service teachers in the faculties of education for individuals to move society forward in our age of science, was at a low level. Considering that these pre-service teachers will nurture the future generations, especially since they are a pre-school department, which means the beginning of basic education, they must first learn these skills themselves. Gaining these skills is possible with the Montessori and STEM education that has recently been introduced in the education system. Even though the significance of integrating the Montessori and STEM education into all levels from pre-school education has been emphasised, it was determined that there was an insufficient number of research studies in the literature. The present study is of great significance in terms of eliminating the lack of studies compared to the importance of the Montessori approach and STEM education in the literature and the contribution of the integration of the education programmes in the education faculties to individuals. Regarding limitations, since it is closely related to the purpose, it can be claimed to be limited to the pre-service teachers enrolled in the pre-school department only.

In addition, only the university in the city where the researcher was located was considered due to time and cost. Another limitation is that consent was obtained only from four experts in the field of science and mathematics education during the reliability determination stage of the semi-structured interview form prepared by the researcher in the study. Some positive recommendations that can be made based on the positive results of the study can be stated as follows. Laboratory studies and courses related to Montessori and STEM education can be offered in the faculties of education. Educational practices and training seminars can be given to pre-service pre-school teachers related to integrating the Montessori and STEM education together and their awareness can be raised. It is useful that our teachers who will nurture the future generation are equipped with this training, by integrating it into all branches not only in the pre-school teaching department but also in the faculties of education.

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Montessori Yaklaşımı Temelli STEM Eğitimlerinin Okul Öncesi Öğretmen Adaylarının Öz Yönetimli Öğrenmeleri Üzerindeki Etkisi[1]

Zehra Çakır (Dokt. Öğr.)
Erzincan Binali Yıldırım Üniversitesi-Türkiye
ORCID: 0000-0003-4585-8214
zehracakir.29@hotmail.com

Prof.Dr. Sema Altun Yalçın
Erzincan Binali Yıldırım Üniversitesi-Türkiye
ORCID: 0000-0001-6349-2231
sayalcin@erzincan.edu.tr

Özet

Araştırmada Montessori yaklaşımı temelli STEM eğitimlerinin; okul öncesi öğretmen adaylarının öz yönetimli öğrenme becerileri üzerindeki etkisi incelenmiştir. Araştırmada karma yöntem kullanılmıştır. Araştırmanın örneklemini Doğu Anadolu' nun orta ölçekli bir ilindeki devlet üniversitesinin Eğitim Fakültesi Okul Öncesi Öğretmenliği Bölümünde öğrenim gören 53 öğretmen adayı oluşturmuştur. Araştırmada öğretmen adaylarının öz yönetimli öğrenme becerilerindeki değişimi belirlemek amacıyla tek grup öntest sontest deseni oluşturulmuştur. Araştırmada nicel verilerin elde edilmesinde "Öz Yönetimli Öğrenme Becerileri" ölçeği ve nitel veriler için de "Yarı Yapılandırılmış Mülakat Formu" kullanılmıştır. Araştırma süresince toplamda 14 hafta boyunca haftada 2 ders saati olmak üzere adaylara Montessori yaklaşım temelli STEM eğitimleri verilmiştir. Araştırmada elde edilen nicel verilerin analizi ilişkili örneklem t testi ile nitel verilerin analizi ise içerik analizi ile yapılmıştır. İçerik analizinde verilerin kodlaması yapıldıktan sonra, kodlama yapılan verilerin temaları yazılmıştır. Araştırmanın geçerliliğine katkı sağlamak için, bulgular bölümünde katılımcı grubun doğrudan alıntılarına yer verilmiş ayrıca katılımcı teyidi gerçekleştirilmiştir. Veri analizinin güvenirliğine katkı sunmak için, veri analizi esnasında beş uzman tarafından sonuçların birbiri ile tutarlılığı kontrol edilmiştir. Araştırma sonucunda öz yönetimli öğrenme becerilerinin öntest ve sontest puanları arasında, anlamlı bir farklılık olduğu ve yapılan nitel analiz sonuçlarının da bu farkı gelişim yönünde desteklediği gözlenmiştir. Bu gelişimler öğretmen adaylarının mülakatlarında eğitimlerin kişisel ve sosyal gelişimlerine oldukça katkı sağladıklarını, bir konu hakkında öğrenme ve öğretme becerisi kazanma konusunda yardımcı olduğunu belirten ifadelerinden tespit edilmiştir. Elde edilen sonuçlar doğrultusunda Montessori yaklaşımı temelli STEM eğitimlerinin okul öncesi öğretmen adaylarının özgüven, sebat gösterme, kendi kendine planlı öğrenme, öz değerlendirme yapabilme gibi öz yönetimli öğrenme becerilerinin geliştiği yorumu yapılabilir.

Anahtar Kelimeler: *Montessori yaklaşımı, Okul öncesi öğretmen adayları, Öz yönetim, STEM*

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Genişletilmiş Özet

Problem: Bilginin hızla değiştiği ve arttığı günümüz toplumlarında, bireylerin öğrenme ihtiyaçlarının karşılanması, bilgilerin doğrudan aktarılmasıyla sağlanamamaktadır (Timur ve Taşar, 2020). Artık önemli olan, bireylere bilgiye kendilerinin ulaşma yollarını öğrenme becerilerinin kazandırılmasıdır. Böylece, kendi öğrenmesini planlayabilen, düzenleyebilen, yönetebilen, kendi öğrenme ihtiyaç ve sorumluluklarını karşılayarak kendini gerçekleştiren; dolayısıyla öğrenmeyi öğrenmiş, öz-yönetimli, yaşam boyu öğrenmeyi gerçekleştirmiş bireylerin yetiştirilmesi gerekmektedir. Bunu sağlamanın en etkili yolu ise erken yaşta başlanan nitelikli bir eğitimdir. Okul öncesi dönemde çocuklarının araştırma, tasarım, öz yönetimli öğrenme, 21.yy ve akıl yürütme becerilerini geliştirmek için hangi eğitim yaklaşımlarının etkili olduğu konusunda araştırmalar artmıştır (Keulen, 2018). Literatürlerde okul öncesi dönemde uygulanan Montessori yaklaşımı (Çakır, Yalçın ve Yalçın, 2020) ve STEM eğitimi çocuklara bahsedilen becerilerin kazandırması açısından (Uğraş, 2017) önemi vurgulanmıştır. STEM eğitimi, disiplinler arası yaklaşımları içinde barındıran; bilim, teknoloji, mühendislik ve matematik disiplinlerinin entegrasyonuna dayanan bir öğretim sürecini ifade etmektedir (Erol ve İvrendi, 2021). Montessori yaklaşımı ise bir yaşam tarzı, bir var olma ve geleceğe doğru yürüme tarzı olarak tanımlanabilir (Jara, Zapata & Alcívar, 2021). Bender (2018) ise STEM eğitimini gerçek hayat problemlerini çözmek, Çakır ve Yalçın (2019) ortak benzerlikteki Montessori yaklaşımını da gerçek yaşam becerilerini ve sorunları çözebilme becerisi kazandırmak olarak tanımlamaktadır. Bu yaklaşımın amacı çocukların fiziksel, kişisel ve sosyal gelişimlerinin bütün yönlerden desteklemek ve yaşam boyu öz yönetimli öğrenme sorumluluğuna sahip bireyler yetişmesini amaçlamaktadır (Güney ve Öz, 2021). Montessori yaklaşımı felsefesi ile hazırlanmış materyaller çocuğa; işbirliği içerisinde çalışma isteğini ve zevkini, üretkenliğini, dikkatini yoğunlaştırmayı, sorgulayabilmeyi, yaratıcılığı, özgüveni, analiz edebilmeyi, sorumluluk bilincini, bir problemi nasıl çözeceğini, kendisine ve başkalarına saygı duymayı içeren davranış ve becerileri kazandırır. STEM eğitimi için de Chesloff (2013) STEM' in merkezindeki kavramları; merak, analiz, yaratıcılık, işbirliği, problem çözme, yaşam boyu öğrenme, öğrenme sorumluluğuna sahip ve eleştirel düşünme olarak görmektedir. Ayrıca STEM eğitimi bireyin 21.yy becerilerini geliştirerek teknolojinin ilerlemesine ve böylece ekonominin canlanmasına katkı sağlayacaktır (Wang, 2012). Görüldüğü üzere STEM ve Montessori yaklaşımı amaçları ortak becerileri kazandırmayı amaçlamaktadır. Bu nedenle bireyde bu becerilerin temelden kazandırılması ve kalıcılığının sağlanması için STEM eğitimin okul öncesi dönemde uygulana Montessori yaklaşımı felsefesiyle harmanlanarak çocuğa verilmesi gerektiği savunulmaktadır (Çakır ve Yalçın, 2020a). Montessori-STEM' de amaç, Montessori felsefesinin temel ilkelerini ve müfredatını esas alarak öğrencilerin STEM düşünme ve uygulama alanlarını bir dizi tasarım etkinliklerle geliştirmek ve bilim içeriğini güncel, doğru bir şekilde aktarmaktır (Ibes ve Ng, 2011). Elkin vd. (2014), STEM' deki temel mühendislik kavramları ve Montessori ilkeleri alanları arasında çok sayıda uyumlar olduğunu belirtmişlerdir. Örneğin Montessori sınıflarında öğrencilerin uygulamalı materyalleri kendileri kullanmada, çeşitli beceri düzeylerine sahip gruplarda çalışmada ve aynı probleme yönelik birden fazla çözümü birlikte tartışma konularında çok iyidirler. Dolayısıyla bu Montessori yaklaşımı unsurlarının STEM ile sunulan yeni problemlere karşı başarılı bir şekilde gerçekleştireceklerini belirtmiştir (Szostkowski, 2017). Montessori, kişisel keşfi ve her çocuk için anlamlı olan bir yoldan hedefe ulaşmayı temel alması STEM' inde, çocuklara içeriği keşfetmeleri konusunda onlar için anlamlı olacak şekilde yeni fikirlerle mücadele etmeleri için bir yol sunması iki eğitimin birlikte uygulanmasının etkililiğini öne çıkarmaktadır (Elkin vd. (2014). Araştırmanın amacı, okul öncesi dönem eğitiminin önemi dikkate alınarak Montessori yaklaşımı temelli STEM eğitimlerinin okul öncesi öğretmen adaylarının öz yönetimli öğrenme becerileri üzerindeki etkisini araştırmaktır. Ayrıca öğretmen adaylarına hizmet öncesinde verilecek bu eğitimler ile meslek hayatlarında STEM ve Montessori eğitimleri alnında birer uzman olmalarını sağlamaktır.

Yöntem: Araştırmada, karma yöntem türlerinden biri olan açıklayıcı deseni kullanılmıştır. Karma yöntem araştırması, bir araştırmacının veya araştırmacılar ekibinin, konuyu geniş ve derinlemesine incelemek, daha net anlaşılmasını ve doğrulanmasını sağlamak için nitel ve nicel araştırma yöntemlerinin unsurlarını (örn. nitel ve nicel bakış açılarının kullanımı, veri toplama, analiz, çıkarım teknikleri) birleştirdiği, harmanladığı araştırma türüdür (Johnson, Onwuegbuzie & Turner, 2007). Açıklayıcı karma desen ise araştırmacı ilk önce nicel verileri toplayıp analiz eder. Daha sonra nitel verileri niceli desteklemek için toplar ve sonuçları ilişkilendirir (Büyüköztürk, Kılıç- Çakmak, Akgün, Karadeniz ve Demirel, 2016).

Açıklayıcı desenin amacı, araştırma problemine nicel aşama ile başlayıp, ikinci aşamada elde edilen nicel sonuçları açıklamak için nitel çalışma yürütmektir. Bu araştırma gücünü çalışmanın birbiri üzerine inşa edilen kolayca anlaşılan ve ayırt edilen iki aşamasından almaktadır (Sözbilir, 2017). Araştırmanın örneklemini, Doğu Anadolu Bölgesindeki bir devlet üniversitesinde 2020-2021 eğitim öğretim yılı, eğitim fakültesi okul öncesi öğretmenliği bölümünde öğrenim gören 53 öğretmen adayı oluşturmaktadır. Çalışmaya katılan öğretmen adaylarının, daha önce herhangi bir STEM ve Montessori etkinliklerine yönelik, eğitim almadıkları (bazıları teorik anlamda bölümleri gereği azda olsa bilgiye sahiptir) tespit edilmiştir. Daha sonra öğretmen adaylarına 14 hafta boyunca haftada 2 saat olmak üzere Montessori yaklaşımı, temelli STEM etkinlikleri uygulatılmıştır. Okul öncesi öğretmen adaylarının öz yönetimli öğrenme becerilerini ölçmek için, Aşkın (2015) tarafından geliştirilen "Öz Yönetimli Öğrenme Becerileri" ölçeği kullanılmıştır. Öz yönetimli öğrenme ölçeği, derecelendirme şeklinde 5 likertli ve toplamda 21 maddeden oluşmaktadır. Öz yönetimli öğrenme ölçeğinin boyutları sırasıyla güdülenme (7 madde), öz-kontrol (5 madde), öz-izleme (5 madde) ve özgüven (4 madde) olarak belirlenmiştir. Yarı yapılandırılmış mülakat formu ise 12 açık uçlu sorudan oluşmaktadır. Bu soruların kapsam ve görünüş geçerliliği için kullanılan ölçeğin maddeleri dikkate alınmıştır. Bu maddeler teker teker incelenerek Montessori temelli STEM eğitimlerinin bu maddelerle ilişkisi, hangi özelliklerinden dolayı ve nasıl etkilemiş olduğu gibi sorulara cevap aranarak detaylı bir şekilde ortaya konulmaya çalışılmıştır. Sorular çalışmanın amacına ve öz yönetimli öğrenme ölçeğinin alt boyut maddelerine paralel olarak hazırlanmıştır. Ayrıca çalışma konusuyla ilgili olan çalışmaların nitel soruları incelenmiştir. Sorular bu maddelere paralel olarak hazırlanmış ve amacına uygunluğu bir matematik, iki fen bilimleri eğitimi alanındaki 3 uzmana inceletilerek onayları alınmıştır.

Bulgular: Çalışmada Montessori yaklaşımı temelli STEM eğitimlerinin okul öncesi öğretmen adaylarının öz yönetimli öğrenmeleri üzerindeki etkisi incelenmiştir. Ayrıca bu amaç kapsamında öğrenmede öz izleme, öz kontrol, güdülenme ve özgüven boyutlarındaki etkilere de hem nicel hem nitel verilerle ayrı ayrı bakılmıştır. Sonuç olarak uygulanan eğitimlerin okul öncesi öğretmen adaylarının öz yönetimli öğrenme becerilerinin ve alt boyutları olan öğrenmede öz düzenlemelerini yapma, öz izleme, güdülenme ve öz güven boyutlarının ön ve son test puanları arasında anlamlı farklılıklara ulaşılmıştır. Testin sonuçlarında uygulama öncesi puan ortalaması (Öntest = 85,15) ile uygulama sonrası yapılan puan ortalaması (Sontest =100,21) arasında anlamlı bir fark görülmüştür (t51: -9,65, p=0,000< 0,05). Ayrıca alt boyutların sonuçlarındada anlamlı fark buunmuştur. Testin sonuçlarında öz kontrol boyutunda; uygulama öncesi puan ortalaması (öntest = 18,05) ile uygulama sonrası yapılan puan ortalaması (sontest =23,31) arasında anlamlı bir fark görülmüştür (t51: -9,731; p=0,000< 0.05). Öz izleme boyutunda ise uygulama öncesi puan ortalaması (öntest = 19,64) ile uygulama sonrası yapılan puan ortalaması (sontest =23,68) arasında anlamlı bir fark görülmüştür (t51: -8,877; p=0,000< 0.05). Güdüleme ve özgüven alt boyutlarındaki ön-son test puanlarının arasındaki etkiyi belirlemek amacıyla bağımlı gruplar t testi (paired samples t-test) yapılmak istenmiş ancak son test – ön test fark puanlarının normal dağılmaması nedeniyle bu testin nonparametrik karşılığı olan Wilcoxon işaretli sıralar testi yapılmıştır. Öğretmen adaylarının güdülenme alt boyutunda ön-test ve son-test puanları arasında anlamlı bir fark görülmüştür (Z = -5,314; p=,000<.05).

Çalışmanın nitel veri kısmındaki sonuçlarında bu anlamlı farklılıkları destekler nitelikte çıkmıştır. Nitel sonuçlarda öğretmen adaylarının öğrenme konusunda öz izleme, güdülenme-motivasyon, öz kontrol ve özgüven becerilerinin geliştiğini belirten sonuçlara ulaşılmıştır. Adaylar farklı öğrenme stratejileri öğrendiklerini, kendi öğrenme süreçlerini izlemeyi öğrendiklerini ve öğrenme planları yapmaya başladıklarını belirtmişlerdir. Verilen eğitimler neticesinde yeni şeyler öğrenme konusunda motivasyon-güdülenme duygularının geliştiğini, öğrenmeyi sevmeye başladıklarını ve bir problem karşısında çözümünü öğrenmekten vazgeçmemeyi, sebat göstermeyi öğrendiklerini belirtmişlerdir. Yine nitel sonuçlar arasında adaylar öğrenmeye yönelik kendi ihtiyaç ve amaçlarını belirlemeyi öğrendiklerini, bunları çıktıları olan öğrenme sonuçlarını öz değerlendirme yapabilmeye başladıkları sonuçları kaydedilmiştir. Öğrenme ve öğretme konusunda öz güvenlerinin arttığını, eğitim alanlarında girişkenlik seviyelerinin arttığını, düşüncelerini bağımsızca sunabilmeye başladıklarını ve öğrenme sorumluluğuna sahip olduklarını belirtmişlerdir.

Öneriler: Literatüre bakıldığında eğitim fakültelerinde öğretmen adaylarının yaşadığımız bilim çağında bireylerin toplumu ileriye götürebilmek adına sahip olması gereken temel becerilerden biri; öz yönetimli öğrenme becerilerinin düşük olduğu tespit edilmiştir. Bu adayların özellikle okul öncesi bölüm olması yani temel eğitimin başlangıcı konumunda olmasıyla ilerde geleceğin bireylerini yetiştirecekleri düşünüldüğünde öncelikli olarak kendilerinin bu becerileri sağlamaları gerekliliği ortaya çıkmaktadır. Bu becerilerin elde edilmesi ise son zamanlarda ülkemizde eğitim sisteminde yer almaya başlayan Montessori ve STEM eğitimiyle mümkündür. Montessori ve STEM eğitiminin okulöncesi eğitimden itibaren bütün kademelere entegre edilmesinin önemi belirtilmesine rağmen literatürde yapılan araştırmaların yetersiz olduğu tespit edilmiştir. Çalışmanın olumlu sonuçları doğrultusunda yapılacak bazı öneriler ise Montessori ve STEM eğitimi uygulamalarıyla ilgili eğitim fakültelerinde laboratuvarlar ve dersler açılabilir. Montessori ve STEM eğitiminin birlikte entegre edilmesine yönelik uygulamalar, eğitimler okul öncesi öğretmenlerine seminerler düzenlenerek bilinçlenmeleri sağlanabilir. Bu eğitimlerin sadece okul öncesi öğretmenli bölümüyle kalmayıp eğitim fakültelerinde bütün branşlara ders şeklinde entegre edilerek verilmesi gelecek nesli yetiştirecek öğretmenlerimizin donanımlı olması açısından önemlidir.