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EXAMINATION OF THE EFFECTS OF DESIGN-ORIENTED STEM ACTIVITIES ON THE 21ST CENTURY SKILLS OF PRE-SCHOOL CHILDREN AGED 3-4

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ABSTRACT

In this study, the effects of D-STEM activities on the 21st-century skills of pre-school children aged 3-4 were investigated. The research was carried out in a mixed design, both quantitative (experimental design with experimental and control groups (N:84) with pretest-posttest and retention test) and qualitative (observation and researcher diary). To test hypothesis four, serial 3 (time: pre-test, post-test, and follow up) x2 (experiment group and control group) mixed factorial analysis of variances (ANOVA) was used. As a result of the research, it was observed that D-STEM activities permanently increased the total dimension of the 21st century and all sub-dimensions of Life and Career Skills, Learning and Innovation Skills in the experimental group children. In addition to these, it was concluded that the qualitative findings obtained within the scope of the research supported the quantitative results of the study. On the other hand, it was concluded that there was no statistically significant difference between the sub-dimensions and total scores of the 21st century skills pre-post and permanence tests of the children in the control group. It was concluded that the D-STEM activities carried out permanently increased the 21st century skills of the experimental group children. In line with the results of the study, preschool teachers can contribute to the multi-faceted development of children by doing more activities related to STEM education and Design Thinking Model.

Keywords: early childhood education, design thinking model, STEM education, 21st century skills

INTRODUCTION

Early childhood period indicates drastic changes in an individual's social and personal development (Ali, & Saleh, 2022). During this period, it is very important for children to spend time in areas with rich stimulants in order to prepare them for the future. In this context, enrichment of outdoor playgrounds such as home environments, school environments or gardens is very critical for raising 21st-century children. Because interacting with children in

an outdoor activity could develop mutual exchanges, besides promoting knowledge expansion (Hashim & Said, 2021). In the nineteenth-century world of education, the main purpose was to prepare children for work. In the twentieth century, however, the man was freed from the mission of exploited labour imposed on him but began to be seen as an investment tool. The education process has taken on a form that cares about the job satisfaction of the individual as well as the purpose of teaching the individual job. Although the education programs were expanded in this direction, the programs continued their standardized, linear and static function in the 19th century (OECD, 2019).

When it comes to the twenty-first century we are in; some technological, industrial and economic needs have come to light due to the conditions of the day. For this reason, plans have been made to meet the current needs at all levels of education. Contrary to previous centuries, these conditions recently faced by society have also changed the balance of supply and demand in the world. Employers, educators, students and policies interact with the demands of an unusually changing world (Anugerahwati, 2019). This change in the supply-demand balance imposes some skills and responsibilities on the people of the twenty-first century, from early childhood to adulthood. There are specific critical periods during which human beings gain knowledge, skills, and habits to survive as a social entity (Kural & Ceylan, 2022). Along with what these skills are, how to gain them and what to pay attention to in the educational process are also of great importance (Tanın, 2021).

In this study, the effects of activities prepared according to the design-oriented STEM model on the 21st-century skills of preschool children 3-4 years old were examined.

21st Century Skills

It is possible to define the skill sets that individuals need to have and continuously develop in order to lead their lives in a qualified and active way in the information age as of 21st-century skills (Hamarat, 2019). There are different interpretations in the literature about which skills are covered by 21st-century skills. Kennedy and Odell (2014) considered 21st-century skills as life and career skills and classified them as leadership, responsibility, critical thinking, creativity, problem-solving, information and media literacy, global awareness, technology literacy, communication, and productivity. According to Allen and Van der Velden (2012), 21st-century skills include problem-solving, critical thinking, creativity, cooperation, communication, technology literacy and cultural skills. Also, National Research Council [NRC] (2011) 21st-century skills; expressed in three dimensions as cognitive skills, interpersonal skills and internal skills (NRC, 2011). Similarly, the North Central Regional Educational Laboratory (NCREL) (2003), with its studies, can develop 21st-century skills under the headings of globalization and digitality; universal literacy, creativity, communication skills and productivity (EnGauge, 2003). In addition to all these definitions, the organization called Partnership for 21st Century Skills [P21] (2019) has revealed the most comprehensive classification for 21st-century skills, and this classification has been widely accepted (Dinler, Simsar & Yalçın, 2021; Göksün & Kurt, 2017; Yalçın, Simsar & Dinler, 2020). Skills in the relevant classification; learning and innovation skills, life and career skills, and information and media technology skills. These include learning and innovation skills; It includes skills and competencies such as creativity and inventiveness, communication skills, critical thinking and problem solving, and cooperation. Life and career skills include flexibility and adaptability, entrepreneurship and self-management, productivity and accountability, social and

interculturalism, leadership and responsibility. Finally, the concepts of information, media and technology literacy are included in information, media and technology skills (P21, 2018a; 2018b; 2015; 2009). Each title includes very important skills for the life of the individual. Studies show that these skills affect the competencies and features needed in the future work and profession. In this respect, Partnership for 21st Century Skills draws attention to the skills that children in other educational levels should have, starting from early childhood. When the literature on 21st-century skills is examined, the skills framework determined by P21 is widely accepted and referenced (Beers, 2011; Brown, 2018; Gelen, 2017; Lamb et al., 2017; Partnership for 21st Century Skills (P21), 2018a; 2018b; 2015; 2009). In this context, the 21st-century skills determined by P21 were taken into consideration while creating the theoretical framework of the study.

While information and access to information were at the forefront in the last century, how to use information has become more important in the 21st century. Accordingly, in this century, there is a need for well-equipped individuals who do not memorize information, but question, change and transform existing knowledge with newly learned knowledge (Çevik & Şentürk, 2019). Developed countries, aware of this situation, have made some differences in their education policies and started studies to raise individuals with the above-mentioned qualifications (Brown, Lauder, & Ashton, 2008; Gewertz, 2008; Moyer, 2016; Rotherham & Willingham, 2009; Varis, 2007). In addition to the developments in education policies, different teaching models and approaches such as STEM and design-oriented thinking that will help raise individuals with 21st-century skills have come to the fore (Erden & Yalçın, 2021; Yalçın, 2022; Yalçın & Erden, 2021; Yalçın, 2019).

The STEM Model of Design Thinking in Early Childhood

First coined by Judith A. Ramaley, director of the Department of Education and Human Resources of the US National Science Foundation (NSF), STEM abbreviation refers to the disciplines "Science", "Technology", "Engineering" and "Mathematics" (Breiner Et al., 2012). STEM education is defined as "an educational approach that aims to identify the problems that individuals encounter in real life from early childhood to adulthood and to produce creative solutions to these problems, develops the skills required by the 21st century in individuals, includes multidisciplinary activities in the application process and integrates different disciplines" possible (Gökbayrak & Karışan, 2017; Mobley, 2015; Yalçın, 2019).

STEM approach in the literature; It takes place under different names such as e-STEM, plus STEM, maker STEM, and finally STEAM, which advocates the view that art should be included in STEM studies (Akgündüz et al., 2015; Bilişimgarağı, 2021). The main purpose here is to make STEM more effective and usable. In the application phase of this research, D-STEM activities were used, in which the design thinking process was used.

Design Thinking covers a non-linear process in which we understand individuals, examine possible solutions and redefine problems to develop new and different solution proposals, which are not visible at first glance (Dam & Siang 2018a; 2018b). In addition, Desing Thinking enables individuals to develop new and creative solutions to the problems they encounter with a solution-oriented perspective.

Many studies on 21st century skills, STEM and Design Thinking have been found in the literature (Akdemir, 2017; Akgündüz & Akpınar, 2018; Çetin & Çetin, 2021; Dinler,

Simsar & Yalçın, 2021; Erden & Yalçın, 2021; Mutlu, 2010; Uluyol & Eryılmaz, 2015; Uzun, 2019; Yalçın, 2022;Yalçın & Erden, 2021). On the other hand, in the literature study, no study was found that examines the effect of design-oriented STEM activities for pre-school children aged 3-4 on the 21st-century skills of children. In this context, it is thought that this research will make important contributions to the literature by filling the gap in the literature.

This study, it is aimed to examine the effect of D-STEM activities on the 21st-century skills of pre-school children aged 3-4. For this purpose, answers to the following questions were sought;

i) Is there a statistically significant difference between the Learning and Innovation Skills (4Cs) pretest, posttest and retention test scores of the experimental and control group children?
ii) Is there a statistically significant difference between the Life and Career Skills pretest, posttest and retention test scores of the experimental and control group children?
iii) Is there a statistically significant difference between the pretest-posttest and retention test scores in the experimental group children's Learning and Innovation Skills (4Cs) and Life and Career Skills dimensions?
iv) Is there a statistically significant difference between the pretest-posttest and retention test scores in the children's Learning and Innovation Skills (4Cs) and Life and Career Skills dimensions in the control group?
v) Is there a statistically significant difference between the total scores of the 21st-century skills pretest-posttest and retention test of the experimental and control group children?

METHOD

Model of the Research

A mixed-method design was used in this study, examining the effects of D-STEM activities on the 21st-century skills of pre-school children aged 3-4 (Creswell, 2013). Mixed method design in research can be strengthened, and the weaknesses of other methods used can be maintained. More comprehensive and precise results can be obtained by providing a balance between the data (Axinn & Pearce, 2006). In this study, nested mixed design, one of the mixed research designs, was used. The nested mixed design method is a study design with no quantitative or qualitative data collection priority. The data can be collected before, at the same time or later and interpreted (Creswell & Clark, 2014). The primary purpose of this research design is to collect quantitative and qualitative data simultaneously or at different times and to enable one data type to play a supporting role for the other data type (Creswell, 2013). This study used qualitative data to support the findings and results obtained from quantitative data.

The quantitative part of the study was carried out with an experimental design with a control group in which pretest, posttest and retention tests were made. A control group with similar characteristics to the experimental group was determined to compare the effects of applied design-oriented STEM activities on children's 21st-century skills. In addition, a follow-up test was applied to the experimental group to determine the permanence of design-oriented STEM education. Regarding the retention test, Brown, Irving, and Keegan (2008) emphasize that there should be no significant difference between the measurements made between 3-6

weeks and the post-test measurements. Accordingly, the retention test was carried out in the fifth week after the posttests were applied in this study. It was tried to determine whether design-oriented STEM activities had a lasting effect on the 21st-century skills of 3-4 years old children. In the qualitative part of the research, the study's quantitative findings were supported by the data obtained from the observation and research diaries made during the implementation of D-STEM activities.

Validity and Reliability

Multiple triangulation method was used to increase the validity and reliability of the research. Triangulation is used in the study to minimize misperception and increase the validity of the results (Stake, 1995). The primary purpose is to compare the data obtained from different perspectives and get more comprehensive and valid results (Mayring, 2011). Multiple triangulation (Denzin, 1970; Polit & Hungler, 1995) uses two or more measurement sources, several observers, or methods in a study.

Regarding multiple triangulation, Banik (1993) emphasizes that data triangulation is very important in social sciences as no single data source can be perfect. The collection, coding, analysis and reporting of data during the research process brings the researchers closer to the goal (Denzin, 1970; Mitchell, 1986), increasing the internal validity and, therefore, the reliability of the research (Boyd, 2000). Figure 1 shows the types of triangulation used in this study.

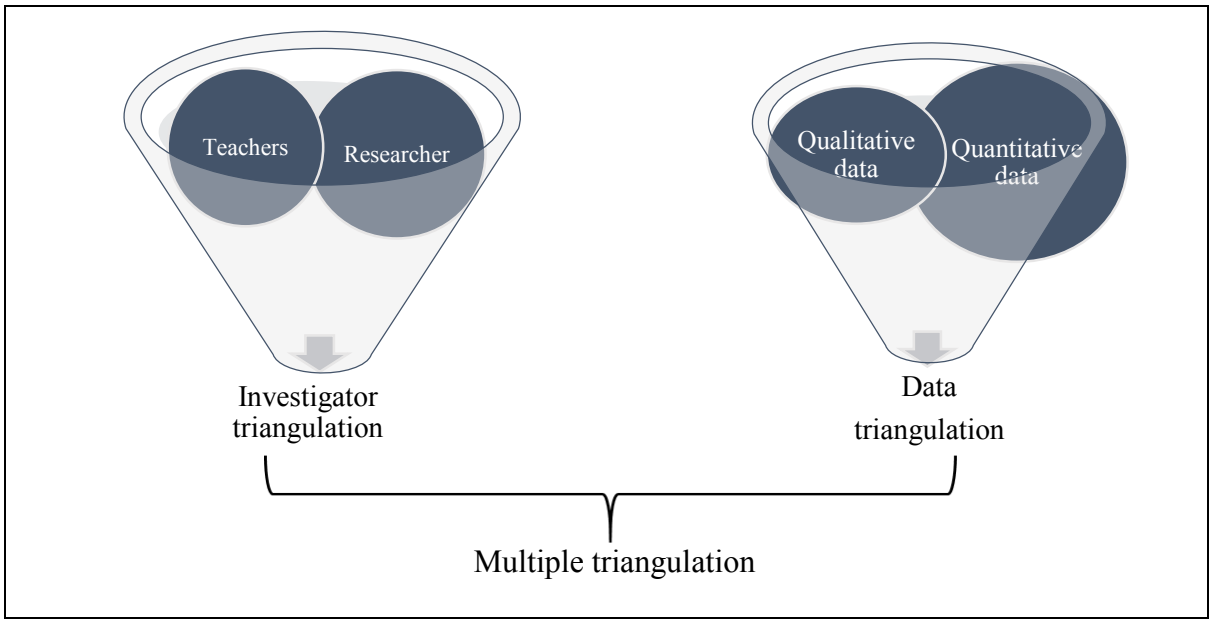

Figure 1. Types of triangulation used in the study

The first triangulation used in this research is observer triangulation. During her design-oriented STEM education, she kept a diary by the classroom teacher and the researchers. In addition, the researcher made unattended observations during the activities and observer triangulation was made with the qualitative data obtained from both diaries and observations. In qualitative research, observations try to observe the research process as naturally as possible, instead of less structured and predetermined categories and classifications (Punch, 2011).

Especially in qualitative studies, the number of observers being two or more is one of the important factors that increase the validity and reliability of the study by reducing the researcher bias.

One of the triangulations used in the research is data triangulation. Data triangulation is the most widely used triangulation type in education and social sciences (Işık & Semerci, 2019). In this context, data triangulation was made by collecting research data, quantitative data obtained through scales, observations and diaries. According to Neuman (2016), it is stated that making more than one measurement about the researched subject will help to realize and reveal as many different aspects of the subject as possible. In this context, the researchers collected the quantitative data of the experimental and control groups. In addition to the quantitative data, the qualitative data of the research were collected through observations and diaries, and data triangulation was made.

Sample Group

The study's sample group consisted of a special kindergarten determined according to the random sampling method in the universe. One class of 3 and 4 years old, from 10 classes in the nursery, formed the experimental group of the study and the control group of the 3 and 4-year-old classes, which also had similar characteristics. In addition, 44 of the children participating in the study were girls, and 40 were boys. Demographic information of the participants is given in Table 1.

Table 1
Demographic information of the children in the experimental group and control group.

Frequencies for age	**Age**	**Frequency**	**Percent**
Experimental Group	3	21	48.83
	4	22	51.16
Control Group	3	20	48.78
	4	21	51.22
	Total	84	100
Frequencies for gender			
Experimental Group	Girl	25	58.14
	Boy	18	41.86
Control Group	Girl	19	46.34
	Boy	22	53.65
	Total	84	100

Implementation Process of D-STEM Activities

Before the STEM activities, the researchers provided both theoretical and practical STEM education to the experimental group classroom teachers. Then, pretests for 21st-century skills of the experimental and control groups were applied. Then, the researcher used design-oriented STEM education as a small group activity of 4 each by the classroom teachers, two days a week, eight weeks and 16 sessions on the experimental group Tuesdays and Thursdays.

Practices started at 9.30 am. The activities lasted between 40-50 minutes on average. Before the activities, a lively play activity was held for the children to discharge their energies. At the end of the 8-week D-STEM activities, post-tests for 21st century skills were administered to the children in the experimental and control groups. The classroom teacher used scale applications for each child. The preparation process before the application is given in Figure 2 in general terms.

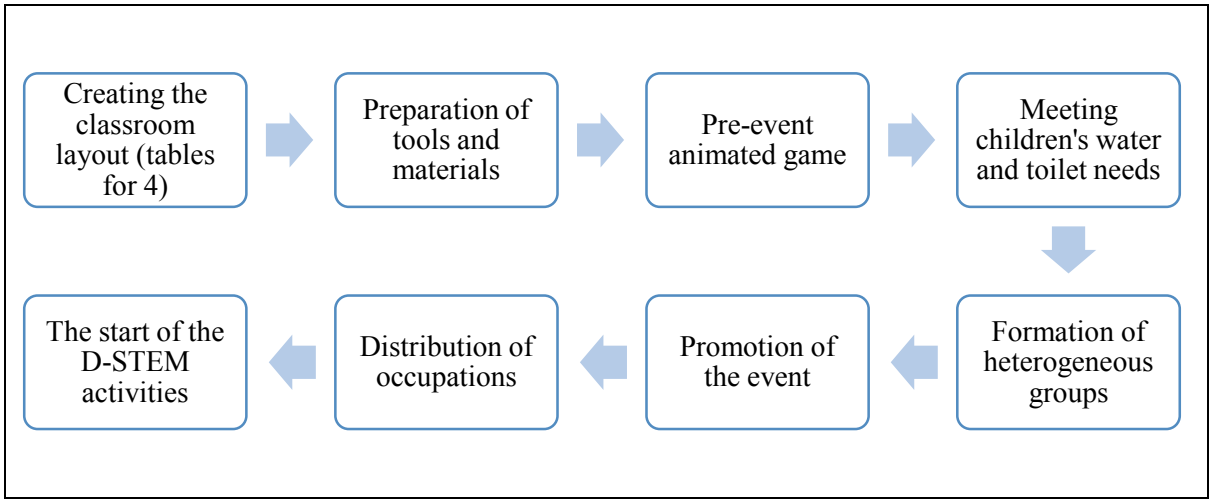

Figure 2. Preparation process before design-oriented STEM education.

Data Collection Tools

Demographic information form: It was prepared by the researchers to collect the information of the children participating in the study and their families. The demographic information form generally includes information about the gender of the children, the number of siblings, the education level of the mother, the education level of the father, the employment status of the mother, and the father's employment status.

For Children Aged 3-4 21st Century. Skills Scale (DAY-1): Developed by Simsar, Yalçın, and Dinler (2020). Preschool children aged 3-4 years 21st century. The DAY-1 scale, which measures skills, is a four-point Likert-type scale consisting of 28 items. The DAY-1 scale has two sub-dimensions, each of which consists of adverbs of frequency as "Never", "Rarely", "Usually" and "Always" measuring tool. It consists of 2 sub-dimensions. These are learning and innovation skills (4Cs) (items 1-22) and life and career skills (items 16-28). In this direction, a scale consisting of 19 items for the learning and innovation skills (OSCT) sub-dimension and a Cronbach Alpha coefficient of .97 for the life and career skills (YKBT) sub-dimension of 9 items and a Cronbach Alpha coefficient of .92 was developed. In addition, the general structure of the scale is "For 3-4 Years-Old Children 21st Century. Skills (DAY-1)" 's Cronbach's Alpha coefficient has a high internal consistency score of .97, indicating that the scale is valid and reliable.

The ratio of Chi-square and degrees of freedom was 3.2 in the first level CFA analysis of the scale model, which was determined as three factors; CFI .91; TLI .90; NFI value .90; IFI value .91; RMSEA value is .07; The SRMR value, on the other hand, was stated to have an acceptable degree of .05. However, in the second level CFA analysis, the ratio of Chi-square

and degrees of freedom was 3.27; CFI .91; TLI .90; NFI .88; IFI .91; RMSEA .074; SRMR was found to be .055. In this case, it was stated that the factor loads obtained were generally sufficient. The internal consistency coefficients of the DAY-1 scale were calculated after first-level and second-level CFA, and McDonald ω .97 and Cronbach α were determined as .97 for the overall scale. For the sub-dimensions, McDonald ω .97 and Cronbach α were calculated as .97 for the learning and innovation skills sub-dimension, McDonald ω .92 and Cronbach α for the life and career skills were calculated as .92, and the researchers stated that the scale is statistically valid and reliable. (Simsar et al., 2021).

Data Analysis

Before analyzing the quantitative data, it was observed that the data were within acceptable values by testing whether they were usually distributed (See Table 2). For this reason, parametric tests were used in the statistical analysis.

To test hypothesis three, serial 3 (time: pretest, posttest, and follow up) x2 (experiment group and control group) mixed factorial analysis of variances (ANOVA) was used. Simple main effects and interactions between time and group were tested.

Power analysis was tested via G*Power (Faul, Erdfelder, Buchner & Lang, 2009) for mix ANOVA. The effect size was estimated based on Cohen's (1988) guidelines (medium effect size η^2= 0.06). The effect size entered into power analysis was α=.05, power =.80 allocation ratio=1.1. The Power analysis results suggested that N= 64 particiıpants are required for difference between two groups with 80% probability. In this study, 82 people were studied. For classical Anovas IBM SPSS 26 program, for Power analysis, G*Power were used.

Table 2
Descriptive Statistics of the 21st Century Skills of the Children in the Experimental and Control Group

Variables	Group	Valid	Mean	Std. Deviation	Skewness	Kurtosis
Pretest Life and Career Skills Score	Experimental group	43	26.000	5.132	-0.314	-0.656
	Control group	41	26.512	5.011	-0.245	-0.893
Pretest Learning and Innovation Skills Score	Experimental group	43	47.140	12.043	0.143	-0.366
	Control group	41	47.854	11.652	0.198	-0.340
Pretest 21st Century Skills Total Score	Experimental group	43	73.140	16.345	0.017	-0.480
	Control group	41	73.756	16.331	-0.010	-0.502
Posttest Life and Career Skills Score	Experimental group	43	30.186	3.923	-1.151	1.153
	Control group	41	26.512	5.011	-0.245	-0.893

Posttest Learning and Innovation Skills Score	Experimental group	43	62.465	10.905	-1.104	0.680
	Control group	41	47.854	11.652	0.198	-0.340
Posttest 21st Century Skills Total Score	Experimental group	43	92.651	14.531	-1.141	0.783
	Control group	41	74.366	15.802	0.045	-0.510
Follow-up Test Life and Career Skills Score	Experimental group	43	30.256	3.910	-1.194	1.285
	Control group	41	26.561	5.015	-0.204	-0.863
Follow-Up Test Learning and Innovation Skills Score	Experimental group	43	62.488	10.765	-1.109	0.743
	Control group	41	47.220	11.986	0.214	-0.365
Follow-up Test 21st Century Skills Total Score	Experimental group	43	92.744	14.384	-1.164	0.886
	Control group	41	73.780	15.788	0.161	-0.505

As seen in Table 2, all variables for the times measured in the study show the normal distribution in both the experimental and control groups. The skewness values ranged from -0.31 to 0.21, while the kurtosis values ranged from 1.28 to -0.89. When the literature on the subject is examined, Tabachnick and Fidell (2013) emphasize that skewness and kurtosis values should be between +2.0 -2.0 for the data to be in the normal distribution range. It can be said that the kurtosis mentioned above and skewness values are within acceptable normal distribution values, according to Tabachnick and Fidell (2013) and George and Mallery (2010). In addition, histograms and Q-Q plots of the variables were examined based on groups, and it was seen that the assumption of normality was achieved.

FINDINGS

Quantitative Findings of The Study

Findings related to the learning and innovation skill scores of the experimental group and the control group pretest, posttest and retention test results.

Mixed design ANOVA was used to compare the experimental and control groups' learning and innovation skill scores, pretest, posttest and retention test scores. Whether the learning and innovation skill scores change according to the group was tested with the mixed design ANOVA, and the ANOVA summary table is given below.

Table 3
Two-way mixed (2x3) Anova analysis results for Learning and Innovation Skills pretest, posttest and follow-up test.

Cases	Sum of Squares	df	Mean Square	F	p	η²
Within Subjects Effects						
time	3.160.589	1.306	2.419.634	87.782	.001	0.070
time ✻ group	3.433.382	1.306	2.628.475	95.359	.001	0.076
Residuals	2.952.403	107.111	27.564			
Between Subjects Effects						
group	5.951.292	1	5.951.292	16.481	.001	0.132
Residuals	29.609.469	82	361.091			

First of all, two-way mixed Anova was applied for learning and innovation skills pretest, posttest and follow-up test. According to Levene's test, variances are homogeneous. However, the Greenhouse Geisser test was reported for Sphericity Correction, since sphericity was violated according to the Mauchly test. According to the results, the main effect for measurement time was F (1.306, 107.111) = 87.782, p=0.001, η^2 =0.07 and the interaction of measurement time in the context of the group was significant F (1.306, 107.111)= 95.359, p=0.001, η^2 =0.076. The effect between groups was also found to be significant f (1, 82) = 16,481, p=0.001, η^2 = 0.132.

Tukey test was used to determine which groups and at which test time the significant difference in Learning and Innovation Skills was in favor. According to the test results, while the pretest experimental and control groups were equal, it was determined that there was a significant increase in favor of the experimental group in the posttest. It was concluded that this increase continued in favor of the experimental group in the follow-up test. While the control group did not show any change in terms of measurement time, the posttest and follow-up test were significantly higher than the pretest in the experimental group.

Table 4
Post Hoc Tests Results Learning and Innovation Skills

Post Hoc Comparisons - grup ✻ RM Factor 1

		Mean Difference	SE	t	p tukey
Experimental group, Pretest	Control group, Pretest	-0.714	2.511	-0.284	1.000
	Experimental group, Posttest	-15.326	0.915	-16.748	< .001
	Control group, Posttest	-0.714	2.511	-0.284	1.000
	Experimental group, follow-up test	-15.349	0.915	-16.774	< .001
	Control group, follow-up test	-0.080	2.511	-0.032	1.000
Control group, Pretest	Experimental group, Posttest	-14.611	2.511	-5.818	< .001

	Control group, Posttest	-8.882	0.937	-9.478	1.000
	Experimental group, follow-up test	-14.635	2.511	-5.828	< .001
	Control group, follow-up test	0.634	0.937	0.677	0.984
Experimental group, Posttest	Control group, Posttest	14.611	2.511	5.818	< .001
	Experimental group, follow-up test	-0.023	0.915	-0.025	1.000
	Control group, follow-up test	15.246	2.511	6.071	< .001
Control group, Posttest	Experimental group, follow-up test	-14.635	2.511	-5.828	< .001
	Control group, follow-up test	0.634	0.937	0.677	0.984
Experimental group, follow-up test	Control group, follow-up test	15.269	2.511	6.080	< .001

Findings related to the life and career skill scores of the experimental group and the control group pretest, posttest and retention test results.

A mixed design ANOVA was used to compare the life and career skill scores of the experimental and control groups, pretest, posttest and retention test scores. Whether the Life and Career Skill scores change according to the group was tested with the mixed design Anova and the Anova summary table is given below.

Table 5
Two-way mixed (2x3) Anova analysis results for Life and Career Skills pretest, posttest and follow-up test.

Cases	**Sum of Squares**	**df**	**Mean Square**	**F**	**p**	**η²**
Within Subjects Effects						
time	252.323	1.027	245.625	64.038	.001	0.040
time ✻ group	246.418	1.027	239.877	62.539	.001	0.040
Residuals	323.098	84.236	3.836			
Between Subjects Effects						
group	328.894	1	328.894	5.302	.024	0.053
Residuals	5.086.185	82	62.027			

Secondly, a two-way mixed ANOVA was applied for the Life and Career Skills pretest, posttest and follow-up test. According to Levene's test, variances are homogeneous. However, the Greenhouse Geisser test for Sphericity Correction is reported because sphericity is violated according to the Mauchly test. According to the results, the main effect for measurement time was F (1.027, 84.236) = 64.038, p=0.001, η^2 =0.04, and the interaction of measurement time in the context of the group was significant F (1.027, 84.236) = 62.539, p=0.001, η^2 =0.04. The effect between groups was also found to be significant f (1, 82) = 5.302, p=.024, η^2 = 0.053.

Tukey test was used to determine which groups and at which test time the significant difference in Life and Career Skills was in favour. According to the test results, while the pretest experimental and control groups were equal, it was determined that there was a significant increase in favour of the experimental group in the posttest. It was concluded that this increase continued in favour of the experimental group in the follow-up test. While the control group did not show any change in terms of measurement time, the posttest and follow-up tests were significantly higher than the pretest in the experimental group.

Table 6
Post Hoc Tests Results Life and Career Skills

Post Hoc Comparisons - grup ✻ RM Factor 1

		Mean Difference	SE	t	p tukey
Experimental group, Pretest	Control group, Pretest	-0.512	1.024	-0.500	0.996
	Experimental group, Posttest	-4.186	0.303	-13.829	< .001
	Control group, Posttest	-0.512	1.024	-0.500	0.996
	Experimental group, follow-up test	-4.256	0.303	-14.059	< .001
	Control group, follow-up test	-0.561	1.024	-0.548	0.994
Control group, Pretest	Experimental group, Posttest	-3.674	1.024	-3.589	0.007
	Control group, sPretest	-1.443	0.310	-4.656	1.000
	Experimental group, follow-up test	-3.744	1.024	-3.657	0.006
	Control group, follow-up test	-0.049	0.310	-0.157	1.000
Experimental group, Posttest	Control group, Posttest	3.674	1.024	3.589	0.007
	Experimental group, follow-up test	-0.070	0.303	-0.230	1.000
	Control group, follow-up test	3.625	1.024	3.542	0.008

Control group, Posttest	Experimental group, follow-up test	-3.744	1.024	-3.657	0.006
	Control group, follow-up test	-0.049	0.310	-0.157	1.000
Experimental group, follow-up test	Control group, follow-up test	3.695	1.024	3.610	0.006

Findings regarding the 21st century skill scores pretest, posttest and retention test results of the experimental group and control group.

A mixed design ANOVA was used to compare the 21st Century Skills total scores of the experimental and control groups, pretest, posttest and retention test scores. The mixed design Anova was tested to see if the 21st Century Skills total scores changed by group, and the anova summary table is given below.

Table 7
Two-way mixed (2x3) Anova analysis results for 21st Century Skills pretest, posttest and follow-up test.

Cases	**Sum of Squares**	**df**	**Mean Square**	**F**	**p**	**η²**
Within Subjects Effects						
time	5.529.746	1.218	4.539.178	108.225	.001	0.070
time ✻ group	5.184.952	1.218	4.256.149	101.477	.001	0.065
Residuals	4.189.778	99.895	41.942			
Between Subjects Effects						
group	9.388.227	1	9.388.227	13.942	.001	0.118
Residuals	55.215.436	82	673.359			

Finally, a two-way mixed ANOVA was applied for a total of 21st Century Skills pretest, posttest and follow-up tests. According to Levene's test, variances are homogeneous. However, according to the Mauchly test, the Greenhouse Geisser test was reported for Sphericity Correction since sphericity was violated. According to the results, the main effect for measurement time was F (1.218, 99.895) = 108.225, p=0.001, η^2 =0.07, and the interaction of measurement time in the context of the group was significant F (1.218, 99.895) = 101.477, p=0.001, η^2 =0.04. The effect between groups was also found to be significant f (1, 82) = 13,942, p=.024, η^2 = 0.118.

Tukey test was used to determine which groups and which test time the significant difference in 21st Century Skills was in favour of. According to the test results, while the pretest experimental and control groups were equal, it was determined that there was a significant increase in favour of the experimental group in the posttest. It was concluded that this increase continued favouring the experimental group in the follow-up test. While the control group did

not show any change in measurement time, the posttest and follow-up tests were significantly higher than the pretest in the experimental group.

Table 8
Post Hoc Tests Results 21st Century Skills

Post Hoc Comparisons - grup ✻ RM Factor 1

		Mean Difference	SE	t	p tukey
Experimental group, Pretest	Control group, Pretest	-0.617	3.392	-0.182	1.000
	Experimental group, Posttest	-19.512	1.090	-17.899	< .001
	Control group, Posttest	-1.226	3.392	-0.362	0.999
	Experimental group, follow-up test	-19.605	1.090	-17.985	< .001
	Control group, follow-up test	-0.641	3.392	-0.189	1.000
Control group, Pretest	Experimental group, Posttest	-18.895	3.392	-5.570	< .001
	Control group, Posttest	-0.610	1.116	-0.546	0.994
	Experimental group, follow-up test	-18.988	3.392	-5.598	< .001
	Control group, follow-up test	-0.024	1.116	-0.022	1.000
Experimental group, Posttest	Control group, Posttest	18.285	3.392	5.391	< .001
	Experimental group, follow-up test	-0.093	1.090	-0.085	1.000
	Control group, follow-up test	18.871	3.392	5.563	< .001
Control group, Posttest	Experimental group, follow-up test	-18.378	3.392	-5.418	< .001
	Control group, follow-up test	0.585	1.116	0.524	0.995
Experimental group, follow-up test	Control group, follow-up test	18.964	3.392	5.591	< .001

Qualitative Findings of The Research

In this part of the study, the data obtained from the observations and researcher diaries made within the scope of the study were analyzed, and the qualitative results of the study were presented.

The first of the findings obtained from the analysis of the observations and researcher diaries is that the children in the experimental group who participated in the research generally showed improvement in the sub-dimensions of 21st-century skills and 21st-century skills.

However, the most striking finding in the observation is that children show improvement in 21st-century skills, especially in the Learning and Innovation Skills (4Cs) sub-dimension. Learning and Innovation Skills (4Cs), creativity and innovation, critical thinking and problem solving, communication and collaboration include fundamental skills in terms of life. In this context, regarding creativity and innovation skills, "They can be creative and productive in producing solutions to problems by having prior knowledge about the subject. In my opinion, the emergence of more creative activities, especially towards the last activities, may be related to the fact that children gain experience. … as a natural consequence of generating ideas, children are at a better point in creative problem solving".

On the other hand, in the observation notes on problem-solving skills, "Children try to find solutions to problems by acting in groups. Children generally participate" and "children are quite good at making the stages of the design thinking model". However, in the diaries, "the children's communication with each other increased a lot during the application process. Now they can establish better cause and effect relationships. They have come to a better level in generating ideas and solving problems". In addition to these, in the diaries, "children are in constant communication during the implementation process. Children are now more active and can express their thoughts without hesitation" and "… children's communication with each other has increased in design-oriented STEM applications. The fact that the activity was carried out in small groups gave the children more opportunities to talk. This helped children discover their potential". Based on all the observations and diary notes mentioned above, it can be concluded that D-STEM activities are effective in improving children's 21st-century skills and especially "Learning and Innovation Skills (4Cs)".

CONCLUSION AND DISCUSSION

The results obtained by analyzing the data obtained in this study, which examines the effects of STEM activities prepared according to the design thinking model on the 21st century skills of preschool children aged 3-4, are discussed in this section.

Within the scope of this study, it was concluded that STEM activities prepared according to the design thinking model were effective in all sub-dimensions of Learning and Innovation Skills, and Life and Career Skills of the children in the experimental group, and the said skills increased statistically significantly. In addition, in the permanence test, it was concluded that the said increase was permanent. On the other hand, it was concluded that there was no statistically significant difference between the pre-post and permanence tests in the aforementioned sub-dimensions of the children in the control group.

Similarly, in the analyzes made on the total scores of 21st century skills, it was concluded that STEM activities prepared according to the design thinking model increased the 21st century skills of the children in the experimental group statistically. In addition, in the permanence test, it was concluded that the said increase was permanent. On the other hand, it was concluded that there was no statistically significant difference between the total scores of the 21st century skills pre-post and permanence tests of the children in the control group.

In this context, it was concluded that the D-STEM activities applied in summary permanently increased the 21st century skills of the children in the experimental group, while there was no change in the 21st century skills scores of the children in the control group.

In the literature review on the subject, no research has been found that directly examines the effects of design-oriented STEM activities in early childhood on the 21st-century skills of 3-4-year-old children. In this context, the 21st century. Flexibility and adaptability, assertiveness and self-management, social and intercultural interaction, productivity and accountability, leadership and responsibility skills for life and career skills sub-dimensions (Bal, 2018; Başaran, 2018; Carroll et al., 2010; Cavas et al., 2013; Deniz Özgök, 2019; P21, 2019; Trilling & Fadel, 2009; Yalçın & Erden, 2021; Wang, 2012), and for the learning and innovation skills sub-dimension, critical thinking and problem solving, communication, cooperation and creativity (Başaran, 2018; Carroll et al., 2010; Trilling & Fadel, 2009; Yalçın & Erden, 2021) skills were examined separately.

Among these studies, STEM activities increase children's problem-solving skills (Akçay, 2019; Yalçın & Erden, 2021), and preschool children's cognitive thinking skills improve their skills to understand the problem, make logical inferences and interpret it in the context of cognitive thinking skills (Deniz Özgök, 2019; Yalçın & Erden, 2001) was reached. Yalçın and Erden (2021), on the subject, stated that design-oriented STEM activities improve the creativity and problem-solving skills of preschool children, increase their communication and cooperation skills, contribute to peer learning, help children transfer the skills they have gained at school out of school, increase their self-confidence, and increase their self-confidence. They have concluded that it encourages them to produce and improves their empathy skills. Bal (2018) also concluded that STEM activities improve children's scientific process and problem-solving skills in his study. From this point of view, it can be said that the results of the studies on the subject in the literature support the results of this research.

In addition, design-oriented activities contribute to the development of participants' observation, understanding, idea generation, prototyping and testing phases increase their motivation and thus lead children to cooperation (Kröper et al., 2011), the design-oriented process is about improving children's learning and questioning skills. Different research results provide support to children, enable peer learning, children are active in the process, the product creation phase enables rapid learning, and encourages children to express their ideas (Carroll et al., 2010; Yalçın & Erden, 2021). appears to have been achieved. In this research, STEM activities were prepared especially with problems from life; the activities were done in small groups of 4, the distribution of tasks within the group, the application process made children active and learning by doing. Therefore, the D-STEM activities in this study showed that the children's 21st century could be interpreted as effective in improving the skills of the 21st century.

Limitations

The qualitative results of this study are limited to the data obtained from the observations and research diaries.

Suggestions

Preschool teachers can contribute to the multi-faceted development of children by doing more activities related to STEM education and the design thinking model.

DECLARATİONS

Consent to Participate

All participants were informed about the study and their consent was obtained, following the ethical rules.

Conficts of Interest

There is no any conflict of interest in this study.

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