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Evaluation of Mathematics Course STEM Activities of Students with Learning Disabilities

Öğrenme Güçlüğü Olan Öğrencilerin Matematik Dersi STEM Etkinliklerinin Değerlendirilmesi

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Abstract

This study aimed to evaluate the teaching of patterns to students with learning disabilities through STEM activities. The study employed a qualitative multiple case design, one of the qualitative research approaches. The participants were three students diagnosed with learning disabilities receiving fully inclusive education in a third-grade classroom at a public school. The data were collected through observations, interviews, video recordings, the STEM Skills Rubric, the Product Evaluation Form, achievement tests and analyzed using descriptive statistics and content analysis. The findings revealed that STEM activities contributed to increased academic achievement among students with learning disabilities. The students could utilize their patterning skills in mathematics and reflect their knowledge of science in the materials they designed. Additionally, they demonstrated proficiency in fine motor skills related to engineering, such as cutting with scissors and gluing. However, the students needed to improve in mathematical skills such as measurement and alignment and utilizing technology. The analysis of interviews conducted with the students at the end of the implementation indicated that the students found the activities enjoyable. They reported experiencing the most difficulty while designing and drawing materials but derived the most enjoyment from coloring and creating patterns. The students also stated that they benefited from science, mathematics, engineering, and technology in their designed products. Based on the findings, further studies are recommended on using STEM activities in different mathematical topics or with various disability groups.

Keywords: STEM Activities, Mathematics Skills, Pattern, Learning Disabilities.

Öz

Bu araştırmada, öğrenme güçlüğü olan öğrencilere örüntü konusunun STEM etkinlikleriyle öğretiminin değerlendirilmesi amaçlanmıştır. Çalışmada nitel araştırma yöntemlerinden çoklu durum çalışması deseni kullanılmıştır. Araştırmanın katılımcıları üçüncü sınıfta öğrenim gören, tam zamanlı kaynaştırma eğitimi alan, öğrenme güçlüğü tanısı almış, üç öğrenciden oluşmaktadır. Araştırma verileri gözlemler, görüşmeler, görüntü kayıtları, STEM becerileri rubriği, ürün değerlendirme formu ve başarı testleriyle toplanmıştır. Veriler içerik analizi ve betimsel istatistikle analiz edilmiştir. Araştırma sonucunda öğrenme güçlüğü olan öğrencilerin akademik başarılarında artış sağladığı, etkinlik amacı doğrultusunda tasarladıkları materyallerde matematikte örüntü becerilerini kullanabildikleri, fen alanında bilgilerini materyale yansıtabildikleri ve makasla kesme, yapıştırma gibi mühendislikle ilgili ince motor becerilerde yeterli oldukları görülmüştür. Ancak, ölçüm yapma, hizalama gibi matematik becerileri ve teknolojiden yararlanma konusunda yetersiz oldukları belirlenmiştir. Uygulama sonunda öğrencilerle gerçekleştirilen görüşmelerin analizi doğrultusunda öğrenciler etkinlikleri eğlenceli bulduklarını, daha çok materyali tasarlarken ve çizim yaparken zorlandıklarını, en çok boyama yaparken ve örüntü yaparken keyif aldıklarını ve tasarladıkları ürünlerde fen, matematik, mühendislik ve teknolojiden faydalandıklarını dile getirmişlerdir. Araştırmanın sonucunda STEM etkinliklerinin kullanımına yönelik matematikle ilgili farklı konularda veya farklı yetersizlik gruplarıyla çalışmalar yapılması önerilmiştir.

Anahtar Kelimeler: STEM Etkinlikleri, Matematik Becerileri, Örüntü, Öğrenme Güçlüğü.

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1. Introduction

STEM education is an interdisciplinary approach that integrates Science, Technology, Engineering, and Mathematics disciplines to foster creativity, critical thinking, and problem-solving skills (Alıcı, 2018; Fajrina et al., 2020; Jindal et al., 2023; Shamkuwar et al., 2023). This approach emphasizes the application of knowledge and technology for problem-solving while focusing on fundamental 21st-century skills such as critical thinking, communication, creativity, and teamwork (Balçın - Yıldırım, 2021; Fajrina et al., 2020; Metpattarahiran, 2021; Uğraş, 2019). Moreover, it aims to equip students with interdisciplinary skills such as coping with uncertainties and solving complex problems (Dereli, 2021; Murphy et al., 2020). STEM education enables students to acquire practical skills in real-world contexts, helping them compete in the 21st century and overcome global challenges, thus contributing to their success in technologically advanced societies (Fajrina et al., 2020).

STEM education offers numerous cognitive, social, and emotional development benefits for students with learning disabilities. STEM instruction can be tailored for students with learning disabilities using the "5E model," which has effectively increased student engagement (So et al., 2022). Additionally, the Universal Design for Learning (UDL) framework supports these students' executive functioning and learning strategies by addressing diverse learning needs, thus enhancing their success in STEM education (Xie et al., 2020). STEM education fosters the development of social and emotional skills such as self-confidence, self-advocacy, and determination in students with learning disabilities. Technology use, inquiry-based learning tailored to students' abilities, and peer coaching positively impact these students' social and emotional development (Davis, 2014; So et al., 2021).

STEM activities provide many benefits, including cognitive, skill development, social, emotional, and long-term effects. These activities support children's cognitive and psychomotor development, contributing to their acquisition of metacognitive knowledge (Balçın-Yıldırım, 2021; Ramesh, 2017). STEM activities significantly enhance problem-solving skills among preschool children (Akcay Malcok-Ceylan, 2022). STEM activities contribute to the development of many skills such as problem-solving, critical thinking, communication, and leadership skills (Chang et al., 2015; Pallavi, 2023; Sözbilir - Bülbül, 2017; Tosun, 2019). From a social and emotional perspective, STEM activities support the fundamental elements of comprehensive education, such as critical thinking, collaboration, and skill development (Pallavi, 2023).

STEM education does not only contribute improvements in developmental areas and skills of students with typically development, but also, foster those of students with special needs placed in inclusive classrooms. For example, students diagnosed with learning disabilities can highly benefit from STEM related activities by gaining knowledge, skills, and attitudes, all of which can prepare these students for future academic and social challenges (So et al., 2022; Sözbilir & Bülbül, 2017; Tosun, 2017). These activities ensure that students with special needs have access to opportunities in STEM fields and contribute to developing skills such as self-confidence, self-advocacy, and determination (Davis, 2014; Dereli, 2021).

In mathematics education, cognitive strategies, assistive technologies, and inclusive educational approaches are crucial for students experiencing learning disabilities. Cognitive strategy instruction has proven effective in developing problem-solving skills (Özkubat et al., 2020). These strategies significantly improve the performance of primary and secondary school students learning disabilities in mathematics (Krawec et al., 2013; Miranda-Casas et al., 2008). Furthermore, cognitive strategy training programs with self-regulation procedures have significantly enhanced verbal problem-solving and overall mathematical achievement (Karabulut et al., 2021; Miranda-Casas et al., 2008). Digital teaching strategies, such as video modeling and virtual manipulatives, enhance mathematics learning by increasing students' independence and accuracy (Satsangi et al., 2019; Satsangi et al., 2018). Supportive technologies, such as manipulatives and computer-based programs, are valuable tools for improving accessibility, participation, and achievement in mathematics for these students (Bouck - Satsangi, 2020; Evmenova - Behrmann, 2013). Best practices in mathematics education include direct instruction, cognitive strategy teaching, and evidence-based applications (Montague, 2021). For example, a cognitive strategy intervention such as "Solve It!" has improved mathematical problem-solving skills among middle school students (Karabulut - Özmen, 2018; Krawec et al., 2013).

While STEM education provides significant opportunities for students with learning disabilities, current research highlights the effective practices, challenges, and recommended strategies in this field. Studies show that STEM education substantially improves self-advocacy, self-confidence, and social skills for children and young people with special needs (Kolne - Lindsay, 2020). The UDL framework has been identified as a practical approach to support these students' learning strategies and executive functions, enhancing their success in STEM fields (Xie et al., 2020). Different types of learning disabilities can affect the effectiveness of STEM education in various ways. For instance, students with specific learning disabilities such as dyslexia may struggle in traditional academic areas but possess unique strengths like three-dimensional thinking, which can provide advantages in STEM learning (Wright - Moskal). Best practices for STEM education include technology use, inquiry-based learning aligned with students' abilities, and peer coaching (So et al., 2021; So et al., 2019). Furthermore, STEAM (STEM + Arts) education has increased academic achievement, motivation, and curiosity among students with learning disabilities (Sari et al., 2024).

Implementing STEM education for students with learning disabilities presents several challenges. These students have historically been underrepresented in STEM fields, highlighting the need to provide general and special education teachers with strategies to improve their success in these areas (Green, 2014). Cognitive processing difficulties in problem-based STEM learning tasks pose significant barriers to their achievement (Asghar et al., 2017). Comparisons of the effects of applied STEM lessons reveal that while the general student population and students with learning disabilities benefit, the gains are more pronounced for students with learning disabilities (Plasman - Gottfried, 2018). From a research ethics perspective, studies examining the effectiveness of STEM education should utilize more controlled and robust designs to evaluate participant characteristics and the impacts of intervention components (Kolne - Lindsay, 2020). In addition, when the national and international literature is examined, while there are many studies on the use of STEM activities for individuals with special needs (Akay, 2018; Balçın - Yıldırım, 2021; Catteral, 2017; Hwang - Taylor, 2016; Özçelik - Akgündüz, 2017; Sari et al., 2024; Tosun, 2019; Wei et al., 2017), the number of studies on individuals with learning disabilities is quite limited (Çevik et al., 2023). Existing research suggests that the STEM education approach can be beneficial in terms of creating enriched learning environments. These findings suggest that STEM methods should be further investigated in mathematics courses for students with learning disabilities. Accordingly, it is thought that this study will make a significant contribution to the literature on the use of STEM activities in mathematics lessons for students with learning disabilities.

This study aims to evaluate the teaching of the pattern topic to students with learning disabilities through STEM activities. In this context, the following research questions are addressed:

- What are the skill levels of students with learning disabilities during the STEM activities related to teaching the pattern topic?
- What products are created by students with learning disabilities after STEM activities related to teaching the pattern topic?
- How do students with learning disabilities exchange knowledge regarding the pattern topic through STEM activities?
- What are the perspectives of students with learning disabilities on STEM activities in relation to the pattern?

2. Method

2.1. Research Design

In this study, a multiple case study design, one of the qualitative research methods, was used. Multiple case study is a research approach based on examining more than one situation both within itself and with other situations (Stake, 2005). In this study, each student was considered as a separate case, and the processes of the students were analyzed both within themselves and in comparison, with each other. The evidence gathered by qualitative multiple case studies are robust and powerful (Yin, 2014).

2.2. Study Group

The study group consisted of three third-grade students, aged 8, 8, and 9, who were diagnosed with learning disabilities and received full-time inclusive education. The participants were selected through purposive sampling. The inclusion criteria for students were as follows: (a) participation in inclusive education, (b) a diagnosis of learning disabilities, (c) possession of fine motor skills, and (d) prerequisite abilities such as focusing attention on auditory and visual stimuli.

The participants were selected from two private education and rehabilitation centers in Mersin, which cater to students with learning disabilities. Participants' medical diagnoses and reports from the Guidance and Research Center were examined. The researcher interviewed classroom teachers at the school and special education teachers at the rehabilitation centers to collect information about the students. Additionally, observations were conducted at the institutions. Based on the interviews and observations, it was determined that the students met the prerequisite criteria. Before the study, the researcher met with the families of the selected students and obtained written consent for their participation.

Furthermore, permissions were secured from the directors of the rehabilitation centers. To maintain confidentiality, pseudonyms were assigned to the students. The interventions were carried out in one of the rehabilitation centers. Table 1 provides an overview of the general characteristics of the study group.

Table 1. Demographic information on participants

Students	Age	Gender	Grade Level	Diagnosis
S1	8	F	3	Learning Disabilities
S2	8	M	3	Learning Disabilities
S3	9	F	3	Learning Disabilities

2.3. Setting and Materials

The study was conducted at a private education and rehabilitation center in Mersin, where the participating students received their education. The research process took place in the group education classroom of the center at times convenient for the participants. The materials used in the study included a video camera, tripod, data collection forms, audio recorder, pens, and paper.

2.4. Data Collection Tools

In a case study, relying on a single data source may not suffice to answer research questions; thus, various data sources appropriate to the context need to be utilized (Gay et al., 2012). This study collected data from multiple sources to address the research questions. Specifically, the data were gathered through observations, interviews, video recordings, the STEM Skills Rubric, product evaluation forms, and achievement tests. All data were systematically recorded throughout the research process. Before data collection, ethical approval was obtained from the Social Sciences Human Research Ethics Committee of Bolu Abant İzzet Baysal University and written and verbal consent was secured from the parents of the participating students. Participants were informed, and consent was obtained before audio and video recordings were made.

2.4.1. Observation Form

During the research process, the researcher observed the students, and an observation form was prepared based on the research topic and literature review. Field notes and video recordings obtained during the activities were documented using the observation form. The form was developed by the researchers and included dimensions such as participation and interest levels, pattern creation and application, problem-solving, creativity, collaboration and communication, and utilization of the engineering design process. Based on these dimensions, 13 criteria were established, and the observation form was finalized after obtaining expert feedback. Completed observation forms are presented in the findings.

2.4.2. STEM Skills Rubric

A STEM Skills Rubric was developed to assess the STEM skills of students with learning disabilities, particularly in pattern-related tasks. This rubric evaluated aspects such as using mathematical skills, planning, preparing appropriate materials, and designing models. The items were created based on the literature (Balçın - Yıldırım, 2021; Hynes etc., 2011; 2017; Yayla – Eskici, 2023) and aligned with the study's targeted objectives. Each content/principle in the rubric was evaluated and scored in 5 steps. The developed rubric was finalized by taking the opinions of three experts in the field of special education and mathematics education and content validity was ensured. The rubric consisted of 12 items, scored on a scale of 1 to 5: (1) far below expectations, (2) below expectations, (3) at the expected level, (4) above expectations, and (5) far above expectations. The minimum score possible was 12, while the maximum score was 60. STEM skills were categorized as weak (12–21 points), needing improvement (22–31 points), average (32–40 points), good (41–50 points), and sufficient (41–60 points).

2.4.3. Product Evaluation Form

The researchers developed a product evaluation form to evaluate the students' design products. This form assessed dimensions such as purpose alignment, originality, functionality, aesthetics, and adherence to criteria. It consisted of 19 items, and the students' designs were scored based on the items in the form. Scores were categorized as follows: below expectations (1 point), at the expected level (2 points), and above expectations (3 points). Students could receive a minimum of 19 points and a maximum of 57 points for their designs. Design products scoring 19–31 points were considered weak, 32–44 points were rated average, and 45–57 points were rated good.

2.4.4. Semi-Structured Interview Form

Semi-structured interviews were conducted with the participants to understand students' perspectives on STEM activities. The researchers prepared an interview form of 10 open-ended questions, which experts reviewed for feedback. Two special education experts and one mathematics education expert provided suggestions, which were incorporated to finalize the form. The interviews were conducted in a designated room at the rehabilitation center, and audio recordings were taken. Each interview lasted approximately 15–20 minutes.

2.4.5. Achievement Test

An achievement test was developed to determine the change in the success levels of students with learning disabilities concerning patterns in STEM activities. In the preparation of the achievement test, the following sequence was followed: examining the literature (Kidd, 2014; Moss - London McNab, 2011) and the curriculum, preparing the test questions, obtaining expert opinion and finalizing the test. The test comprised ten questions aligned with the curriculum objectives for students' grade levels. After the achievement test was prepared, it was sent to three experts working in the field of special education and mathematics education and expert opinions were obtained. After the expert opinion, the test was finalized. The achievement test was administered to all students before the intervention and again after completing the activities.

2.5. Role of the Researcher

The researchers assumed various roles at different stages of the study. One of the researchers, having completed a doctoral degree in special education and a bachelor's degree in mathematics education, conducted the implementation. Other researchers were involved in designing the methodology, evaluating the results, and preparing the manuscript. The researcher conducting the implementation performed tasks such as observing the process, executing STEM activities with the students, and conducting interviews.

2.6. Validity and Reliability

In order to ensure credibility in the study, inter-coder reliability calculation, expert opinion and data triangulation (observation, interview and document analysis) techniques were used (Brantlinger et al., 2005; Cresswell, 2012; Cresswell & Miller, 2000). Expert opinions, as well as audio and video recordings, were collected throughout the research process. Instead of relying on a single data collection method, multiple methods were employed, and the data were presented with direct quotations to enhance reliability. For the consistency factor of the research, the agreement factor between the analyzes conducted by two different researchers was taken into consideration. In the qualitative data analysis process, the researchers carried out the coding process separately. As a result of the coding made, the consistency factor was tried to be ensured by conducting interviews with dissimilar coding and looking at the harmony between observers.

2.7. Implementation Process

This study, which evaluated the STEM activities concerning patterns in mathematics for students with learning disabilities, was planned over three weeks. In the first week, the achievement test on the "Geometric Patterns" unit was administered. The lesson plans integrating STEM activities related to patterns were implemented during the subsequent two weeks.

The materials used included colored cardboard, stickers with images of animate and inanimate objects, everyday inanimate objects (e.g., pens, notebooks, water bottles), scissors, glue, colored pencils, markers, colored sticks, foam board, A4 paper, internet access, and a computer.

The lesson plans with STEM activities were designed according to the 5E Model, commonly used in STEM education. The 5E Model includes the stages of Engage, Explore, Explain, Elaborate, and Evaluate. Active learning techniques were employed throughout the STEM activities. Before starting the stages of the 5E Model, the researcher prepared the necessary materials and arranged the implementation area. A brief explanation of the activities was provided to the students before beginning. To capture students' attention and motivate them, the researcher asked, "I see you are ready; shall we begin?" Upon receiving the response, "Yes, I am ready!" the researcher positively reinforced the student by saying, "Great! Let us get started!"

Engage: In the Engage stage, the lesson was initiated with an entertaining and curiosity-provoking introduction. Before beginning the lesson, questions were asked to assess the student's readiness and prior knowledge of the topic. A pattern made from leaves and pencils was shown to draw attention to the lesson and spark interest. This visual example captured the student's attention and aroused curiosity. Questions prompting the student to recognize the sequence were posed, encouraging reflection without expecting an immediate correct answer. Different pattern examples were provided, and students were asked to examine these examples and think about the logic behind their sequences. The researcher demonstrated a pattern with classroom items (e.g., notebook-book-pencil) and asked, "Can you create a new pattern by adding something else to this sequence?"

Explore: Students were given geometric shapes and asked to create simple geometric patterns (e.g., triangle-square-triangle-square). They also created patterns using images of animate and inanimate objects, sharing their results within the group. Questions were asked about how they arranged the animate and inanimate objects in their patterns. Additionally, a mosaic image made of squares, triangles, and rectangles was shown to the students. They were asked to draw the pattern they observed on A4 paper and describe the sequence they followed. Students were given opportunities to establish connections and explore relationships within the patterns through active participation.

Figure 1. Examples of activities for students to color geometric shape patterns

Explain: During the Explain stage, the researcher provided explanations using slides and videos prepared in advance. The researcher explained that patterns are frequently found in nature and daily life and consist of repetitive and orderly structures. Examples include animal patterns, carpet and rug designs, and geometric shapes on building facades. Students were then given worksheets containing geometric shape patterns and were asked to color them according to the pattern rules using colored markers.

Elaborate: In this stage, students were asked to apply their learning to a new situation by creating a house model. They decorated the exterior of the house models with geometric shapes and images of animate and inanimate objects to form patterns. Students were encouraged to create unique patterns using geometric shapes and images.

Figure 2. Student S1's design

Figure 3. Student S2's design

Figure 4. Student S1's design

Evaluate: Students presented their house model and the patterns they created to the class. Following the presentations, an academic achievement test on patterns was administered.

2.8. Data Analysis

In the data analysis process, the data collected to answer the research questions are classified in an accurate, reliable, and systematic way, and the themes that cannot be directly observed but are revealed through conceptual coding and classification and the meaningful relationships between these themes are determined; thus, the findings of the research are reached (Patton, 2014; Yıldırım - Şimşek, 2021).

In the research, the data obtained from the interviews were transcribed and read until the transcripts were mastered and analyzed using content analysis. In the content analysis approach, the researchers read the data, and the data are grouped. Each data group is given a code. Sub-themes and themes are reached through these codes in the following process. While presenting the findings in the content analysis approach, direct quotations are included in order to convey the views of the participants of the research to the reader in a more striking way (Yıldırım - Şimşek, 2021). The researchers carried out the coding process separately during the data analysis process. As a result of the coding made, the interobserver agreement was checked by conducting interviews with dissimilar coding. In this direction, it was calculated using the formula of Agreement / Agreement + Disagreement (Miles - Huberman, 2019). Accordingly, the reliability rate was determined to be 95.5%. The codes and categories were then checked by a faculty member who specialized in qualitative research and a research assistant who had taken the qualitative research methods course and defended her doctoral thesis on qualitative research.

In the presentation of the interview data, ethical elements were taken into consideration, the names of the participants were not given in the text, the participants were numbered, and direct quotations were included for the students' answers coded as S1, S2, and S3. In addition, the data obtained through achievement tests, tests, observation forms, product evaluation forms, and

STEM skills rubrics were interpreted with descriptive statistics and analyzed by the study's first author.

3. Findings

3.1. Findings Related to Skill Levels of Students with Learning Disabilities During STEM Activities on Teaching Patterns

The research question, "What are the skill levels of students with learning disabilities during STEM activities on teaching patterns?" was addressed using an observation form and a STEM skills rubric. The data analysis from the observation form revealed findings as presented in Table 2.

Table 2. Findings Obtained from the Observation Form

Dimension	Criteria	S1 Y/N	%	S2 Y/N	%	S3 Y/N	%
Level of participation and interest	Willingness to participate in the activity	+	%100	+	%100	+	%100
Pattern creation and application	Applying a specific pattern rule in design	+		+		+	
	Use regular repetition and sequencing in the pattern	+	%100	+	%100	+	%100
	Complete the pattern correctly and completely	+		+		+	
Problem solving	Trying different ways to solve problems encountered during the activity	+		+		+	
	Solving problems with help when needed	+		+		+	
Creativity	To create different designs by using colors and shapes in their own unique style	+	%100	+	%100	+	%100
Collaboration and communication	Exchange ideas and communicate with group members	+	%100	+	%100	+	%100
Using the engineering design process	Planning your design	+	%100	+	%100	+	%100

Drawing the planned design	-	+	-
Measurement	-	-	-
Aligning materials	-	-	-
Completing the design using the given materials	+	+	+

Upon examining Table 2, it was observed that all students were generally willing to participate in the lesson. All students applied specific pattern rules in their designs, used regular repetition and sequencing, and completed the patterns accurately and comprehensively. While the students generally did not attempt different methods to solve problems encountered during the activity, one student (S2) explored alternative approaches. All participants sought help to resolve the issues they faced. In their designs, all students utilized colors and shapes in their unique styles to create diverse pattern designs. The students generally exchanged ideas and communicated with their group members. None of the students demonstrated measurement and alignment skills in their designs. While only one student could draw the planned design, all participants planned and completed their designs using the provided materials. Despite difficulties in drawing, measuring, and aligning their designs, the students successfully incorporated patterns to complete their products.

Additionally, Table 3 shows that the most successful aspects for participants (S1 = 100%, S2 = 100%, S3 = 100%) were participation and engagement, pattern creation and application, creativity, collaboration, and communication. The least successful aspect (S1 = 40%, S2 = 60%, S3 = 40%) was utilizing the engineering design process.

To answer the research question about skill levels during STEM activities, the researchers observed the STEM activity processes for each student and completed the STEM skills rubric. The findings from the STEM skills rubric, aligned with the score ranges, are presented in Table 3.

Table 3. STEM Skills Levels

Student	Level
S1	Acceptable
S2	Adequate

S3	Good

According to the findings in Table 3, the STEM skills of the students were determined to be at moderate, reasonable, and sufficient levels based on their scores. While students demonstrated adequate knowledge in mathematics and science related to the topic, as well as fine motor skills such as cutting with scissors and gluing (engineering-related skills), they were found to need to improve in mathematical skills like measuring and aligning and in utilizing technology.

3.2. Findings Related to Products Developed by Students with Learning Disabilities Following STEM Activities on Teaching Patterns

The students' designs were evaluated using the criteria from the product evaluation form. The findings related to the levels determined by the scores obtained from the students' products are presented in Table 4.

Table 4. Findings Related to Product Evaluation Form

Student	Level
S1	Acceptable
S2	Good
S3	Acceptable

An examination of Table 4 indicates that the materials created by the students were generally at moderate and reasonable levels. When the designs were evaluated based on the criteria of the product evaluation form, it was observed that students could use their patterning skills in mathematics in the materials they designed for the activity. Additionally, observations revealed that students struggled with accurately placing the wooden sticks on the roof and adjusting the lengths of shapes to fit the building. These findings are consistent with the results obtained from the STEM skills rubric.

3.3. Findings Related to Changes in Achievement of Students with Learning Disabilities on Patterns Through STEM Activities

The research question, "How do the knowledge levels of students with learning disabilities change regarding patterns through STEM activities?" was addressed using achievement tests as the data collection tool. Pattern achievement tests were administered to the students before and after the intervention. The findings from the pre-and post-tests are presented in Table 5. An examination of Table Q shows an increase in the achievement levels of the students in the post-tests compared to their pre-tests.

Table 5. Students' Pre-Test and Post-Test Results

Student	Pre-Test		Post-Test	
	Correct Answers	Percentage	Correct Answers	Percentage
S1	2	%20	9	%90
S2	3	%30	10	%100
S3	4	%40	10	%100

3.4. Findings on Students' Opinions Regarding STEM Activities

The sub-research question, "What are the opinions of students with learning disabilities regarding STEM activities?" was addressed using data collected through a semi-structured interview form. The transcripts of the interviews were analyzed through content analysis, which revealed four main themes: Evaluation of the STEM Activity Process, Use of Science, Use of Engineering, and Use of Technology. The first theme, Evaluation of the STEM Activity Process, was divided into three sub-themes: General Evaluation, Enjoyable Aspects, and Challenging Aspects.

Under the first sub-theme, General Evaluation, S1 stated, "It went well; I had fun," while S2 expressed, "It was enjoyable; let us do it again." Regarding the Enjoyable Aspects of STEM activities, S3 shared, "I enjoyed gluing, creating patterns, and coloring." Similarly, S1 remarked, "Decorating was fun. Coloring shapes with colorful markers was enjoyable. The markers were nice." S2 added, "The most enjoyable part was preparing the patterns. However, I also had much fun gluing."

The second theme, the Use of Science in STEM Activities, was framed around the concept of animate and inanimate objects. S1 commented, "I used science concepts, like animate and inanimate objects." S2 stated, "I created patterns using animate and inanimate objects," while S3 said, "We learned about animate and inanimate objects, and I used them. I also stuck stickers of them."

The third theme, Use of Engineering in STEM Activities, highlighted the emphasis on drawing and design. S1 mentioned, "I used it while drawing and making the model," S3 shared, "I used engineering when I was drawing and designing the model." S2 echoed similar sentiments: "I used it while designing the house."

The final theme, Use of Technology in STEM Activities, revealed varying experiences with technology. S2 explained, "I used a hot glue gun and researched on the computer how to do it," S3 stated, "I used glue and scissors." In contrast, S3 remarked, "I did not use technology," emphasizing that they did not incorporate technology during the activities.

4. Discussion, Conclusion and Recommendations

This study aimed to evaluate the teaching of patterns to students with learning disabilities through STEM activities. In this section, the research findings are discussed in light of the existing literature, and recommendations for future research are provided, considering the overall process.

The first finding related to the skill levels of students with learning disabilities during STEM activities on teaching patterns revealed that students were generally willing to participate in the activities, as observed through the prepared observation form. Hwang - Taylor, 2016 emphasized that STEM activities benefit students with special needs and increase their willingness to participate. The observation form findings showed that the students were able to create and apply patterns accurately and collaborated effectively with their peers. Similarly, Özçelik - Akgündüz, 2018 found that STEM education for gifted/special needs students enhanced their science and mathematics achievements as well as their 21st-century skills, such as collaboration and communication. Group-focused STEM education for individuals with special needs is believed to not only increase academic success but also improve social harmony and peer relationships through mutual support and collaboration (Balçın - Yıldırım, 2021).

In line with these findings, STEM activities are recommended to foster interest in mathematics among students with learning disabilities, warranting further research in this area. According to the observation form, one participant demonstrated skills in planning and drawing designs, while the other two participants did not. Additionally, none of the participants exhibited measurement skills. Similar to this finding, (Balçın - Yıldırım, 2021) noted that inclusive education students faced disabilities in measurement and drawing during STEM activities. Contrary to these findings, Akay, 2018 concluded that STEM activities positively contributed to gifted students' computational thinking and design skills before transitioning to pro-duct design. This outcome may stem from strengthening students' analytical thinking, problem-solving, and systematic approach skills (Kaplan et al., 2017). Furthermore, computational thinking processes are believed to enhance students' logical and creative thinking skills, fostering a deeper understanding of the design process.

Based on the STEM skills rubric, the student with the highest score demonstrated sufficient STEM skills, one student showed good skills, and the student with the lowest score exhibited moderate skills. In contrast, Balçın - Yıldırım (2021), found that students with mild intellectual disabilities did not achieve very high STEM skill levels after the material development process, with skill levels categorized as good, moderate, and low. They recommended implementing STEM-focused programs for special needs students in supportive education settings. The variation in findings may be attributed to individual differences, prior experiences, and learning processes affecting students' STEM skills. Considering these findings, integrating STEM approaches into core subjects like mathematics and science for students with learning disabilities and conducting further studies on this integration are recommended.

The product evaluation form findings revealed that students were able to use their patterning skills in mathematics while designing products, generally creating products of good or moderate quality. This outcome might be attributed to the use of engaging materials, such as colorful sticks, geometric shapes, and stickers of animate and inanimate objects, which captured the students' attention. This supports the idea that using appealing materials is crucial for helping special needs students focus on the topic being taught. Materials can help students concentrate, increase interest and motivation (Barus - Djukri, 2013). The use of concrete materials in STEM activities enables special needs students to create their products, fostering a positive attitude toward the lesson (Das - Pal, 2024). STEM education's emphasis on applying knowledge through design and product creation has been shown to increase motivation and curiosity among students with learning disabilities (Sari et al., 2024). Teachers are encouraged to use materials tailored to the characteristics of students with learning disabilities in their classrooms. Adapting materials appropriately can facilitate learning processes for special needs students (Maryanti et al., 2021; Özkubat & Karabulut, 2022).

The findings related to changes in the achievement of students with learning disabilities regarding patterns through STEM activities suggest that STEM activities positively impacted their ability to create patterns. Similarly, (Çevik et al., 2023), concluded that STEM activities actively involving students with learning disabilities were effective in enhancing their learning. STEM education has been reported to improve the academic achievement of students with learning disabilities (Sari et al., 2024). Hwang - Taylor (2016), also noted the effectiveness of STEM activities for students with special needs. The findings align with previous studies highlighting the benefits of STEM activities (Ayverdi, 2018; Balçın - Yıldırım, 2021; Biçer, 2019; Özçelik - Akgündüz, 2018; Tosun, 2019; Wei et al., 2015), when inclusive education students designed STEM-focused materials, they had opportunities to reflect unexpressed thoughts, develop problem-solving skills, and establish social collaboration, all of which supported their academic development. STEM lesson plans foster students' active participation through curiosity and discovery (Alan, 2020; Catterall, 2017).

The findings on students' opinions of STEM activities revealed that they found the activities enjoyable and fun. This finding aligns with other studies (Özçelik - Akgündüz, 2018; Balçın - Yıldırım, 2021; Çevik et al., 2023). For instance, Özçelik - Akgündüz (2018) concluded that students enjoyed the design process and were satisfied with transforming their designs into products. Balçın - Yıldırım (2021) observed that inclusive education students' interest in lessons increased, and they enjoyed creating materials after STEM activities. Similarly, Çevik et al. (2023), reported that students described STEM activities as "the most enjoyable experience of their lives" and expressed having fun while learning. When asked about the challenges they faced, all three students mentioned disabilities in design creation, making the roof of the model, drawing, and cutting. Consistent with this, Balçın – Yıldırım (2021) found that inclusive education students faced challenges in cutting and gluing during STEM activities. Students expressed enjoying creating patterns, decorating, and using stickers. When asked about the concepts and mathematics skills they benefited from, they mentioned using animate and inanimate objects, patterns, and geometric shapes.

Considering the findings, the integration of STEM activities focusing on mathematics and science outcomes and requiring the use of engineering skills achieved the intended objectives. This aligns with the goals of STEM education and supports findings from other studies (Özçelik - Akgündüz, 2018; Balçın - Yıldırım, 2021). When asked about their use of engineering, students stated they utilized engineering skills during drawing and model creation. Regarding technology, students mentioned using tools like phones, scissors, glue, and silicone guns. While students' self-reports indicated they benefited from STEM skills in science, mathematics, engineering, and technology, the STEM skills rubric findings showed sufficient proficiency in science and mathematics skills but insufficient proficiency in technology use. In parallel with these findings, Balçın - Yıldırım, (2021) noted that while students rated their skills in mathematics and engineering as strong, researchers observed inadequacies in these areas. This discrepancy may be attributed to students' lack of understanding of what constitutes technology and engineering skills.

This study demonstrated that teaching patterns through STEM activities is effective in facilitating learning and skill development among students with learning disabilities. Similarly, further studies could explore the use of STEM activities in mathematics for different topics or with different disability groups.

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