Uludağ Üniversitesi Eğitim Fakültesi Dergisi / Journal of Uludag University Faculty of Education
e-ISSN: 2667-6788 https://dergipark.org.tr/tr/pub/uefad
Yıl **2025,** Cilt **38**, Sayı **2**, **392-413** | DOI: https://doi.org/10.19171/uefad.1575839 **Araştırma Makalesi | Research Article**

Determining the Effectiveness of STEM-Based Activities in Science Classes for Individuals with Intellectual Disabilities

Zihin Yetersizliği Olan Bireylere Fen Bilimleri Dersinde Uygulanan STEM Temelli Öğretim Etkinliklerinin Etkililiğinin Belirlenmesi

Havva Aysun KARABULUT
Dr. Öğr. Üyesi ◆ Abant İzzet Baysal Üniversitesi, Özel Eğitim Bölümü ◆ havvakarabulut@ibu.edu.tr ◆ ORCID: 0000-0001-9119-3626

Kadriye UÇAR
Dr. Öğr. Üyesi ◆ Mersin Üniversitesi, Özel Eğitim Bölümü ◆ kadriye.ucar@mersin.edu.tr ◆ ORCID: 0000-0002-9522-7624

Ahmet Serhat UÇAR
Dr. Öğr. Üyesi ◆ Mersin Üniversitesi, Özel Eğitim Bölümü ◆ asucar@mersin.edu.tr ◆ ORCID: 0000-0001-5910-8751

Abstract

This study aimed to determine the effectiveness of STEM-based instructional activities in teaching the topic of "light propagation and reflection" to students with mild intellectual disabilities. A single-subject research model was used in this study, specifically the multiple probe design across participants. The participants were three fifth-grade students diagnosed with intellectual disabilities who received supplementary education at a special education and rehabilitation center. The study's findings indicated that the STEM-based instructional activities were effective in teaching the topic of "light propagation and reflection" to students with mild intellectual disabilities. Furthermore, the participants were able to generalize the topics they learned to different individuals and maintained their performance on these topics at 1, 3, and 5 weeks following the completion of instruction. The social validity findings obtained after the STEM-based instructional activities also indicated that the students with mild intellectual disabilities had positive perceptions of the study.

Keywords: Intellectual Disability, STEM, Science Teaching

Özet

Bu araştırmada hafif düzeyde zihin yetersizliği olan öğrencilerin "ışığın yayılması ve yansıması" konusunun ediniminde STEM yaklaşımıyla uygulanan öğretim etkinliklerinin etkililiğinin belirlenmesi amaçlanmıştır. Araştırmada tek denekli araştırma modellerinden katılımcılar arası yoklama evreli çoklu yoklama modeli kullanılmıştır. Araştırmanın katılımcıları, beşinci sınıfa devam eden ve özel eğitim ve rehabilitasyon merkezinde destek eğitim alan zihin yetersizliği tanısı olan üç öğrencidir. Araştırmadan elde edilen bulgular, STEM yaklaşımıyla uygulanan öğretim etkinliklerinin hafif düzeyde zihin yetersizliği olan öğrencilere "ışığın yayılması ve yansıması" konularının öğretiminde etkili olduğunu göstermiştir. Ayrıca katılımcılar edindikleri konuları farklı kişilere genelleyebilmiş ve öğretim tamamlandıktan 1, 3 ve 5 hafta sonra da edindikleri konulara ilişkin performanslarını sürdürmüşlerdir. Ayrıca STEM yaklaşımıyla uygulanan öğretim etkinlikleri sonrasında elde edilen sosyal geçerlik bulguları hafif düzeyde zihin yetersizliği olan öğrencilerin araştırmaya ilişkin görüşlerinin olumlu olduğunu gösterir niteliktedir.

Anahtar Kelimeler: Fen Öğretimi, STEM, Zihin Yetersizliği

Kabul Tarihi / Received: 29.10.2024 | Onay Tarihi / Accepted: 03.05.2025

1. Introduction

STEM education is an interdisciplinary approach that combines science, technology, engineering, and mathematics, focusing on solving real-world problems (Metpattarahiran, 2021; Sanders, 2009). This approach aims to equip students with 21st-century skills, such as critical thinking, communication, creativity, and problem-solving (Alıcı, 2018; Duran & Şendağ, 2012; Jindal et al., 2023; Uğraş, 2019). Besides enhancing students' abilities to cope with various challenges, STEM education equips them with careers in STEM fields (Fajrina et al., 2020; Selisne et al., 2019). It is crucial for teachers to effectively impart knowledge, motivate their students, and support their learning processes (Metpattarahiran, 2021). Unlike traditional education, STEM education teaches students how to apply knowledge and technology to solve real-world problems through an interdisciplinary approach (Dereli, 2021; Metpattarahiran, 2021). In this respect, STEM education offers a holistic approach to preparing students for success in a rapidly evolving and technologically advanced society.

As an interdisciplinary approach, STEM education aims to provide students with a well-rounded education, offering cognitive, social, and economic benefits (Günay & Haliloğlu, 2022; Yıldırım & Altun, 2015; Xie et al., 2015). It focuses on enabling students to use knowledge and technology in problem-solving (Irak, 2019) and contributes to the development of 21st-century skills (critical thinking, communication, teamwork, and creativity) (Ekici, 2022). However, there are specific challenges in implementing STEM education. These challenges can be categorized as limitations in educational resources, lack of academic support, biases, discrimination, and knowledge gaps (Le et al., 2024). In their study, Toker-Gökçe and Yıldırım (2019) noted that teachers face difficulties in developing assessment tools suited to students' skill levels, integrating mathematics with other disciplines, and managing time effectively, which are obstacles encountered in STEM education. Teachers need to make innovative changes in their professional practices and overcome the challenges they face while implementing STEM education (Sukarman & Retnawati, 2022). In conclusion, although STEM education aims to provide various benefits to students, the challenges encountered in practice present limitations to its widespread adoption.

STEM education is of great importance for individuals with intellectual disabilities. In terms of cognitive development and inclusivity. However, specific challenges and obstacles are encountered in practice (Das & Pal, 2024; Davis, 2014; Kolne & Lindsay, 2020; So, Li, & He, 2019). Issues in cognitive processes and inequalities in educational opportunities make access to STEM education difficult for individuals with intellectual disabilities (Das & Pal, 2024). Therefore, teachers must adapt the content, products, and methods of STEM activities according to the interests, abilities, and differences of students with intellectual disabilities (Ayverdi & Avcı, 2023). It is stated that STEM education contributes to students' cognitive development by enhancing spatial visualization skills (Doğan, 2020). Innovative approaches such as STEM have also been shown to improve the quality of daily life for students with special needs (So et al., 2021). Considering these benefits, it is deemed essential to implement STEM education for individuals with intellectual disabilities as well (Bülbül & Sözbilir, 2017). When designing and implementing STEM education for students with intellectual disabilities, equal access to research opportunities should be ensured, and students' individual differences should be considered (Tosun, 2019). According to Bülbül & Sözbilir (2017) and Hwang & Taylor (2016), teachers must know their students well and design activities accordingly.

STEM activities provide cognitive benefits for individuals with intellectual disabilities, support the integration of assistive technologies, and can create positive social and emotional impacts (Gupta, 2019; Igier & Pennequin, 2020; Mahmood et al., 2024; Xie et al., 2020; Zgonec & Bogataj, 2022). Effective use of assistive technologies in the educational processes of students with special needs

enhances their quality of life by enabling broader participation at home, school, and community settings (Kaya et al., 2024; Michaels & McDermott, 2003). Assistive technologies can improve the overall quality of life for individuals with intellectual disabilities by providing support in cognitive, communication, and motor skills (Gupta, 2019). Through inquiry, engineering, and technology, STEM education increases cognitive, affective, and behavioral engagement for students with mild intellectual disabilities (So et al., 2022). STEM education designed to meet the needs of individuals with intellectual disabilities can positively impact their social and emotional development (Igier & Pennequin, 2020). It has been found that the socio-emotional environment significantly affects the performance of adults with intellectual disabilities in cognitive tasks, emphasizing the importance of considering social and emotional factors in STEM education for these individuals (Igier & Pennequin, 2020). In conclusion, based on this information, it can be said that STEM activities can be beneficial in supporting cognitive processes for individuals with intellectual disabilities and contribute positively to their social and emotional development.

STEM activities in science lessons for students with intellectual disabilities are essential in supporting these students' cognitive and social skills (Kolne & Lindsay, 2020; Green, 2014). Using concrete materials in STEM activities, allowing students to practice and produce their products, can enable individuals with intellectual disabilities to understand abstract concepts and develop a positive attitude towards the course (Das & Pal, 2024; So et al., 2022).

When we look at the national and international literature, we can observe that while there are many studies (Ayverdi, 2018; Barış & Ecevit, 2019; Biçer, 2019; Ceylan et al., 2018; Kanlı & Özyaprak, 2015; Özçelik & Akgündüz, 2017 Tofel-Grehl et al., 2018) on the use of STEM activities with individuals who have special abilities, there are a limited number of studies on the use of STEM activities specifically with individuals who have intellectual disabilities (Ayverdi & Avcu, 2023; Balçın & Yıldırım, 2021; So et al., 2019; So et al., 2022; Tosun, 2019). When the findings of these studies are examined, it is observed that the STEM education approach can be beneficial in creating enriched learning environments. Given these benefits, it is thought that further research should be conducted on using the STEM approach in science courses for students with intellectual disabilities. Considering all these, this study is expected to contribute to the literature on using STEM activities in science lessons for students with intellectual disabilities and to guide teachers in adopting more innovative approaches in their classroom practices. The aim of this study is to determine whether the teaching activities implemented with the STEM approach are effective in the acquisition of the topic of light propagation and reflection in science lessons for students with mild intellectual disabilities. In line with this aim, the following questions were sought:

1. Are the teaching activities implemented with the STEM approach effective in the acquisition of the topic of light propagation and reflection in science lessons for students with mild intellectual disabilities?
2. Does the effectiveness of the STEM approach intervention on the topic of light propagation and reflection in science lessons for students with mild intellectual disabilities continue 1, 3, and 5 weeks after the intervention has ended?
3. Are students with mild intellectual disabilities able to generalize the skills they have gained through the STEM approach to teaching activities to other settings and individuals?
4. What are the views of students with mild intellectual disabilities regarding the STEM approach teaching activities?

2. Method

2.1. Experimental Design

In this study, which aims to determine the effectiveness of STEM-based instructional activities implemented for individuals with intellectual disabilities on the topic of “Light Propagation and Reflection,” the multiple probe design across participants, one of the single-subject research models, was used. In this design, the effectiveness of an independent variable- in other words, the impact of an instructional or behaviour change programme- is examined on three different participants (Tekin-İftar, 2012). Before starting instruction, baseline data were collected simultaneously from all participants. Once a stable baseline was established, instruction began with the first participant. After the first participant met the criterion for the target behavior, a probe session was initiated for all participants. Upon achieving stable data again, an instructional session was conducted with the second participant. When the second participant also met the criterion, another full probe session was held with all participants. After stable data were obtained, the instruction proceeded with the third participant. When this participant reached the criterion, a final full probe session was held with all participants, and the intervention was concluded. Additionally, follow-up data were collected at 1, 3, and 5 weeks after the intervention had ended.

2.2. Independent Variable

The study's independent variable is the STEM approach integrated with the 5E instructional model used in the science course. In the study, lesson plans were prepared and implemented based on the 5E model using the STEM approach and were adapted to the characteristics of students with intellectual disabilities, in accordance with the 5th Grade science curriculum on the topic of "light propagation and reflection". In addition, the students who participated in the implementation had not previously received instruction on the topic of "light propagation and reflection."

2.3. Dependent Variable and Response Measurement

The study's dependent variable is the level of acquisition of the topic "light propagation and reflection" targeted for the participants in the science course. The participants' performance levels on the targeted topic were collected using a data recording form of 10 questions. (+) was put on the data recording form for the participants' correct responses, (-) was put on the data recording form for the participants' incorrect responses or lack of response, and the percentage of correct answers was calculated. In this study, the learning criterion for the participants to acquire the targeted topic "light propagation and reflection" as the dependent variable was set at 90%.

2.4. Participants

The participants of this study consist of the practitioner, students, and observers. Three students participated in the study, all of whom were diagnosed with intellectual disabilities. They were enrolled in a 5th-grade inclusive general education classroom and were aged 11, 11, and 10, respectively. Specific prerequisite criteria were used to select the students. These prerequisites included (a) receiving education in an inclusive setting, (b) having a formal diagnosis of intellectual disability, (c) having basic literacy skills, (d) demonstrating reading comprehension abilites, (e) the ability to attend to both auditory and visual stimuli, and (f) the ability to perform addition and subtraction with two-digit numbers.

In order to identify three students with these prerequisite skills, interviews were first conducted with the science teachers working with the students in the general education classroom, as well as with teachers at the rehabilitation center. The researcher also conducted classroom observations to identify suitable students within the institution where the study was conducted. The combination of observations and interviews confirmed that the selected students met the required criteria. Additionally, the necessary parental consent was obtained for the student's participation in the study. Based on the interviews with their teachers, it was determined that the students needed to gain prior knowledge of light propagation and reflection. The demographic characteristics of the participants are presented in Table 1.

Table 1. *Demographic Characteristics of the Participants*

Participant	Gender	Age	Class	Type of disability
Ayşe	Female	11	5	Mild intellectual disability
Emre	Male	11	5	Mild intellectual disability
Can	Male	10	5	Mild intellectual disability

All of the implementations and generalization sessions of the study were conducted by the first researcher. Implementation fidelity and inter-observer reliability data were collected by two special education specialists who had completed their master's degrees and were continuing their doctoral studies in special education.

2.5. Settings and Materials

This study was conducted in a special education and rehabilitation centre in Mersin province in Türkiye for students who received supportive education services. All sessions related to the probe, implementation, follow-up and generalization sessions with the participants were conducted one-on-one in the individual education classroom of the rehabilitation centre where the students received education. The classroom had a study desk, two chairs, a smart board, and a storage cabinet. Before implementation, the classroom's temperature, lighting, and cleanliness conditions were adjusted to be suitable for instruction. The tools used in the study included data collection forms, a pen, paper, and a camera. A "Light Propagation and Reflection Data Recording Form" consisting of 10 questions was prepared to assess the performance level of the target concept of light propagation and reflection intended to be taught to the student. In creating data collection forms, expert opinions were obtained from one person who had completed their Ph.D. in science education and two who had completed their Ph.D. in special education.

2.6. General Procedure

The implementation process included baseline, intervention, follow-up, and generalization sessions. All experimental sessions were conducted at the special education and rehabilitation center. Possible responses were categorized into three groups during the baseline, follow-up, and generalization sessions. For the dependent variable in these sessions, it was anticipated that the participant children could provide 1) a correct response, 2) an incorrect response, and 3) no response.

In cases of no response, this was evaluated as an incorrect response across all study sessions. The possible responses of the participants were recorded in the "Baseline, Follow-up, and Generalization Session Data Collection Form for the Topic of Light Propagation and Reflection" prepared for the targets.

2.6.1. Probe Sessions (Baseline, Full Probe and Daily Probe Sessions)

The probe sessions of the study consisted of full probe and daily probe sessions. The first full probe session was conducted to obtain baseline data. These sessions were continued until stable data were obtained from each participant for at least three consecutive sessions. The other full probe sessions were held simultaneously for all participants immediately after the criterion was met in the teaching sessions. Daily probe sessions were held immediately after the teaching sessions in order to determine the performance levels of the participants on the subject of “light propagation and reflection”. These sessions were also conducted following the same steps as the full probe sessions.

In the evaluation tool consisting of 10 questions, a (+) sign was placed on the data collection form for the correct answers of the participants, and a (-) sign was placed for incorrect answers or questions left blank. No prompts or reinforcements were provided to the students during the probe sessions.

2.6.2. Instructional Sessions

In the instruction sessions of the study, lesson plans were implemented using the STEM approach. A total of ten STEM lesson plans were prepared for the implementation. The stages of the lesson plans designed with the STEM approach were developed and implemented based on the 5E model, which is recommended and widely used in STEM education. Accordingly, the instruction was planned to include the following stages: a) Engage, b) Explore, c) Explain, d) Elaborate, and e) Evaluate. In the Engage stage, questions are asked to capture students' attention on the topic. In the Explore stage, students are asked inquiry-based questions and encouraged to share their thoughts. The Explain stage is the teacher-led stage, where concepts related to the topic are clarified. In the Elaborate stage, students are encouraged to apply the knowledge and skills they have acquired to new scenarios. The evaluation stage is where students' performance is assessed. In this study, adaptations were made to the 5E model for individuals with intellectual disabilities, including reinforcements, prompts, and error corrections.

Before starting the stages of the 5E model, the practitioner prepared the materials and arranged the area where the instruction would occur. The practitioner informed the students about the topic to be studied. To capture the student's attention and motivate them, the practitioner said, "I see you are ready. Shall we start if you are ready?" and reinforced the student's behavior with, "Great, then let us start!" when the student responded, "Yes, I am ready."

Engage: Before starting the lesson, questions related to the topic are asked to check the participant's readiness and prior knowledge, and picture cards displaying images of light from a flashlight, a lighthouse, and a car's headlights are shown to capture the participant's interest in the topic. This draws the student's attention to the lesson. The participant is asked how the light from the flashlight, lighthouse, and car headlights appears, and at this stage, the participant is expected to think and approach the answer but has yet to give a correct response. The aim is to uncover the participant's prior knowledge. Picture cards showing images of reflections on still and wavy water are presented. The participant is asked what might cause the difference between the two images. The participant is then asked to explain a smooth and rough surface and provide examples. At this stage, the participant

is encouraged to think and approach the answer, but a correct response is yet to be expected, as the aim is to reveal the participant's prior knowledge.

Explore: The student is provided with a flashlight and instructed to observe how light disperses on an A4 sheet of paper positioned in front of them, then asked to sketch their observations. The student is asked to hold the cardboard upright and place an A4 sheet in front. When the laser is pointed at all three items, the student is asked to observe the light's path and draw it on the provided paper. The participant is given various-shaped tubes and an empty paper towel roll. A candle is placed at the end of each tube or roll, and the participant is asked to indicate whether they can see the light through each tube and describe the path the light follows. The participant is expected to draw their observations. If needed, the researcher provides feedback on the drawings. The researcher gives the student a mirror, a piece of cardboard with smoothly applied aluminum foil, and another with wrinkled aluminum foil. The participants were asked which one they saw themselves in most clearly. The participant was then asked about the path the light takes on the mirror, smooth aluminum, and wrinkled aluminum and why the light follows a different path. Examples of the activities carried out by the students are given in Figure 1.

Figure 1. *Some selected photos from STEM activities*

Explain: Drawings are made for the participant to illustrate how light propagates and how rays emitted from a light source are represented, with necessary explanations provided. Reflection is explained, noting that clear images are formed on smooth and shiny surfaces due to regular reflection. In contrast, diffuse reflection could make images on rough and matte surfaces more transparent. Concepts such as incident ray, reflected ray, regular reflection, and diffuse reflection are introduced. Explanations are also given on drawing rays reflected from various surfaces and calculating the angles of incidence and reflection. This stage includes presenting the topic through slides, drawing on the board, and watching relevant videos.

Elaborate: The participant is informed about a planned evening camp in a garden without electricity. Considering the topics discussed in the previous stage, they are asked to design a way to illuminate this camp area. The participant is asked to sketch their design. After completing the sketches on paper, they move to the construction stage and use the materials before them to create the design. The participant presents information about their product and discusses it with the researcher. During this stage, the practitioner provided prompts as needed to support the participant.

Figure 2. *Example of Student Campsite Design Product*

Evaluate: Evaluation is taken from the participant. At the end of each instruction, questions such as "How do light rays propagate? What is a light ray? What are natural light sources? What are artificial light sources? What is the reflection of light? What is a uniform reflection? What is diffuse reflection? How many degrees is the angle of incidence in the figure given below? A ray of light is sent to a plane mirror at an angle of incidence of 40° and the ray is reflected as shown in the figure. What is the angle between the reflected ray and the mirror? Draw a light ray with an angle of incidence of 45 and an angle of reflection of 45. etc." were asked and recorded on the data recording form.

2.6.3. Follow-Up and Generalization Sessions

Follow-up sessions were conducted in the same setting as the instruction sessions 1, 3, and 5 weeks after the instruction was completed to determine whether the skills acquired by the students during the instruction were retained. These follow-up sessions were organized in the same manner as the baseline sessions.

Generalization sessions were conducted as pre- and post-tests in a different setting and with a different practitioner from the one who conducted the instruction once the criterion for the target behavior had been met. The data obtained from the generalization sessions were recorded in the generalization data recording form.

2.7. Reliability

Inter-observer and treatment reliability data were collected for at least 30% of all sessions in each phase for all participants, covering both the dependent and independent variables. The reliability data were collected by a research assistant with a master's degree in special education. Inter-observer reliability data were calculated and analyzed using the formula (Agreement / [Agreement + Disagreement] x 100) (Erbaş, 2012). The inter-observer reliability data are presented in Table 2.

Table 2. *Inter-Observer Reliability Findings*

Participant	Baseline	Intervention	Probes	Follow Up	Generalization	Overall
Ayşe	100%	88,88%	92,59%	100%	100%	96,29%
Emre	100%	92,59%	96,29%	100%	100%	97,77%
Can	100%	85,18%	88,88%	100%	100%	94,81%

Treatment fidelity aims to determine the degree to which the independent variable is implemented correctly throughout the study. Implementation reliability was calculated using the

formula specified by Kırcaali-İftar & Tekin-İftar (1997) ([Realised Practitioner Behaviour / Targeted Practitioner Behaviour] x 100). The treatment fidelity data are presented in Table 3.

Table 3. *Implementation Reliability Findings*

Participant	Baseline	Intervention	Probes	Follow Up	Generalization	Overall
Ayşe	100%	88,88%	92,59%	100%	100%	96,29%
Emre	100%	96,29%	85,18%	100%	100%	96,29%
Can	100%	92,59%	100%	100%	100%	95,51%

2.8. Social Validity

Social validity data were collected from the students participating in the study regarding the methods used and the skills taught. Interviews were conducted with students using five closed-ended questions prepared about the study, and their opinions were obtained. During the interview, the students were asked questions about whether the subject of the study was important, whether it contributed to them, whether they enjoyed the study, whether they were satisfied with the Stem activities, and whether their opinions were positive or negative about participating in the activity. The collected social validity data were analyzed through descriptive analysis.

2.9. Data Analysis

In the study, the effectiveness data were analyzed graphically. In the graphic, the horizontal axis represents the number of sessions and the vertical axis represents the percentage of correct responses. The data obtained from the social validity form in the study were analyzed using the descriptive analysis technique.

2.10. Ethical Precautions

In order to adhere to ethical guidelines, the parents of participants were informed about the study, and written consent was obtained to confirm their voluntary involvement. Real names of participants were not used; code names were assigned instead. In photographs used in the study, students' faces were not shown. The research was conducted by obtaining ethics committee permission from Bolu Abant İzzet Baysal University Human Research Ethics Committee in Social Sciences with the decision numbered 2023/04 dated 07.05.2023.

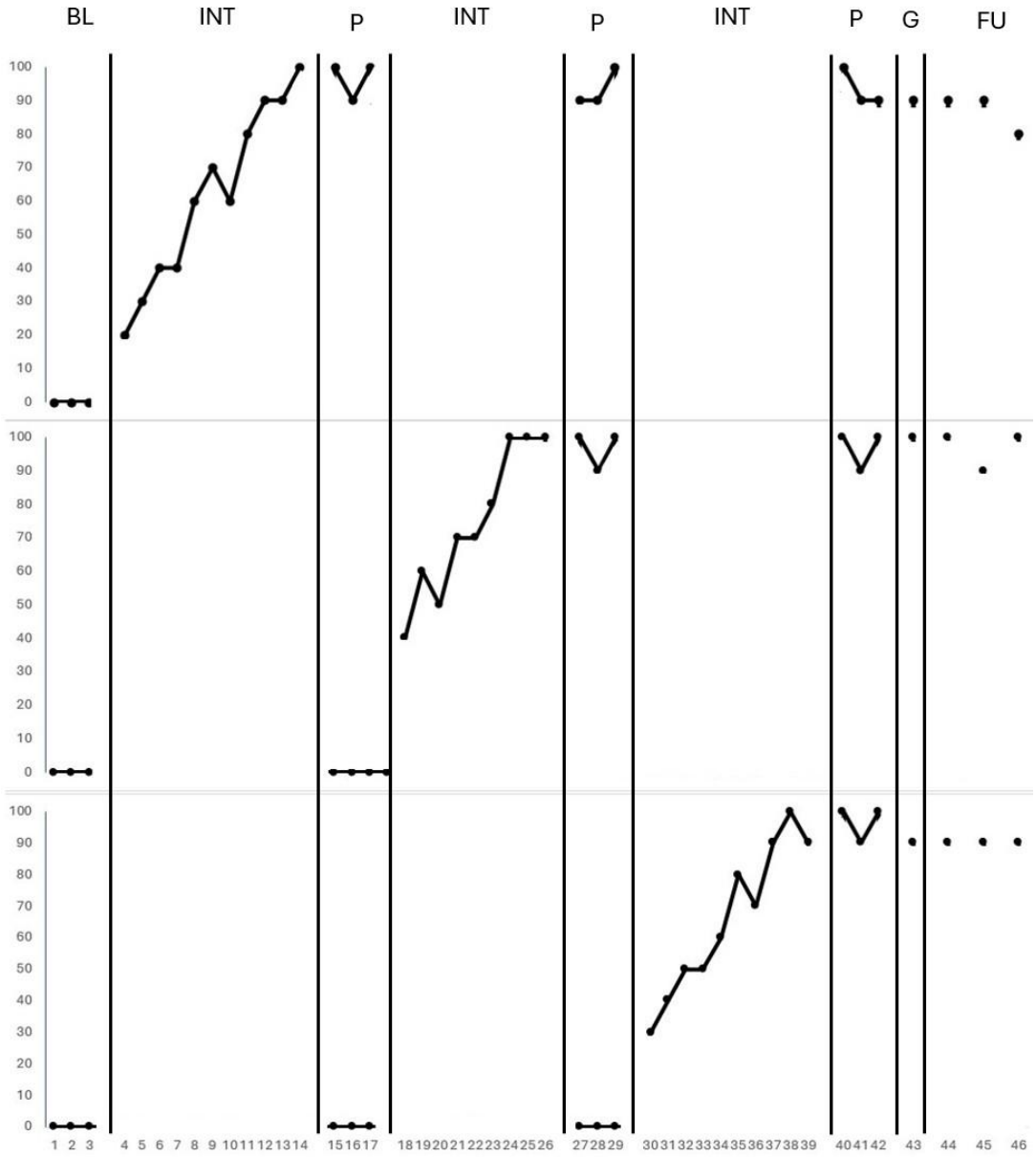
3. Findings

The findings related to the study's effectiveness, generalization, and social validity data are presented in order.

3.1. Effectiveness Findings

The data on the effectiveness of the teaching activities implemented with the STEM approach for Ayşe, Emre, and Can in acquiring the topic of light propagation and reflection are shown in Figure 1. The graph's horizontal axis represents the number of sessions, while the vertical axis represents the percentage of correct responses by the participants in daily probe sessions. Figure 3 presents the graph showing the correct responses for each participant in the baseline, intervention, full probe, generalization, and follow-up sessions.

Figure 3. *Response Percentages Related to the Effectiveness of STEM-Based Teaching Activities on the Topic of Light Propagation and Reflection for Ayşe, Emre, and Can. Baseline (BL), Intervention (INT), Generalization (G), Probes (P), Follow Up (FU)*



3.1.1. Findings on the Effectiveness of STEM-Based Teaching Activities for Ayşe on the Topic of Light Propagation and Reflection

Eleven instructional sessions were conducted with Ayşe, the first participant in the study. Figure 3 shows that Ayşe's percentage of correct responses in the baseline sessions conducted before instruction on light propagation and reflection was 0% across three sessions. During the STEM-based instructional sessions, Ayşe's average correct response rate was 61.8% (range: 20% - 100%). The instructional sessions were concluded after demonstrating a performance accuracy of 90% or higher across three consecutive sessions. The average accuracy for Ayşe's stable responses in the last three sessions was 93%. In the full probe sessions conducted after the instructional sessions concluded, Ayşe's accuracy ranged from a minimum of 90% to a maximum of 100%. In the follow-up sessions conducted 1, 3, and 5 weeks after the conclusion of STEM-based instructional activities on light

propagation and reflection, Ayşe achieved accuracy levels of 90%, 90%, and 80%, respectively. The findings indicate that the skills Ayşe acquired on light propagation and reflection through STEM-based instructional activities were retained after the instruction.

3.1.2. Findings on the Effectiveness of STEM-Based Teaching Activities for Emre on the Topic of Light Propagation and Reflection

Nine instructional sessions were conducted with Emre, the second participant in the study. Figure 3 shows that Emre's percentage of correct responses in the baseline sessions conducted before instruction on light propagation and reflection was also 0% across three sessions. During the instructional session, Emre's average correct response rate was 74.4% (range: 40% - 100%). Instructional sessions were terminated after Emre achieved a 90% or higher performance accuracy across three consecutive sessions. The average of Emre's stable responses in the last three sessions was 100%. In the full probe sessions conducted after the instructional sessions, Emre's accuracy ranged from a minimum of 90% to a maximum of 100%. In the follow-up sessions conducted 1, 3, and 5 weeks after the conclusion of STEM-based instructional activities on light propagation and reflection, Emre achieved accuracy levels of 100%, 90%, and 100%, respectively. These findings indicate that Emre acquired light propagation and reflection skills through STEM-based instructional activities, which were also retained after the instruction had concluded.

3.1.3. Findings on the Effectiveness of STEM-Based Teaching Activities for Can on the Topic of Light Propagation and Reflection

Ten instructional sessions were conducted with Can, the third participant in the study. Figure 3 shows that Can's percentage of correct responses in the baseline sessions conducted before instruction on light propagation and reflection was 0% across three sessions. During the instructional session, Can's average correct response rate was 66% (range: 30% - 100%). Instructional sessions were concluded after Can demonstrated 90% or higher performance accuracy across three consecutive sessions. The average of Can's stable responses in the last three sessions was 93.3%. In the full probe sessions conducted after the instructional sessions concluded, Can's accuracy ranged from a minimum of 90% to a maximum of 100%. The follow-up sessions conducted 1, 3, and 5 weeks after the conclusion of STEM-based instructional activities on light propagation and reflection Can achieve accuracy levels of 100%, 90%, and 90%, respectively. These findings indicate that the skills Can acquired on light propagation and reflection through STEM-based instructional activities were retained after the instruction had concluded.

3.1.4. Generalization Findings

The findings related to the ability of Ayşe, Emre, and Can to generalize the skills they acquired on light propagation and reflection to different individuals and settings are presented in Figure 3. After the final full probe sessions, each of the three participants was expected to demonstrate the skills they had acquired on light propagation and reflection with a different individual and in a different environment. After the instruction, Ayşe performed 90%, Emre 100% and Can 90% in generalization sessions conducted in different settings and with different individuals. Figure 1 shows that the STEM-based teaching activities enabled the participants to generalize their acquired skills on light propagation and reflection to different settings and individuals.

3.2. Social Validity Findings

Social validity data were gathered based on interviews with the three students participating in the study. All students expressed that the topic studied was essential and that they enjoyed the activities. All participants indicated they were satisfied learning about light propagation and reflection through STEM activities. Finally, the students expressed positive views regarding participating in the STEM-based instructional activities.

4. Conclusion, Discussion and Recommendations

The purpose of this study was to determine whether STEM-based instructional activities are effective in helping individuals with intellectual disabilities acquire, retain, and generalize the topic of "light propagation and reflection" in the context of a science course, as well as to explore the views of the participating individuals with intellectual disabilities. The findings indicate that STEM activities were effective in supporting the acquisition, maintenance, and generalization of the topic of "light propagation and reflection" for individuals with intellectual disabilities. The social validity results revealed that all students participating in the study held positive perceptions of the study. This section discusses the conclusions derived from the findings, compares the results with those reported in the existing literature, addresses the limitations encountered during the study, and provides recommendations for future research based on the overall process.

When examining the findings related to the study's first aim, it was determined that the use of STEM-based instructional activities enhanced all three participants' acquisition of the targeted science concept, "light propagation and reflection," among students with intellectual disabilities. The baseline data indicated an acquisition level of 0%, which increased to between 90% and 100% by the end of instruction. These findings suggest that STEM activities were effective in helping individuals with mild intellectual disabilities acquire science topics. The effectiveness findings of this study align with previous research indicating that STEM activities are effective in teaching science topics to individuals with special needs (Ayverdi, 2018; Barış & Ecevit, 2019; Biçer, 2019; Karasu, 2019; Özçelik & Akgündüz, 2017; Tosun, 2019; Tofel-Grehl et al., 2018; Wei et al., 2017).

Biçer (2019) found that using the STEM approach enhanced the academic achievement of students with learning difficulties in the topic of electrical circuits. Similarly, Tosun (2019) concluded that adapting STEM activities through simplification and creating enriched learning environments was effective in teaching scientific concepts to students with mild intellectual disabilities. Karasu (2019) found that teaching the topic of sensory organs using the 5E method was effective for students with mild intellectual disabilities in special education classes. In a study evaluating the STEM skills of students with special needs, Balçın and Yıldırım (2021) found that students were able to apply their science knowledge to the materials they created but struggled to relate their work to mathematics, technology, and engineering. Wei et al. (2017) identified that STEM education increased the academic success of individuals with autism spectrum disorder. Barış and Ecevit (2019) found that STEM activities helped gifted students develop positive attitudes toward science and acquire scientific process skills. Tofel-Grehl et al. (2018) found that STEM education created opportunities for deep learning among gifted students. In a similar vein, Ayverdi (2018) concluded that STEM education supported the development of scientific process skills in gifted students, and Özçelik and Akgündüz (2017) discovered that STEM education helped gifted students acquire 21st-century skills like creativity, critical thinking, teamwork, and communication, along with advancements in science and math.

The literature indicates that STEM activities have positive outcomes for individuals with special needs; however, more studies in this area need to be conducted. In this respect, the STEM activities prepared within the scope of this study contribute to expanding the relevant literature. According to Tofel-Grehl et al. (2018), implementing the STEM approach increases class participation levels for typically developing students and students with special needs. Researchers suggest that educators and special education specialists working with children with special needs should be encouraged and supported with in-service training to design STEM activities tailored to these individuals' interests, needs, and abilities (Brenneman et al., 2019; Jamil et al., 2018). Wells and Kommers (2022) emphasized that individuals with special needs often lack adequate access to STEM education. Based on the findings of this study and other research, it is recommended that STEM activities for individuals with special needs be increased in both international and national literature.

When examining the retention findings of the study, it was found that STEM activities were effective in helping individuals with intellectual disabilities maintain their acquired skills after the intervention had concluded. All individuals with intellectual disabilities retained their performance levels at 1, 3, and 5 weeks following the end of instruction. This study's retention findings are similar to those of Biçer (2019), who found that students with learning difficulties retained knowledge of electrical circuit components when instructed through the STEM approach.

Generalization data were collected from participants in the study. Pre-test and post-test generalization assessments were conducted during sessions held with individuals with intellectual disabilities. In these sessions, the children were expected to generalize the science topics they had learned to different settings and individuals. During the generalization sessions, the children performed at a level that met the predetermined criteria for the targeted science topics. It is well-known that individuals with disabilities often face challenges in generalizing skills from one situation to another (Steere et al., 1989). Therefore, this study emphasizes the importance of generalization and includes generalization data to address the specific challenges faced by students with special needs. Unlike some previous studies that did not incorporate generalization sessions (Biçer, 2019), this study provides a meaningful contribution to the literature by emphasizing and documenting generalization outcomes.

Social validity data were collected from participants with intellectual disabilities following the intervention. An examination of the social validity data collected showed that participants generally held positive views. This finding aligns with other quantitative studies that measure the interests and attitudes of students with special needs toward STEM when instructed through STEM activities. Tosun (2019) concluded that simplified STEM education in science courses for students with mild intellectual disabilities increased their interest and shifted their attitudes from negative to positive. Kışoğlu et al. (2024) found that science activities using the 5E model effectively increased motivation in students with mild intellectual disabilities. Özçelik and Akgündüz (2018) found that STEM activities designed for gifted students made lessons more enjoyable. Similarly, Ceylan et al. (2018) concluded that gifted students held positive attitudes toward STEM education. Based on these studies and findings, as well as the positive attitudes of students with special needs toward STEM and the effectiveness of STEM education, it is essential to expand access to STEM education for these students, as it would contribute significantly to both national and international literature. In light of the study’s limitations, it should be noted that while the literature recommends collecting data for at least five sessions during the baseline phase, only three baseline sessions were conducted in this study. This decision was made to prevent students with mild intellectual disabilities from becoming bored or losing motivation.

This study demonstrated that STEM-based instructional activities were effective in supporting students with intellectual disabilities in acquiring science topics. n a similar vein, future research could explore the use of STEM activities across different subject areas and with diverse disability groups. Additionally, STEM-based approaches have increasingly been recognized for their effectiveness in special education. Therefore, future studies may focus on designing professional development programs aimed at equipping teachers of students with special needs with the necessary skills to implement STEM-based instruction. Furthermore, it can be suggested that the activities presented in the study can guide teachers who want to incorporate STEM activities into their classroom practices.

References

Alıcı, M. (2018). *Probleme dayalı öğrenme ortamında STEM eğitiminin tutum, kariyer algı ve meslek ilgisine etkisi ve öğrenci görüşleri* [Yüksek lisans tezi, Kırıkkale Üniversitesi]. Ulusal Tez Merkezi.

Asghar, A., Sladeczek, I. E., Mercier, J. & Beaudoin, E. (2017). Learning in Science, Technology, Engineering, and Mathematics: Supporting Students with Learning Disabilities. *Canadian Psychology. 58*(3), 238-249. https://doi.org/10.1037/cap0000111

Ayverdi, L. (2018). *Özel yetenekli öğrencilerin fen eğitiminde teknoloji, mühendislik ve matematiğin kullanımı: FeTeMM yaklaşımı* [Yüksek lisans tezi, Balıkesir Üniversitesi]. Ulusal Tez Merkezi.

Ayverdi, L. ve Avcu, Y. E. (2023). Design and implementation of a STEM activity for the education of students with mild intellectual disabilities. *İnformal Ortamlarda Araştırmalar Dergisi, 8*(2), 134-158.

Balçın, M. D. ve Yıldırım, M. (2021). Kaynaştırma öğrencilerinin fen bilimleri dersi STEM çalışmalarının değerlendirilmesi. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi, 22*(2), 307-341. https://doi.org/10.21565/ozelegitimdergisi.660695

Barış, N. ve Ecevit, T. (2019). Özel yetenekli öğrencilerin eğitiminde STEM uygulamaları. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi, 13*(1), 217-233. https://doi.org/10.17522/balikesirnef.529898

Biçer, A. (2019). *STEM yaklaşımına dayalı elektrik devre elemanları konusu öğretiminin 5. sınıf özel öğrenme güçlüğü olan öğrencilerin akademik başarılarına ve kalıcılığına etkisi* [Yüksek lisans tezi, Aksaray Üniversitesi]. Ulusal Tez Merkezi.

Brenneman, K., Lange, A. & Nayfeld, I. (2019). Integrating STEM into preschool education; designing a professional development model in diverse settings. *Early Childhood Education Journal, 47*(1), 15-28. https://doi.org/10.1007/s10643-018-0912-z

Bülbül, M. Ş. & Sözbilir, M. (2017). Engelsiz STEM Eğitimi. S. Çepni (Ed.), *Kuramdan Uygulamaya STEM+E+A Eğitimi* (s. 511-537). Pegem Akademi.

Ceylan, Ö., Ermiş, G. ve Yıldız, G. (Kasım, 2018). Özel Yetenekli Öğrencilerin Bilim, Teknoloji, Mühendislik, Matematik (STEM) Eğitimine Yönelik Tutumları. [Bildiri sunumu]. International Conference on Gifted and Talented Education-IGATE'18', Malatya, Türkiye.

Das, B. & Pal, J. (2024, February). Exploring the Challenges and Opportunities of Making STEM More Accessible to Specially-Abled Persons Using Assistive Technology. [Paper presentation]. In NIELIT's International Conference on Communication, Electronics and Digital Technologies. Singapore.

Davis, K. E. B. (2014). The need for STEM education in special education curriculum and instruction. *STEM Education: Strategies for teaching learners with special needs*, 1–20.

Dereli, E. (2021). *Robotik kodlama, STEM ve teknoloji eğitiminin teknolojik liderlik açısından orta kademedeki öğrenciler üzerinde etkileri: Muş ili örneği* [Yüksek lisans tezi, Dokuz Eylül Üniversitesi]. Ulusal Tez Merkezi.

Doğan, M. (2020). *STEM yaklaşımıyla hazırlanan etkinliklerin okul öncesi dönemdeki çocukların matematiksel kavram gelişimine etkisi* [Yüksek lisans tezi, Hasan Kalyoncu Üniversitesi]. Ulusal Tez Merkezi.

Duran, M. ve Sendag, S. (2012). A Preliminary investigation into critical thinking skills of urban high school students: Role of an IT/STEM Program. *Creative Education, 3*(2), 241-250. http://dx.doi.org/10.4236/ce.2012.32038

Ekici, F. (2022). *Fen bilgisi öğretmen adaylarının stem farkındalıkları, stem görüşleri ve stem odaklı argümantasyon becerilerinin incelenmesi* [Yüksek lisans tezi, Necmettin Erbakan Üniversitesi]. Ulusal Tez Merkezi.

Erbaş, D. (2012). Güvenirlik. E. Tekin-İftar (Ed.), *Eğitim ve davranış bilimlerinde tek denekli araştırmalar* içinde (ss. 109–128). Türk Psikologlar Derneği Yayınları.

Fajrina, S., Lufri, L. & Ahda, Y. (2020). Science, technology, engineering, and mathematics (STEM) as a learning approach to improve 21st century skills: a review. *International Journal of Online & Biomedical Engineering, 16*(7), 95-104.

Green, S. L. (2014). *STEM education: Strategies for teaching learners with special needs.* Nova Science Publishers, Incorporated.

Gupta, S. K. (2016). Use of assistive technology to empower persons with intellectual disabilities. In *Handbook of Research on Diagnosing, Treating, and Managing Intellectual Disabilities* (pp. 331–345). IGI Global.

Günay, A., & Haliloğlu, E. Y. (2023). The importance of stem fields in higher education in a post-pandemic world. In *Advancing stem education and innovation in a time of distance learning* (pp. 253-264). IGI Global.

Igier, S. & Pennequin, V. (2021). Links of socio-emotional context on performance in categorization task of adults with moderate to severe intellectual disabilities. *Advances in Mental Health and Intellectual Disabilities, 15*(2/3), 55-65. https://doi.org/10.1108/AMHID-10-2020-0026

Irak, M. (2019). *5. sınıf fen bilimleri dersi ışığın yayılması ünitesine yönelik STEM uygulamalarının akademik başarı ve STEM'e karşı tutum üzerine etkisinin incelenmesi* [Yüksek lisans tezi, Kocaeli Üniversitesi]. Ulusal Tez Merkezi.

Jamil, F. M., Linder, S. M. & Stegelin, D.A. (2018). Early childhood teacher beliefs about STEAM education after a professional development conference. *Early Childhood Education Journal, 46*, 409–417. https://doi.org/10.1007/s10643-017-0875-5

Jindal, P., Singh, A. & Aggarwal, R. (2023). *STEM: A multi-disciplinary approach to integrate pedagogies, inculcate innovations and connections.* Nova Science Publishers

Kanlı, E., & Özyaprak, M. (2015). Stem education for gifted and talented students in Turkey. *Journal of Gifted Education Research, 3*(2), 1-10.

Karasu, S. (2019). *Özel eğitim öğrencilerine fen bilimleri dersinde duyu organları konusunun 5E yöntemi ile sunulmasının etkililiği* [Yüksek lisans tezi, Necmettin Erbakan Üniversitesi]. Ulusal Tez Merkezi.

Kaya, F., Kasap, C., Karabulut, H. A., & Uçar, A. S. (2024). Özel eğitim öğretmenlerinin yardımcı teknoloji kullanmaya ilişkin deneyimleri. *Yaşadıkça Eğitim, 38*(2), 354-371. https://doi.org/10.33308/26674874.2024382618

Kırcaali-İftar, G., & Tekin, E. (1997). *Tek denekli araştırma yöntemleri*. Türk Psikologlar Derneği.

Kışoğlu, M., Yalçın, G. ve Doğru, A. (2024). Hafif zihinsel yetersizliği olan öğrencilere fen etkinliği örneği: Deprem. *Fen Bilimleri Öğretimi Dergisi, 12*(1), 78-98. https://doi.org/10.56423/fbod.1410881

Kolne, K. & Lindsay, S. (2020). A systematic review of programs and interventions for increasing the interest and participation of children and youth with disabilities in STEM education or careers. *Journal of Occupational Science, 27*(4), 525–546. https://doi.org/10.1080/14427591.2019.1692692

Le, V. N. P., Nguyen, L. T. & Tran, T. A. (2024). *Barriers to students' access to stem education in the education system in Vietnam.* 9th International STEM Education Conference. https://doi.org/10.1109/iSTEM-Ed62750.2024.10663144

Mahmood, P., Ruffing, J., Ilozumba, O. & Ebuenyi, I. D. (2024). Bridging the gap: challenges and opportunities of assistive technology loan library systems for individuals with intellectual disabilities in the United States. *Disability and Rehabilitation: Assistive Technology,* 1–10. https://doi.org/10.1080/17483107.2024.2400997

Metpattarahiran, C. (2021). STEM education for developing undergraduates' 21st century skills. *Journal of Multidisciplinary in Social Sciences, 17*(3), 82-87.

Özçelik, A. ve Akgündüz, D. (2018). Üstün/özel yetenekli öğrencilerle yapılan okul dışı STEM eğitiminin değerlendirilmesi. *Trakya Üniversitesi Eğitim Fakültesi Dergisi, 8*(2), 334-351. https://doi.org/10.24315/trkefd.331579

Ribenfors, F. & Blood, L. (2023). To report or not to report: the ethical complexity facing researchers when responding to disclosures of harm or illegal activities during fieldwork with adults with intellectual disabilities. *Ethics and Social Welfare, 17*(2), 175-190. https://doi.org/10.1080/17496535.2022.2149831

Sanders, M. (2009). STEM, STEM Education, STEMmania. *The Technology Teacher, 68*(4), 20–26.

Selisne, M., Sari, Y. S. & Ramli, R. (2019, April). Role of learning module in STEM approach to achieve competence in physics learning. *In Journal of Physics: Conference Series, 1185*(1), 012100. https://doi.org/10.1088/1742-6596/1185/1/012100

So, W. W. M., He, Q., Chen, Y., Li, W. C., Cheng, I. N. Y. & Lee, T. T. H. (2022). Engaging students with intellectual disability in science, technology, engineering, and mathematics learning. *Science Education International, 33*(1), 25-37. https://doi.org/10.33828/sei.v33.i1.3

So, W. W. M., He, Q., Cheng, I. N. Y., Lee, T. T. H. & Li, W. C. (2021). Teachers' professional development with peer coaching to support students with intellectual disabilities in STEM learning. *Educational Technology & Society, 24*(4), 86-98.

So, W. W. M., Li, J. & He, Q. (2019). Teacher professional development for STEM education: Adaptations for students with intellectual disabilities. *Asia-Pacific STEM Teaching Practices: From Theoretical Frameworks to Practices*, 83-102. https://doi.org/10.1007/978-981-15-0768-7_6

Sorby, S., Stark, S. & Carnahan, C. (2022, August). Developing the spatial skills of neurodiverse students. In 2022 ASEE Annual Conference & Exposition.

Steere, D. E., Pancsofar, E. L., Powell, T. H. & Butterworth Jr, J. (1989). Enhancing instruction through general case programming. *Teaching Exceptional Children, 22*(1), 22–24. https://doi.org/10.1177/004005998902200105

Sukarman, S. S. & Retnawati, H. (2022). Teachers' barriers in implementing integrated STEM education: A literature review. *AIP Conference Proceedings, 2575*(1), 050026. https://doi.org/10.1063/5.0108059

Tekin-İftar, E. (2012). Çoklu yoklama modelleri. E. Tekin-İftar (Ed.), *Eğitim ve davranış bilimlerinde tek-denekli araştırmalar* (1. Basım). Türk Psikologlar Derneği Yayınları, No: 38.

Tofel-Grehl, C., Feldon, D. F. & Callahan, C. M. (2018). Impacts of learning standards and testing on gifted learners in STEM schools: A multilevel analytic induction. *Roeper Review, 40*(2), 130-138. https://doi.org/10.1080/02783193.2018.1434714

Toker-Gökçe, A. ve Yıldırım, D. (2019). *Öğretmenlerin STEM eğitiminde yaşadığı sorunlar ve çözümleri*. 14. Uluslararası Eğitim Yönetimi Kongresi Tam Metin Bildiri Kitabı, 45-50.

Tosun, İ. E. (2019). *Özel eğitime gereksinim duyan bireylere yönelik bilgisayar destekli STEM eğitiminin etkileri* [Yüksek lisans tezi, Bursa Uludağ Üniversitesi]. Ulusal Tez Merkezi.

Uğraş, M. (2024). Determination of the effects of problem-based STEM activities on certain variables and the views of the students. *International Online Journal of Educational Sciences, 11*(1), 1-22. http://dx.doi.org/10.15345/iojes.2019.01.001

Wei, X., Yu, J.W., Shattuck, P. & Blackorby, J. (2017). High school math and science preparation and postsecondary stem participation for students with an autism spectrum disorder. *Focus on Autism and Other Developmental Disabilities, 32*(2), 83–92. https://doi.org/10.1177/1088357615588489

Wells, R. & Kommers, S. (2022). Graduate and professional education for students with disabilities: Examining access to STEM, legal, and health fields in the United States. *International Journal of Disability, Development and Education, 69*(2), 672-686. https://doi.org/10.1080/1034912X.2020.1726299

Xie, J., Basham, J. D. & Bensel, A. (2020). Integrating research-based practices and mobile technology to support students with executive functioning challenges in post-secondary STEM. *International Journal of Mobile Learning and Organisation, 14*(2), 184–202. https://doi.org/10.1504/IJMLO.2020.106172

Xie, Y., Fang, M. & Shauman, K. (2015). STEM education. *Annual Review of Sociology, 41*(1), 331–357. https://doi.org/10.1146/annurev-soc-071312-145659

Yıldırım, B. ve Altun, Y. (2015). STEM eğitim ve mühendislik uygulamalarının fen bilgisi laboratuvar dersindeki etkilerinin incelenmesi. *El-Cezeri Journal of Science and Engineering, 2*(2), 28-40.

Zgonec, S. & Bogataj, D. (2022). Assistive technologies supporting the independence of elderly adults with intellectual disability: Literature review and research agenda. IFAC-PapersOnLine, 55(39), 129-134. https://doi.org/10.1016/j.ifacol.2022.12.023

Geniş Özet

1. Giriş

STEM eğitimi, fen, teknoloji, mühendislik ve matematiği bir araya getirerek öğrencileri gerçek dünya problemlerini çözmeye yönelik disiplinler arası bir yaklaşım kazandırmayı amaçlar (Metpattarahiran, 2021; Sanders, 2009). Bu eğitim yaklaşımı, 21. yüzyıl becerileri olan eleştirel düşünme, iletişim, yaratıcılık ve problem çözme gibi yetenekleri öğrencilere kazandırarak onların STEM alanlarında kariyer yapmaları için daha donanımlı olmalarını hedefler (Alıcı, 2018; Duran & Şendağ, 2012). Ancak, STEM eğitimi kaynak eksikliği, önyargılar ve akademik destek yetersizliği gibi çeşitli zorluklarla karşılaşabilir (Le vd., 2024). Öğretmenlerin STEM eğitimini başarıyla uygulayabilmesi için yenilikçi yöntemler geliştirmeleri ve bu zorlukların üstesinden gelmeleri önemlidir (Sukarman & Retnawati, 2022).

Zihin yetersizliği olan bireyler için STEM eğitimi, bilişsel gelişim ve kapsayıcılık açısından özel bir öneme sahiptir. Bu bireylerin STEM'e erişimi, fırsat eşitsizliği ve bilişsel süreçlerde yaşanan zorluklar nedeniyle kısıtlanabilmektedir (Das & Pal, 2024). Bu sebeple, STEM etkinliklerinin içerik, yöntem ve ürünlerinde zihin yetersizliği olan bireylerin ilgi ve ihtiyaçlarına uygun uyarlamalar yapılması önerilmektedir (Ayverdi & Avcı, 2023). STEM eğitiminin, uzamsal görselleştirme becerilerini geliştirerek öğrencilerin bilişsel gelişimine katkı sağlarken, özel gereksinimli öğrencilerin günlük yaşam kalitesini artırmada başarılı olabileceği alanyazında dile getirilmektedir (Doğan, 2020; So vd., 2021). Bu öğrenciler için tasarlanan STEM etkinlikleri, bilişsel süreçlerin desteklenmesine ve sosyal-duygusal gelişime olumlu katkılar sağlama potansiyeline sahiptir (Igier & Pennequin, 2020).

STEM etkinlikleri, zihin yetersizliği olan öğrenciler için fen bilimleri derslerinde soyut kavramların anlaşılmasına yardımcı olabilir. Bu öğrenciler somut materyallerle kendi ürünlerini oluşturarak derslere karşı olumlu bir tutum geliştirebilirler (Das & Pal, 2024; So vd., 2022). Ancak literatürde, zihin yetersizliği olan bireylerde STEM etkinliklerinin kullanımına yönelik sınırlı sayıda araştırma bulunduğu dikkat çekmektedir (Ayverdi ve Avcu, 2023; Balçın & Yıldırım, 2021). Yapılan çalışmalar, zenginleştirilmiş öğrenme ortamlarının STEM eğitimiyle oluşturulmasının faydalı olabileceğini göstermektedir. Bu bağlamda, özellikle zihin yetersizliği olan bireylere yönelik STEM araştırmalarının artırılması gerektiği düşünülmektedir.

Bu araştırmanın amacı STEM yaklaşımıyla uygulanan öğretim etkinliklerinin hafif düzeyde zihin yetersizliği olan öğrencilerin fen bilimleri dersi ışığın yayılması ve yansıması konusunun ediniminde etkili olup olmadığını belirlemektir. Bu amaç doğrultusunda aşağıdaki sorulara cevap aranmıştır:

1. STEM yaklaşımıyla uygulanan öğretim etkinlikleri hafif düzeyde zihin yetersizliği olan öğrencilerin fen bilimleri dersi ışığın yayılması konusunun ediniminde etkili midir?
2. STEM yaklaşımıyla uygulanan hafif düzeyde zihin yetersizliği olan öğrencilere fen bilimleri dersi ışığın yayılması konusuna yönelik öğretim uygulaması sona erdikten 1, 3 ve 5 hafta sonra etkililiği devam etmekte midir?
3. STEM yaklaşımıyla uygulanan öğretim etkinliklerine yönelik hafif düzeyde zihin yetersizliği olan öğrenciler kazandıkları becerileri farklı kişilere genelleyebilmekte midir?
4. STEM yaklaşımıyla uygulanan öğretim etkinliklerine yönelik hafif düzeyde zihin yetersizliği olan öğrencilerin görüşleri nasıldır?

2. Yöntem

Bu araştırma, zihin yetersizliği olan bireylere "Işığın Yayılması ve Yansıması" konusunun öğretiminde STEM yaklaşımının etkililiğini belirlemek amacıyla yürütülmüştür. Araştırmada, tek denekli

araştırma modellerinden katılımcılar arası yoklama evreli çoklu yoklama modeli kullanılmıştır. Katılımcılardan önce başlama düzeyi verisi toplanmış, kararlı veri elde edildiğinde öğretime başlanmıştır. Her bir katılımcı hedef davranışta ölçütü sağladıktan sonra diğer katılımcıya geçilmiş ve bu süreç tüm katılımcılar için tamamlanmıştır. Uygulama sona erdikten sonra 1, 3 ve 5 hafta arayla izleme verileri toplanmıştır.

Araştırmanın bağımsız değişkeni; fen bilgisi dersinde kullanılan STEM yaklaşımı bağımlı değişkeni ise katılımcıların fen bilgisi dersi için hedeflenen "ışığın yayılması ve yansıması" konusunu edinme düzeyidir. Araştırmada, katılımcıların bağımlı değişken olarak hedeflenen "ışığın yayılması ve yansıması" konusunu öğrenme ölçütü %90 olarak belirlenmiştir. Araştırmanın katılımcıları, genel eğitim sınıfında kaynaştırma yoluyla eğitim alan, zihin yetersizliği tanısı olan üç beşinci sınıf öğrencisidir. Katılımcıların seçimi belirli ön koşul ölçütlerine göre yapılmış, velilerden gerekli izinler alınmıştır.

Araştırma, öğrencilerin destek eğitim aldığı özel eğitim ve rehabilitasyon merkezinde gerçekleştirilmiştir. Uygulamalar, özel eğitim sınıfında uygun koşullar sağlanarak yapılmıştır. Veri toplama araçları arasında "Işığın Yayılması ve Yansıması Veri Kayıt Formu" ve diğer değerlendirme formları yer almaktadır. Bu araçlar fen bilgisi ve özel eğitim alanında uzman kişiler tarafından gözden geçirilmiştir. Uygulama sürecinde başlama düzeyi, öğretim, izleme ve genelleme oturumları yapılmıştır. Öğretim oturumlarında STEM yaklaşımıyla hazırlanmış ve 5E modeline göre düzenlenmiş on adet ders planı uygulanmıştır. 5E modeli aşamaları Giriş (Engage), Keşfetme (Explore), Açıklama (Explain), Derinleştirme (Elaborate) ve Değerlendirme (Evaluate) olarak belirlenmiştir. Başlama düzeyi oturumlarında öğrenciler herhangi bir ipucu ya da pekiştireç almamış, üç oturumda kararlı veri elde edildikten sonra öğretim oturumlarına geçilmiştir.

3. Bulgular

Bu araştırmada, STEM yaklaşımıyla hazırlanan öğretim etkinliklerinin zihin yetersizliği olan bireylerde "Işığın Yayılması ve Yansıması" konusunun öğretimindeki etkililiği, genelleme ve sosyal geçerlik bulguları incelenmiştir.

Ayşe ile 11 öğretim oturumu gerçekleştirilmiştir. Başlama düzeyinde verdiği cevapların üç oturumda da %0 olduğu görülmüştür. Öğretim oturumlarında Ayşe'nin doğru cevap oranı ortalama %61,8 (ranj %20-100%) olarak kaydedilmiştir. Ayşe, üç oturum üst üste %90 ve üzeri doğrulukta performans sergilediğinde öğretim oturumları sonlandırılmıştır. Ayşe'nin son üç oturumda %93 kararlılık gösterdiği belirlenmiştir. Öğretim oturumlarından sonra gerçekleştirilen toplu yoklama oturumlarında %90 ile 100% doğruluk arasında değişen performans göstermiştir. Ayrıca, STEM etkinlikleri sona erdikten 1, 3 ve 5 hafta sonra yapılan izleme oturumlarında Ayşe'nin sırasıyla %90, %90 ve %80 doğruluk seviyesinde performans sergilediği kaydedilmiştir. Bu bulgular, STEM yaklaşımıyla yapılan öğretimin Ayşe'nin kazandığı becerileri öğretimden sonra da sürdürebildiğini göstermektedir.

Emre ile 9 öğretim oturumu yapılmıştır. Başlama düzeyi oturumlarında doğru cevap oranı üç oturumda da %0'dır. Emre'nin öğretim uygulama oturumlarında ortalama %74,4 (ranj %40-100%) doğrulukla cevap verdiği görülmüştür. Üç oturum üst üste %90 ve üzeri doğruluk elde ettiğinde öğretim oturumları sonlandırılmıştır. Son üç oturumda 100% kararlılık sergileyen Emre, toplu yoklama oturumlarında %90 ile 100% arasında doğruluk sağlamıştır. İzleme oturumlarında 1, 3 ve 5 hafta sonra sırasıyla 100%, %90 ve 100% doğruluk oranıyla devam etmiştir. Bu bulgular, STEM etkinliklerinin Emre'nin öğrenimini sürdürebildiğini göstermektedir.

Can ile 10 öğretim oturumu gerçekleştirilmiştir. Başlama düzeyinde %0 düzeyinde doğru cevap oranı gözlemlenmiştir. Öğretim oturumlarında Can, ortalama %66 (ranj %30-100%) doğrulukla cevap

vermiştir. Üç oturum üst üste %90 doğruluk sağladığında öğretim oturumları sonlandırılmıştır. Son üç oturumda %93,3 kararlılık oranı elde eden Can, toplu yoklama oturumlarında %90 ile 100% doğruluk arasında performans göstermiştir. İzleme oturumlarında ise 1, 3 ve 5 hafta sonra sırasıyla 100%, %90 ve %90 doğruluk oranını sürdürmüştür. Bu sonuçlar, STEM etkinliklerinin Can'ın öğrenim üzerindeki kalıcılığını gösterir niteliktedir.

Ayşe, Emre ve Can'ın öğrendikleri becerileri farklı kişiler ve ortamlar arasında genelleyebilme bulguları Grafik 1'de sunulmuştur. Üç katılımcının da son toplu yoklama oturumlarından sonra öğrendikleri becerileri yeni bir ortamda ve farklı bir kişiyle sergilemeleri beklenmiştir. Ayşe %90, Emre 100% ve Can %90 doğrulukla genelleme oturumlarında performans göstermiştir. Bulgular, STEM yaklaşımıyla yapılan öğretim etkinliklerinin öğrendikleri becerileri farklı ortamlara ve kişilere aktarabildiklerini göstermektedir.

Sosyal geçerlik verileri katılımcılarla yapılan görüşmeler sonucunda elde edilmiştir. Tüm katılımcılar, konunun önemli olduğunu belirtmiş ve STEM etkinlikleriyle sunulan öğretimden memnun kaldıklarını ifade etmişlerdir. Ayrıca, STEM yaklaşımıyla yapılan etkinliklere katılma konusunda olumlu görüş bildirmişlerdir. Bu bulgular, STEM yaklaşımıyla uygulanan öğretim etkinliklerinin zihin yetersizliği olan bireylerde hem öğrenim hem de öğrenilen becerilerin kalıcılığı ve genellemesine katkı sağladığını göstermektedir. Ayrıca, öğrencilerin STEM etkinliklerine yönelik olumlu tutum geliştirdiklerini ortaya koymaktadır.

4. Tartışma, Sonuç ve Öneriler

Bu araştırmanın amacı, STEM yaklaşımıyla uygulanan öğretim etkinliklerinin zihin yetersizliği olan bireylerde fen bilgisi dersinde hedeflenen "ışığın yayılması ve yansıması" konusunun kazanımında, sürdürülmesinde ve genellemesinde etkili olup olmadığını incelemektir. Ayrıca, araştırmaya katılan zihin yetersizliği olan bireylerin STEM etkinliklerine ilişkin görüşleri de değerlendirilmektedir. Bulgular, STEM etkinliklerinin bu öğrencilerde konu kazanımını sağlama, öğrenimi sürdürme ve farklı kişilere ve ortamlara genelleme konusunda etkili olduğunu göstermektedir. Sosyal geçerlik bulguları ise katılımcı öğrencilerin genel olarak STEM etkinliklerinden memnun kaldığını ve olumlu görüşlere sahip olduklarını ortaya koymaktadır.

Araştırmanın birinci amacı doğrultusunda elde edilen bulgular, STEM etkinliklerinin zihin yetersizliği olan bireylerin fen bilgisi dersinde hedeflenen konuyu öğrenmelerinde etkili olduğunu ortaya koymuştur. Başlama düzeyinde %0 olan edinim düzeyi, öğretim sonunda %90 - 100% seviyelerine ulaşmıştır. Bu sonuçlar, STEM etkinliklerinin zihin yetersizliği olan bireylerin fen konularını edinmelerinde etkili olduğunu kanıtlamakta ve daha önce yapılmış bazı araştırmalarla (Ayverdi, 2018; Barış ve Ecevit, 2019; Biçer, 2019; Karasu, 2019) tutarlılık göstermektedir. Örneğin, Biçer (2019) STEM yaklaşımıyla öğrenme güçlüğü yaşayan öğrencilerin elektrik devre elemanları konusundaki akademik başarılarının arttığını bulmuştur. Tosun (2019) ise STEM etkinliklerinin, hafif düzeyde zihin yetersizliği olan öğrenciler için zenginleştirilmiş öğrenme ortamlarında dersin etkisini artırdığını belirtmiştir.

Kalıcılık bulguları incelendiğinde, STEM etkinliklerinin uygulama sonrasında da etkisini sürdürdüğü görülmüştür. Katılımcılar, öğretim sona erdikten 1, 3 ve 5 hafta sonra konulara ilişkin performanslarını korumuştur. Bu bulgu, Biçer (2019) tarafından yapılan ve STEM eğitiminin bilgilerin kalıcılığını sağladığını gösteren çalışmayla paralellik göstermektedir. Ayrıca, genelleme oturumları sonucunda katılımcıların öğrendikleri becerileri farklı ortamlarda ve kişilerle sergileyebildikleri gözlenmiştir. Zihin yetersizliği olan bireylerde genellemenin önemine vurgu yapılmakta, bu araştırmanın alanyazına katkı sağlayıcı yönlerinden biri olarak genelleme bulgularına yer verilmesi gerektiği belirtilmektedir.

Araştırmada sosyal geçerlik verileri, öğrencilerin STEM etkinliklerine dair olumlu bir görüşe sahip olduklarını göstermektedir. Örneğin, Tosun (2019) hafif düzeyde zihinsel yetersizliği olan öğrencilerde basitleştirilmiş STEM eğitiminin öğrencilerin ilgisini artırdığını ve olumsuz tutumlardan olumlu bir eğilime yönlendirdiğini belirtmiştir. Benzer şekilde, Kışoğlu ve arkadaşları (2024) 5E modeliyle hazırlanan fen etkinliklerinin öğrencilerin motivasyonlarını artırdığını bulmuştur. Özçelik ve Akgündüz (2018) özel yetenekli öğrencilerde STEM etkinliklerinin dersleri daha eğlenceli hale getirdiğini tespit etmiş, Ceylan ve arkadaşları (2018) özel yetenekli öğrencilerin STEM eğitimine yönelik tutumlarının olumlu olduğunu gözlemlemiştir. Bu bulgular ışığında, STEM etkinliklerinin özel gereksinimli öğrencilerin STEM'e ilgilerini artırma ve STEM eğitimini daha uygulanabilir kılma potansiyeline sahip olduğu sonucuna varılmıştır.

Bu araştırma, STEM yaklaşımının zihin yetersizliği olan öğrencilerin fen bilgisinde konu kazanımında etkili olduğunu göstermekte ve farklı konular ile yetersizlik gruplarında da STEM etkinlikleri üzerine çalışmalar yapılmasını önermektedir. STEM etkinlikleri, özel eğitim alanında ulusal ve uluslararası literatürde etkisi giderek belirginleşen bir alan haline gelmektedir. Bu nedenle, ileride STEM etkinliklerinin kullanımını öğretmeyi amaçlayan araştırmaların yapılması önerilmektedir.

Yayın Etiği Beyanı

Bu araştırmanın, Bolu Abant İzzet Baysal Üniversitesi Sosyal Bilimlerde İnsan Araştırmaları Etik Kurulu tarafından 07.05.2023 tarihinde 2023/04 sayılı kararıyla verilen etik kurul izni bulunmaktadır. Bu araştırmanın planlanmasından, uygulanmasına, verilerin toplanmasından verilerin analizine kadar olan tüm süreçte "Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi" kapsamında uyulması belirtilen tüm kurallara uyulmuştur. Yönergenin ikinci bölümü olan "Bilimsel Araştırma ve Yayın Etiğine Aykırı Eylemler" başlığı altında belirtilen eylemlerden hiçbiri gerçekleştirilmemiştir. Bu araştırmanın yazım sürecinde bilimsel, etik ve alıntı kurallarına uyulmuş; toplanan veriler üzerinde herhangi bir tahrifat yapılmamıştır. Bu çalışma herhangi başka bir akademik yayın ortamına değerlendirme için gönderilmemiştir.

Araştırmacıların Katkı Oranı Beyanı

Birinci Yazar %40, İkinci Yazar %35 ve Üçüncü Yazar %25 oranında katkı sağlamıştır.

Çatışma Beyanı

Araştırmanın yazarları olarak herhangi bir çıkar/çatışma beyanımız olmadığını ifade ederiz.