DOI: https://doi.org/10.26529/cepsj.1778

The Effect of STEM Activities on the Academic Performance of Students with Reading Problems

Zeren Gacar[1], Hilal Aktamiş*[2] and Ahmet Bildiren[3]

This research aimed to increase the academic performance of fifth-grade secondary school students (aged 10 years) with reading problems in science classes. Using the single-subject ABA research model, the study was conducted one-on-one with three fifth-grade students with reading problems who were studying at a secondary school in a city centre in the western region of Turkey. The research was carried out over a four-week period, with two lesson hours per week. Semi-structured interviews were conducted with science teachers to develop the activities in the research and activity sheets were subsequently developed based on the interview findings. To determine academic performance in the science course, three group monitoring tests consisting of ten questions were prepared for the Sun, Earth and Moon unit outcomes and checklists added to the activity booklets were used. In addition, a STEM continuity survey was used to determine whether students with reading problems would like to receive education with STEM activities. The results obtained in the research showed that there was an increase in the academic performance of the students. In addition, all three students participating in the study stated that they would like to continue receiving education through STEM activities.

Keywords: STEM, reading problems, disability, special education

1 College of Ozel Dunya, Turkey.
2 *Corresponding Author. Aydın Adnan Menderes University, Turkey; hilalaktamis@gmail.com.
3 Faculty of Education, Aydın Adnan Menderes University, Turkey.

Vpliv dejavnosti STEM na učno uspešnost učencev z bralnimi težavami

Zeren Gacar, Hilal Aktamiş in Ahmet Bildiren

Namen te raziskave je bil povečati učno uspešnost učencev petega razreda osnovne šole (starih 10 let) z bralnimi težavami pri pouku naravoslovja. Z uporabo enosubjektnega raziskovalnega modela ABA je bila raziskava izvedena individualno s tremi učenci petega razreda z bralnimi težavami, ki so obiskovali osnovno šolo v središču mesta v zahodni regiji Turčije. Raziskava je potekala štiri tedne, in sicer z dvema šolskima urama tedensko. Z učitelji naravoslovja so bili opravljeni polstrukturirani intervjuji za pripravo dejavnosti v raziskavi, na podlagi ugotovitev intervjujev pa so bili nato pripravljeni listi z dejavnostmi. Za ugotavljanje učne uspešnosti pri pouku naravoslovja so bili za učne izide enote »Sonce, Zemlja in Luna« pripravljeni trije testi skupinskega spremljanja, sestavljeni iz desetih vprašanj, uporabljeni pa so bili tudi kontrolni seznami, dodani knjižicam z dejavnostmi. Uporabljena je bila tudi anketa o kontinuiteti STEM, s katero smo ugotavljali, ali bi se učenci z bralnimi težavami želeli izobraževati z dejavnostmi STEM. Izsledki, pridobljeni v raziskavi, so pokazali, da se je učna uspešnost učencev povečala. Poleg tega so vsi trije učenci, ki so sodelovali v raziskavi, izjavili, da si želijo nadaljevati izobraževanje z dejavnostmi STEM.

Ključne besede: STEM, bralne težave, motnje pri učenju, posebno izobraževanje

Introduction

The level of development and economic superiority of countries and the ability to ensure continuity in this regard are dependent on success in the field of education. The STEM approach has effects in the education systems of economically developed countries such as European countries and the United States (Kennedy & Odell, 2014). In order to obtain the scientific qualifications of developed countries and to keep up with the ever-increasing technological development, there is a need for an education approach based on the four main disciplines defined as STEM (science, technology, engineering and mathematics), which should be integrated into education systems and included in programmes (Raines, 2012). This includes the components of cyber physical systems, the internet of things, internet services and smart factories. The necessity of giving importance to STEM in education systems emerges from consideration of the contributions of individuals working in the fields of Industry 4.0, technology and innovation, which are based on internet systems, including modern automation systems, data exchange and production technologies. Education systems therefore need to focus on twenty-first century skills, producing individuals who can think creatively, come up with innovative ideas, have an entrepreneurial spirit, think critically and have advanced problem-solving skills, all of which can be achieved by gaining STEM skills (TUSIAD, 2014). STEM studies are gaining importance both nationally and internationally, with an increasing number of studies emerging on the subject (Hare, 2017; Christensen & Knezek, 2017; Holba, 2015; Guzey et al., 2016; Wade-Shepherd, 2016; Hwang & Taylor, 2016).

On examining the STEM literature, it can be seen that views on the integration of the STEM concept into education are generally in the form of the effects of STEM in teaching environments and on gifted students (Kertil & Gürel, 2016). In addition, there are studies on the effects of STEM education among girls (Holba, 2015). Only two national studies have been conducted in Turkey on the impact of STEM on students with learning difficulties (Biçer, 2019; Tosun, 2019), and there are few international studies (Ngubane-Mokiwa & Khoza, 2016; Israel et al., 2016; Lindsay & Hounsell, 2017). Among these studies are social projects including the concepts of learning disability, autism and special learning disabilities. The aim of the projects is to direct the individual to STEM careers with STEM activities. In the present study, unlike in the national literature, changes in the non-verbal cognitive performance of students who have difficulty in reading were examined, along with changes in their career interests (Drobnič, 2023) and motivations.

In terms of science education, the views of students with inclusive education and their teachers are generally included in national studies on learning disability (Dilber, 2017). In this context, it is clear that science teachers do not have enough information about how to implement lessons for students with learning disabilities. A study by Köse (2017) investigated teachers' opinions about education for inclusive students. The author concluded that this education was inadequate: although it should be executed in line with the IEP programmes prepared, teachers did not know how to teach these programmes. Studies including the opinions of teachers reveal that teachers working in this field are not satisfied with their own performance, with some of them stating that they do not know, or were unsure about, which method and material they should use in the classroom. Students who have learning difficulties in literacy and mathematics and have difficulties in adapting to their peers in the classroom may also experience difficulties in science (Dündar & Akyol, 2014). In the regulation published in 2018, the stated aims of special education services were to determine the needs of individuals, taking into account the aims and principles of the education system. This is expressed as ensuring that individuals achieve optimal performance by determining their interests, talents and competencies in various fields, and preparing them for the profession and social life they will choose in the future (MoNE, 2018). It can be seen that the purposes of special education services actually have similarities with career interest in STEM. Considering the effects of developing and changing technology on our daily lives, it is clear that there are changes in professions and that different professions related to STEM have emerged. Including STEM-related activities in special education may therefore result in individuals who need such education adopting a profession in STEM-related fields in the future.

The literature on students with learning disabilities and science education shows that research is generally conducted using the direct teaching method, as well as web-designed and virtual applications (Hopcan, 2017; Tezcan, 2012; Çikili, 2016), teaching methods that increase the interest and motivation of students with learning difficulties (Köse Biber, 2009). For students who have difficulties in learning, concrete activities involving touching, writing and participating in dialogues and discussions in the learning process can provide permanent learning. In the Diagnostic and Statistical Manual of Mental Disorders (2013, p. 67), learning disabilities are divided into three groups: a) reading disorders (dyslexia), b) written expression disorders (dysgraphia), and c) numerical (mathematics) disorders (dyscalculia). The international and national exams in which Turkey participates, such as PISA, TIMMS and ABIDE,[4]

4 ABIDE: Akademik Becerilerin İzlenmesi ve Değerlendirilmesi (Monitoring and Evaluation of Academic Skills)

test reading and reading comprehension, and Turkey's failure in these exams is generally related to these areas (OECD, 2015; ABIDE, 2019). In high school and university entrance exams, which evaluate students and guide them to a career choice, the questions are aimed at testing students' understanding of what they read, reinforcing the need to improve students' reading and reading comprehension skills. It is therefore important to address the reading problems of students with learning disabilities.

Reading problems can negatively affect students' academic success (Dündar & Akyol, 2014). It is thought that these inadequacies and deficiencies can be eliminated with different teaching methods for students with reading problems (Sakarneh, 2023). In this context, the aim of the present study is to determine the effect of STEM activities on the academic performance of students with reading problems and to examine their willingness to continue with STEM education.

Students with reading problems may have difficulty making sense of subjects requiring reading performance. For example, if the student has a reading problem, s/he cannot solve problems encountered in mathematics, thus causing a mathematical disorder. Likewise, most researchers agree that mathematical difficulties are often associated with problems in other domains, such as language difficulties, spatial difficulties and/or difficulties with memory (Dowker, 2009, p. 7). It is thought that STEM activities implemented with students with reading problems will also affect these students in science courses. In this context, the present research aims to reveal the effect of STEM activities on the academic performance of students with reading problems and their willingness to continue studying STEM activities. The research problem is: "Do STEM activities have an effect on the academic performance of students with reading problems?" The sub-problems of the research are:

(1) Is there a change in the academic performance of students with reading problems at the end of the education process with STEM activities?
(2) What is the level of willingness of students to study with STEM activities at the end of the education process with STEM activities?

Method

The ABA design, a single-subject research model, was used in the research. The single-subject research model is used when the participants in a research study group are evaluated by one subject or a small number of subjects. Single-subject designs experimentally examine the effect of an intervention. The ABA design is used when the aim is to create a time series, providing

stronger evidence of the causal effect of a situation (Christensen et al., 2014, p. 315). The dependent variables of the present study were determined as the general mental ability (academic performance) of the subjects in the science course, and the independent variable as the application of STEM activities.

Participants

In Turkey, students between the ages of 10 and 13 study in secondary schools. In this study, the research participants were three fifth-grade students, one girl and two boys aged ten years, with reading difficulties and studying at a randomly selected secondary school in a province in the Aegean region of Turkey. The selection criteria were that the students had not taken STEM activities before, that they had reading problems, that their participation was approved by the school they attended, and that they participated in the study voluntarily with the permission of their families. In addition, the guidance of the classroom teacher was also taken into account in the selection of the participants from the fifth-grade students at the school.

In determining which students should participate in the study, an interview was first conducted with the school administration, who referred the matter to the guidance service. One-on-one interviews were conducted with the students' science, mathematics, informatics and Turkish teachers, as well as with the classroom guidance teachers, with reference to the names of the students obtained from the guidance service and the psychological counsellor. In these interviews, the teachers were asked to evaluate the students' attendance, grades and behaviour in the course in general terms. Opinions about the students were obtained from their subject and class teachers. selected Based on the results of these interviews, the students in question were observed in their classrooms. During the observations, consideration was given to the students' behaviour in the classroom, whether they demanded the right to speak in the lesson, the difficulties they experienced in reading a text if they participated in the lesson, the writings they kept in their notebooks, their attention to the lesson and their academic success. It was observed that the students frequently made reading mistakes, read syllables incorrectly, overlooked some word affixes or added extra affixes while reading a text. It was therefore determined that they had difficulty in reading. When the students' writing notebooks were examined, it was observed that their writings were irregular, they often used lowercase letters at the beginning of sentences and uppercase and lowercase letters in the sentence, they used punctuation incorrectly or not at all, and numbers were reversed. It was also noted that the students paid attention if the teacher gave them the floor during the lesson, but otherwise did not engage

with the lesson voluntarily. The students exhibited behaviours such as being distracted during the lesson, playing with an eraser or pencil, talking to the person sitting next to them, and asking irrelevant questions. With regard to their academic achievements, only one of the students observed had achieved 70 percent in the mathematics course, and their overall average was below grade level. In the teacher interviews, it was learned that the students were indifferent to the lessons, had difficulty answering questions when asked, and were often sick and absent from school. The female students were quieter than the male students in the classroom and followed lessons more attentively. Three of the students were receiving one-on-one training in reading and writing in support training rooms, which provided an opportunity to observe these students in this context. A one-on-one interview was conducted with the students' teacher, who stated that the reading and writing of the three students was weak, which was confirmed by observations in the support training room. In the session observed, the students were given a text from their science textbook and asked to read it for 60 seconds. During this period, the student Ali had difficulty reading, especially syllables. He read slowly and with continuous breaks, reading 15 words in 60 seconds, 5 of which were wrong. The student Hakan managed to read 19 words in 60 seconds, with 5 wrong words, while Defne read 12 words in 60 seconds, with 2 wrong words. The students' fifth-grade peers normally read between 200 and 300 words per minute on average, and fewer than 200 per minute is considered slow reading (Akyol, 2011). The three students observed therefore read very slowly and inaccurately. In a study by Ergül (2012), it was stated that the reading performance of students with reading difficulties was 55.96 words per minute.

Instruments

The data collection tools used in the present research were: a) a monitoring test prepared by the researcher (to observe the pre-post monitoring measurements of the students and assess the development and change in their performance in the Earth and Universe topic), b) STEM activities prepared by the researcher, c) a checklist prepared by the researcher (after the STEM activities, a monitoring test was administered to the students at the end of each session; in each of the applied monitoring tests, equivalent questions measuring the same outcome were prepared in order to prevent the students from giving memorised answers), and d) a STEM continuity questionnaire prepared by the researcher.

Monitoring test and checklist

Tracking Test

A monitoring test was prepared by the researcher to determine the students' levels during the research process. Accordingly, a monitoring test was created for the 'Sun, Earth and Moon' unit in the Primary School Fifth-Grade Science and Technology Curriculum. Content validity was ensured by submitting the created test to expert opinion. An example of the questions in the monitoring test is:

Sample question

(1) How do we place the balls below to form the Sun-Earth-Moon model in the correct order?

(A) Soccer ball-ball-ping pong ball

(B) Ping pong ball-soccer ball-ball

(C) Ball-ping pong ball-soccer ball

(D) Soccer ball-ping pong ball-ball

Control list

The World and Universe Checklist is used to show the level of knowledge the students are expected to exhibit and to make appropriate decisions about education and training by observing their strengths and weaknesses. Based on the performance level determination form developed by Köse Biber (2009) in his master's thesis, the checklist was developed for the present study and submitted to expert opinion. At the beginning of the activity, pre-measurements of the students were taken in order to assess the difference due to the intervention. The final measurements were taken at the end of the application in order to determine the change in the expected performance levels of the students after the intervention. In order to obtain numerical data for evaluation, the students were assigned 1 point for exhibiting each expected behaviour listed in the form, and 0 points for listed behaviours not exhibited. The checklist was applied at the end of each activity to measure the students' ability to remember the material and achieve the objectives of the activity. In addition, the students were required to answer at least 15% of the questions correctly in order to proceed to the new activity booklet (Billingsley, 2011). Examples of expected behaviour in the checklist are given below (Table 1).

Table 1
Examples of Expected Behaviour in the Checklist

	Purpose 1	1st week		2nd week		3rd week		4th week	
		First	Last	First	Last	First	Last	First	Last
1	What is the shape of the Sun? Can you draw it on a piece of paper?								
2	How big is the sun? Can you draw it on a piece of paper?								
3	What geometric structure does the Sun look like? Can you draw it on a piece of paper?								

STEM continuity questionnaire

After the students had completed the intervention with STEM activities, a questionnaire prepared by the researcher was applied to reveal the students' thoughts about the activities and assess their desire to continue their education with such activities after the intervention. Before applying the questionnaire, it was presented to three experts in science education to obtain their expert opinion. The questionnaire items were approved and no changes were made. The study by Gregg et al. (2016) was used as a reference in creating the survey items. There are 11 items in total, such as: "I think that the information I learned through the STEM activities will be useful in my daily life and later in my school life", "The STEM activities provided me with an opportunity to learn and succeed" and "I could choose appropriate tools and materials in the lesson with STEM activities". The maximum number of points that can be obtained in the survey is 44, and the minimum is 11.

Research design

Preparation of the STEM activities

The STEM activities were prepared after taking into consideration the opinions of teachers and a review of the relevant literature. The activities were adapted to the 5E lesson plan, which reflects the constructivist approach. The students were informed about what they would learn in the introductory part and their readiness was tested using story texts, animation and virtual reality (VR) glasses to attract their attention and motivate them, thus commencing the discovery phase. In the exploration part, various experiments and activities were presented to the students using Tolkido playing cards. This was followed by the explanation part, in which the students were expected to internalise and explain the concepts they had experienced in the discovery phase and share the

data they had obtained on the tablets they had been given, using video animations made by the teacher with the Scratch program. In the elaboration part, the students were expected to be able to synthesise what they had learned and transfer their findings to daily life, providing their own explanations through activities and video making. Taking into account STEM, the aim is to obtain a product based on a problem from daily life, which at this stage is similar to 5E. In the evaluation part, the students undertook self-evaluation with end-of-story questions, painting, poster preparation and product extraction. After the activities were prepared, they were presented to a panel for expert evaluation. The panel included five faculty members in the fields of science, mathematics, informatics and special education, four experts in the fields of science education, astronomy, physics and special education, and three science teachers. Booklets were prepared in line with the opinions received.

The implementation process

The implementations were carried out in a room with the guidance of the school administration. It was a large, well-lit room suitable for airing and without heating problems. The process of working one-on-one with each student took place on a square white table. The application was carried out with the students for four weeks, with eight sessions in total. During the implementation process, the students and researchers carried out one-on-one studies and care was taken to establish eye contact with the students. In order to measure the prior knowledge of the students, the follow-up questions on the topic Earth, Sun and Moon prepared by the researcher were applied to the students participating in the application. During the implementation process, the Earth and Universe Checklist was used to determine the performance levels before and after each activity. Based on the application, the checklist prepared by the researcher on the topic Earth, Sun and Moon was applied again in order to take the final measurements. The questions were read aloud by the researcher when the students had difficulty reading or showed signs of fatigue, and the student was asked to mark the answer by him/herself. The process with students who had reading problems was as follows:

In the initiation sessions, all of the students were asked one of the three groups of ten equivalent questions in succession, enabling starting level data to be collected over three sessions. After the starting level data were obtained, the three students involved in the research started learning with the STEM activities prepared for the Sun, Earth and Moon unit in fifth-grade science lessons in secondary school. At the end of each day, the questions on the activity sheet were asked and the number of correct answers was recorded on the Earth

and Universe Checklist. Complete and correct answers to the questions were marked as (+), while incorrect or approximate answers were marked as (-). Before moving on to the next activity sheet, the questions in the previous activity sheet were asked again. If the students answered 15% of the questions correctly, the next activity sheet was implemented. Teaching continued until a stable level of correct answers was reached, after which the application phase was terminated. After the completion of instruction, follow-up sessions were held to examine the extent to which the subjects retained what they had learned during instruction. The monitoring sessions were carried out by the practitioner two, five and seven weeks after the end of instruction.

The data obtained at the end of the sessions with regard to the three students were analysed in accordance with the ABA model. These data are shown in Figure 1. In addition, attendance at the course was determined by the STEM attendance questionnaire at the end of the application.

The initiation, application and follow-up data regarding the students Ali, Hakan and Defne are presented in graphic form in the findings according to the ABA model. The number of correct answers given by the students is given as a percentage.

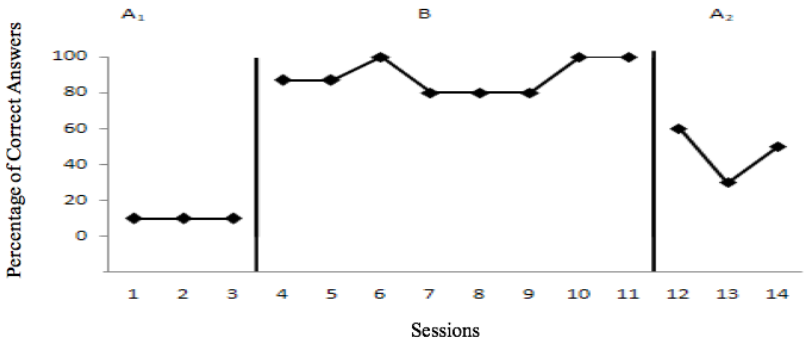
Results

The findings regarding the effect of STEM activities on the academic performance of students with reading difficulties in science lessons are presented below.

1.1 Findings Obtained from Teaching the First Student (Ali) with STEM Activities

Figure 1

Findings of Ali's STEM Activities and Teaching Sessions

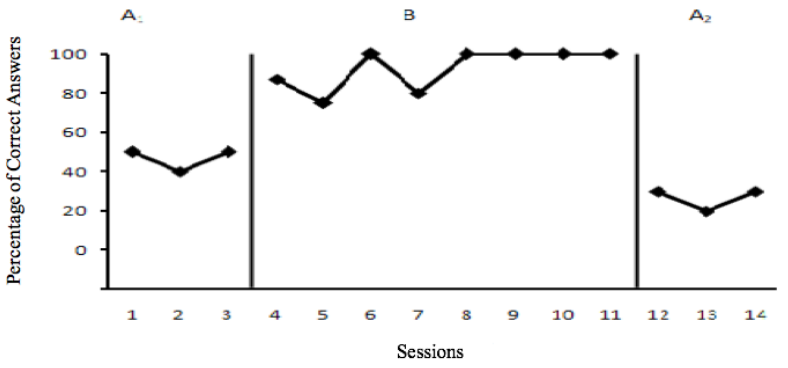


The starting level data for Ali were collected in three sessions, each comprising one group of 10 questions, making a total of 30 questions from the science topic Earth and Universe. Ali correctly answered 10% of the 10 questions in each of the three sessions. After the baseline data reached stability, the teaching sessions were commenced with STEM activities. The learning process took place in eight sessions. It was observed that the response percentages were 87% in the first session, 87% in the second session, 100% in the third session, 80% in the fourth session, 80% in the fifth session, 80% in the sixth session, 100% in the seventh session and 100% in the eighth session. The sessions were then terminated and the monitoring phase commenced. In the monitoring phase, three groups of 10 questions were asked, making a total of 30 questions. Ali correctly answered 60% of the questions in the first session of the monitoring phase, 30% in the second session, and 50% in the third session (Figure 1).

Findings Obtained from Teaching the Second Student (Hakan) with STEM Activities

Figure 2

Findings of Hakan's STEM Activities and Teaching Sessions

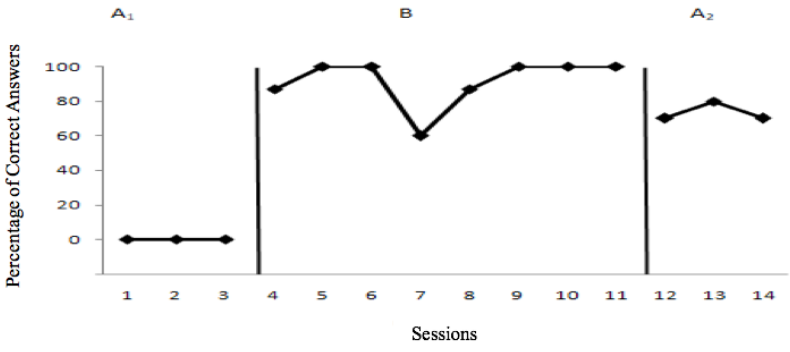


The starting level data for Hakan were collected in three sessions, each comprising one group of 10 questions, making a total of 30 questions from the science topic Earth and Universe. Hakan correctly answered 50% of the 10 questions in the first session, 30% in the second session, and 50% in the third session. After the baseline data reached stability, the teaching sessions were commenced with STEM activities. The learning process took place in eight sessions. It was observed that the response percentages were 87% in the first session, 75% in the second session, 100% in the third session, 80% in the fourth

session, 100% in the fifth session, 100% in the sixth session, 100% in the seventh session, 100% in the eighth session. The sessions were then terminated and the monitoring phase commenced. In the monitoring phase, three groups of 10 questions were asked, making a total of 30 questions. Hakan correctly answered 30% of the questions in the first session, 20% in the second session, and 30% in the third session (Figure 2).

1.2 Findings Obtained from Teaching the Third Student (Defne) with STEM Activities

Figure 3
Findings of Defne's STEM Activities and Teaching Sessions

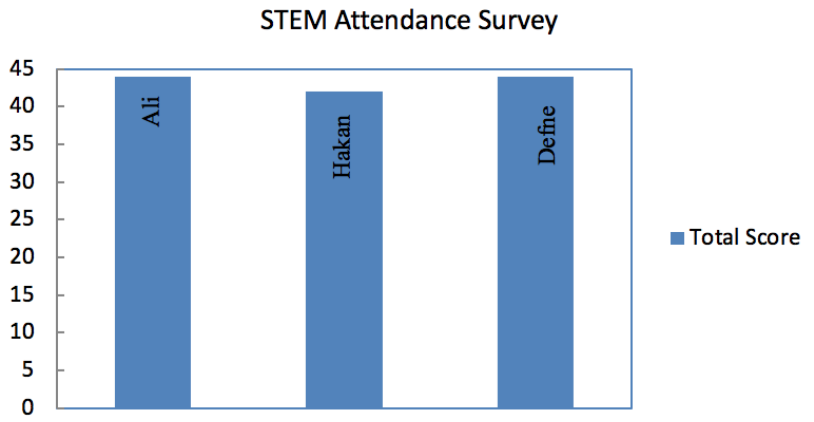


The starting level data for Defne were collected in three sessions, each comprising one group of 10 questions, making a total of 30 questions from the science topic Earth and Universe. Defne correctly answered 0% of the 10 questions in the first session, 0% in the second session, and 0% in the third session. After the baseline data reached stability, the teaching sessions were commenced with STEM activities. The learning process took place in eight sessions. It was observed that the response percentages were 87% in the first session, 100% in the second session, 100% in the third session, 60% in the fourth session, 87% in the fifth session, 100% in the sixth session, 100% in the seventh session, 100% in the eighth session. The sessions were then terminated and the monitoring phase commenced. In the monitoring phase, three groups of 10 questions were asked, making a total of 30 questions. Defne correctly answered 70% of the questions in the first session, 80% in the second session, and 70% in the third session (Figure 3).

1.3 Findings Obtained Regarding the Students' (Ali, Hakan, Defne) Desire to Continue their Education with STEM Activities

Figure 4

Findings Regarding the Students' (Ali, Hakan, Defne) Desire to Continue their Education with STEM Activities



As Figure 4 shows, the students' total scores from the STEM continuity questionnaire range from 44 to 42.

Discussion and conclusion

The research was conducted to determine the effects of STEM activities prepared for students with reading problems on their academic performance and their willingness to undertake STEM activities. Within the scope of the research, data were collected from three students with reading problems studying in a public school. According to the findings obtained in the research, it was concluded that the STEM activities developed were positive for the development of the three students with reading problems.

The research findings show that the proficiency of the first student, Ali, increased during the sessions in which STEM activities were applied, but decreased in the last monitoring sessions. The fact that this student was bored while answering the monitoring test questions but increased in proficiency in the following weeks of monitoring is thought to be due to his current mood and motivation. The evaluations made during and after the implementation of the activities of the students with reading problems are different from the

education and evaluations they receive in the classroom at school. In the later stages of the research, it was observed that the first student answered the questions without getting bored while reading and with a high level of motivation. The student did not undertake any activities during the application of the post-monitoring tests and participated in the sessions reluctantly, stating that he had difficulty in reading and therefore did not want to read. In the areas where he had difficulty in reading, the questions were read clearly to the student and answered accordingly. It is thought that the student's reluctance to read may have been because he was subjected to a monitoring test without doing any activity. While sitting at the table and working one-on-one, the student was not interested in the measurement tool and tended to ask irrelevant questions (e.g., Do you have children? Are you married? How old are you?). He got up, asked for a toilet break and wanted to play with the computer. In the interviews with the student's teachers, it was stated that the student was constantly moving during the lesson and had difficulty concentrating on the lesson, which may explain the student's decrease in motivation in the last sessions of the follow-up test. In the literature, it is stated that students with learning disabilities are typically either withdrawn or hyperactive (Wicks-Nelson & Israel, 2009).

When the performance values are examined, it can be seen that the student's performance increased by one point. Applying the test to the student without STEM activities may have negatively affected the increase in performance value. For this reason, STEM activities are thought to increase the performance of students with reading problems.

The second student, Hakan, achieved higher scores than the other two students included in the study when measuring the starting level. While it was observed that he achieved high scores at the end of the sessions and the education progressed positively, his results decreased in the last monitoring sessions. There were times when he did not follow the instructions given during the study and he complained that the session could not be held in the last week. This student performed well whenever he wanted. While using the computer, he wanted to go out of the planned activities and open other internet pages using the browser, and he did not want to follow the prescribed activity order. When asked to read the questions, he refused, using body language without giving any answer. In other words, he was completely closed. This is thought to have caused the recorded decrease in proficiency in the post-monitoring sessions, resulting in a lower level of success than the initial level. During the activities, the student stated that he did not like science lessons because it was difficult this year. It is thought that commencing the STEM activities with this attitude had an impact on the result.

When the change in the second student's performance is examined, it can be seen that there is approximately a 50% increase in the results. It is thought that the actual performance of the student was revealed during the STEM activities, but was not reflected during monitoring. Another possible explanation could be that the initial measurements were low due to environmental factors (such as the new environment, unfamiliarity, inability to concentrate).

The third student, Defne, started the sessions at a lower level than Ali and Hakan before starting the intervention training. When the initial and final sessions are examined, however, it can be said that the difference is positive. Defne has problems attending school and stated that she only came to practical classes, where knowledge was applied. This was confirmed by the school administration and teachers confirmed. The student's parents requested a one-on-one telephone interview, during which the researchers were asked to persuade the student to attend school. Based on the grades received from the school administration, it is clear that her level of success is low. Her older sister, who is studying at the same school, has a diagnosis of disability, and the guidance service had been requested to guide Defne in this regard. It is thought that the student will be successful if the education process is planned individually or if STEM activities are used in the classroom environment.

The evaluation of the student's performance indicated that the STEM activities made a difference, as she showed a positive development in the monitoring sessions, which is expected to make a difference in her academic performance in parallel with the monitoring sessions. Thus, the student's experience with STEM activities had a positive effect on her academic performance.

Genetic factors have a role in learning disabilities. Research on this subject has shown that genetic factors affect the development and maturation of the brain, and in this case, learning disabilities affect cognitive functions. In addition, environmental factors such as a poor financial situation and a lack of education are thought have an impact, although it has been found that environmental factors affect reading skills more as a result of the combination with heredity. In a study conducted for this purpose, it was found that children who are described as poor have twice as many learning difficulties than children who are not described as poor (Child Trends Data Bank, 2014). In addition, it has been revealed that heredity is effective in reading ability and mathematics skills (Özçivit Asfuroğlu & Fidan, 2016).

The findings regarding the students' desire to continue their education with STEM activities show a strong desire among the students in this respect, including the student who does not want to continue school and only attends the courses during the application period. In a study conducted by Karasu (2019),

it was determined that students liked lessons with the activities prepared in accordance with the 5E learning model for students with learning disabilities.

In the present research, it was observed that the students had fun and their motivation increased during the process of their education with STEM activities. Furthermore, the performances of two of the students clearly improved. Education with STEM activities can be an opportunity for students with reading problems or learning disabilities in special education classification to demonstrate their performance. The participating students with reading problems learned by doing and experiencing in the process of applying the activities and they absorbed what they had learned. It is thought that providing a learning process with STEM activities in a simple and understandable way helps students to make sense of the subjects and concepts more easily. Reading trainings and individual teaching programmes in special education are designed for students who have reading problems, and STEM activities can be individualised for each student. The activities developed in the present study were prepared based on the general characteristics of students with reading problems, but the areas in which individual students have difficulty are different. It was found that, in designing activities, expressions must be simple, step by step and visual, as well as being practical. It is clear that the existing performance of students is revealed with STEM activities.

It can be concluded that the use of contemporary approaches in the education of students rather than the traditional approach is more effective academically (Demir, 2008; Kaplan & Tekinarslan, 2013; Çapraz, 2016).

Limitations of the study

Although the present research is limited to three students with reading problems, it is clear that providing education with STEM activities can be used as a tool to increase students' performance. The fact that the STEM activities were not based on reading enabled the participating students to learn and practise more actively, although they had difficulty in the monitoring tests because they were based on reading. However, this is limited to the findings of the present study; the fact that applications and evaluations made for students with reading problems are not based on reading (they are interactive or computer-supported) may increase students' participation in courses. According to the results of the STEM continuity survey, the students stated that they wanted to continue their education with STEM activities. STEM activities or educational processes using different techniques for students with reading problems can be planned by teachers and academics. Since the present study is limited to students with reading problems, the application could be repeated with students

with different learning disabilities to examine its effect. In the present research, the application with students who have reading problems was limited to three sessions. In STEM-supported studies on students with reading problems, the process could be planned for a longer period of time, enabling its effect to be observed in more detail. The application was carried out one-on-one with each student in a special education classroom. In future studies, STEM activities could be implemented in classrooms by creating heterogeneous groups consisting of students with reading problems and their typically developing peers. The present study was limited only to the monitoring sessions before, during and after the application, but teachers and parents could also be interviewed about the students' post-implementation situations to examine whether any changes have occurred.

References

Akyol, H. (2011). *Türkçe öğretim yöntemleri [Turkish teaching methods].* Pegem Akademi Yayıncılık.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (DSM–5)* (5th ed.). American Psychiatric Association.

Biçer, A. (2019). *STEM yaklaşımına dayalı elektrik devre elemanları konusu öğretiminin 5. sınıf özel öğrenme güçlüğü olan öğrencilerin akademik başarılarına ve kalıcılığına etkisi* (Publication No. 535611) [The effect of teaching electrical circuit elements based on a STEM approach on the academic success and retention of fifth-grade students with specific learning disabilities] [Master's thesis, Aksaray Üniversitesi]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp

Çapraz, C. (2016). *Ortaokul özel alt sınıfta öğrenim gören zihinsel yetersizliği olan öğrencilere doğrudan öğretim yöntemiyle bazı maddelerin'katı-sıvı-gaz'hallerinin öğretimi* (Publication No. 433815) [Teaching the 'solid-liquid-gas' states of some substances to students with intellectual disabilities studying in the special lower class of secondary school by direct teaching method] [Master's thesis, Atatürk Üniversitesi].
https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=fe8HZCN8jLgXELjYXU18vA&no=QQArcPBbQEByf952c3DIyA

Child Trends Data Bank. (2014). *Making the grade: assessing the evidence for integrated student supports.* Child Trends. https://cms.childtrends.org/wp-content/uploads/2014/02/2014-07ISSPaper2.pdf

Christensen, L. B., Johnson, R. B., & Turner, L. A. (2014). *Research methods, design, and analysis* (12th ed.). Pearson Education Limited.

Christensen, R., & Knezek, G. (2017). Relationship of middle school student STEM interest to career intent. *Journal of Education in Science, Environment and Health*, 3(1), 1-13.
https://doi.org/10.21891/jeseh.275649

Çikili, D. (2016). *Hafif derecede zihinsel yetersizliği olan öğrencilere fen konularının öğretiminde doğrudan öğretim ile şematik düzenleyiciyle öğretim* (Publication No. 418165) [Direct instruction and

schematic organiser teaching in teaching science subjects to students with mild mental disabilities] [Master's thesis, Abant İzzet Baysal Üniversitesi]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=Rpa6l1YdFfeTt48MhT93Bw&no=kfImaqlo7MjY9LnS3brTFA

Demir, R. (2008). *Zihinsel engelli öğrencilere fen bilgisi dersinde sindirim konusunu basamaklandırılmış öğretim yöntemiyle sunulmasının etkililiği* (Publication No. 178389) [The effectiveness of presenting the topic of digestion to mentally disabled students with the stepped teaching method in science class] [Master's thesis, Selçuk Üniversitesi]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=CPgDnp6I3NvUolDYHtYc9g&no=6exnatMjxiNNX6a3fEUIAA

Dilber, Y. (2017). *Fen bilimleri öğretmenlerinin öğrenme güçlüğü tanılı kaynaştırma öğrencileri ile yürüttükleri öğretim sürecinin incelenmesi* (Publication No. 471999) [An examination of the teaching process carried out by science teachers with inclusive students diagnosed with learning disabilities] [Master's thesis, Karadeniz Teknik Üniversitesi]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=G4N8YwQ8VIAa5LwINoeSyw&no=iQlmJJFHXamybyZiZesgNQ

Dowker, A. (2009). Use of derived fact strategies by children with mathematical difficulties. *Cognitive Development*, *24*(4), 401-410. https://doi.org/10.1016/j.cogdev.2009.09.005

Drobnič, J. (2023). People with special needs and career development based on strength. *Center for Educational Policy Studies Journal, 13*(3), 213-232. https://doi.org/10.26529/cepsj.1381

Dündar, H. & Akyol, H (2014). Okuma ve anlama problemlerinin tespiti ve giderilmesine ilişkin örnek olay çalışması [A case study on detecting and eliminating reading and comprehension problems]. *Eğitim ve Bilim, 39*(171), 361-377.

Earle, F. S., Gallinat, E. L., Grela, B. G., Lehto, A., & Spaulding, T. J. (2017). Empirical implications of matching children with specific language impairment to children with typical development on nonverbal IQ. *Journal of Learning Disabilities*, *50*(3), 252-260. https://doi.org/10.1177/0022219415617165

Ergul, C. (2012). Okumada güçlük yaşayan öğrencilerin performanslarının öğrenme güçlüğü riski açısından değerlendirilmesi [The evaluation of the performance of students with reading difficulties in terms of the risk of learning disabilities]. *Kuram ve Uygulamada Eğitim Bilimleri*, *12*(3), 2033-2057. https://doi.org/10.37669/milliegitim.983749

Gregg, N., Wolfe, G., Jones, S., Todd, R., Moon, N., & Langston, C. (2016). STEM e-mentoring and community college students with disabilities. *Journal of Postsecondary Education and Disability*, *29*(1), 47-63.

Guzey, S. S., Moore, T. J., Harwell, M., & Moreno, M. (2016). STEM integration in middle school life science: Student learning and attitudes. *Journal of Science Education and Technology, 25*(4), 550-560. https://doi.org/10.1007/s10956-016-9612-x

Hare, L. N. (2017). *The perceptions of STEM from eighth-grade African-American girls in a high minority middle school* [Doctoral dissertation, Gardner-Webb University]. ProQuest Dissertations & Theses Global. https://core.ac.uk/download/pdf/212811453.pdf

Holba, A. (2015). *Middle school girls and one STEM OST program* [Doctoral dissertation, Northern Illinois University]. ProQuest Dissertations & Theses Global.

Hopcan, P, E. (2017). Özel öğrenme güçlüğü yaşayan öğrenciler için kavranabilir bir mobil uygulama tasarımı, geliştirilmesi ve değerlendirilmesi (Publication No. 474976) [The design, development and evaluation of a comprehensible mobile application for students with specific learning difficulties] [Master's thesis, Orta Doğu Teknik Üniversitesi]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=4Rs3sczOykSoRnoNc4VvTg&no=bcgtNybiBDoin6ZDY6Kixw

Hwang, J., & Taylor, J. C. (2016). Stemming on STEM: A STEM education framework for students with disabilities. *Journal of Science Education for Students with Disabilities*, *19*(1), 39-49. https://doi.org/10.14448/jsesd.09.0003

Israel, M., Wang, S., & Marino, M. T. (2016). A multilevel analysis of diverse learners playing life science video games: Interactions between game content, learning disability status, reading proficiency, and gender. *Journal of Research in Science Teaching*, *53*(2), 324-345. https://doi.org/10.1002/tea.21273

Kaplan, G., & Tekinarslan, İ. Ç. (2013). Zihinsel yetersizliği olan ve olmayan öğrencilerin astronomi kavramlarındaki bilgi düzeylerinin karşılaştırılması [Comparison of the knowledge levels of students with and without intellectual disabilities in astronomy concepts]. *İlköğretim Online*, *12*(2), 614-627.

Karasu, S. (2019). *Özel eğitim öğrencilerine fen bilimleri dersinde duyu organları konusunun 5E yöntemi ile sunulmasının etkililiği* (Publication No. 579789) [The effectiveness of presenting the subject of sensory organs to special education students with the 5E method in science lessons] [Doctoral dissertation, Necmettin Erbakan University]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp

Kennedy, T. J., & Odell, M. R. L. (2014). Engaging students in STEM education. *Science Education International*, *25*(3), 246-258. https://doi.org/10.1007/978-3-031-24259-5_4

Kertil, M., & Gurel, C. (2016). Mathematical modeling: A bridge to STEM education. *International Journal of Education in Mathematics Science and Technology, 4*(1), 44-55. https://doi.org/10.18404/ ijemst.95761

Köse Biber, S. (2009). *Web destekli fen bilgisi öğretiminin kaynaştırma eğitimindeki ilköğretim 7. sınıf öğrencilerinin performans düzeyi ve akademik başarılarına etkisi* (Publication No. 255473) [The effect of web-supported science teaching on the performance level and academic achievement of seventh-grade primary school students in inclusive education] [Master's thesis, Ege University]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezDetay.jsp?id=SyatkbZoeFRMlfOdnoKJrg&no=c15QJ7-pIRqRolWBmmPVcg

Köse, K., (2017). *Fen bilimleri dersinde uygulanan kaynaştırma eğitiminin fen bilimleri öğretmenleri ve öğrenci görüşlerine göre değerlendirilmesi* (Publication No. 471811) [An evaluation of inclusive education applied in science classes based on the opinions of science teachers and students] [Master's thesis, Necmettin Erbakan Üniversitesi]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp

Lindsay, S., & Hounsell, K. G. (2017). Adapting a robotics program to enhance participation and interest in STEM among children with disabilities: A pilot study. *Disability and Rehabilitation: Assistive*

Technology, *12*(7), 694-704. https://doi.org/10.1080/17483107.2016.1229047

MoNE. (2018). Özel Eğitim Hizmetleri Yönetmeliği [Special Education Services Regulation]. Resmi Gazete. Retrieved 19 May 2019 from http://orgm.meb.gov.tr/meb_iys_dosyalar/2018_07/09101900_ozel_egitim_hizmetleri_yonetmeligi_07072018.pdf

Ngubane-Mokiwa, S., & Khoza, S. B. (2016). Lecturers' experiences of teaching STEM to students with disabilities. *Journal of Learning for Development-JL4D*, *3*(1). https://doi.org/10.56059/jl4d.v3i1.125

OECD. (2015). *Programme for international student assessment 2015.* OECD. http://www.oecd.org/pisa/pisa-2015-results-infocus.pdf

Özçivit Asfuroğlu, B., & Fidan, S., T. (2016). Özgül öğrenme güçlüğü [Specific learning disability]. *Osmangazi Tip Dergisi*, *38*(Special issue 1), 49-54. https://doi.org/10.20515/otd.17402

Raines, J. M. (2012). FirstSTEP: A preliminary review of effects of a summer bridge program on pre-college STEM majors. *Journal of STEM Education*, *13*(1), 22-29.

Sakarneh, M. (2023). Teachers' attitudes towards the rights of students with special education needs during the Covid-19 pandemic. *Center for Educational Policy Studies Journal*, *13*(2), 143-162. https://doi.org/10.26529/cepsj.1155

Tezcan, C. (2012). *Zihinsel engelli çocuklara web destekli uzaktan eğitim sistemi kurulması: matematik ve fen bilgisi dersleri uygulaması* (Publication No. 318319) [Establishing a web-supported distance education system for mentally disabled children: Application of mathematics and science lessons] [Master's thesis, Trakya Üniversitesi]. https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp

TUSIAD (Türk Sanayicileri ve İş İnsanları Derneği). (2014). STEM (Science, Technology, Engineering and Mathematics) alanında eğitim almış iş gücüne yönelik talep ve beklentiler araştırması [Research on demands and expectations for the workforce educated in STEM (Science, Technology, Engineering and Mathematics)]. TUSIAD. https://tusiad.org/tr/yayinlar/raporlar/item/8054-stem-alaninda-egitim-almis-isgucune-yonelik-talep-ve-beklentiler-arastirmasi

Wade-Shepherd, A. A. (2016). *The effect of middle school STEM curriculum on science and math achievement scores* [Doctoral dissertation, Union University]. ProQuest Dissertations & Theses Global. https://www.proquest.com/docview/1873448981?sourcetype=Dissertations%20&%20Theses

Wicks-Nelson, R., & Israel, A. C. (2009). *Abnormal child and adolescent psychology* (7th ed.). Pearson Prentice Hall.

Biographical note

Zeren Gacar is a Science, Mind Games and Lego-Robotics Teacher at College of Ozel Dunya. She completed her master's degree in Science Education at Aydın Adnan Menderes University. In her research, she implemented STEM activities to be used in science courses for children with reading problems.

Hilal Aktamış, PhD, is a full professor in the field of science education at the Faculty of Education, University of Aydın Adnan Menderes University, Turkey. Her main areas of research are: STEM education, argumentation in science education, Scientific creativity, Astronomy education, Neuroscience in education.

Ahmet Bildiren, PhD, is an Associate Professor in the field of Special Education at the Faculty of Education at Aydın Adnan Menderes University. He has an undergraduate degree in Primary Education, a master degree in Psychological Counseling and a doctorate degree in special education. He has a number of researches on gifted children.