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Learning With STEM is Not Difficult at All!

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Research Article

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ABSTRACT

The aim of this study is to teach how to design a circuit using simple electrical circuit elements with a STEM activity conducted with 4 students with learning difficulties studying at a primary school located in the southern region of Anatolia. The study was carried out in the form of extracurricular activities focused on science lessons on the subject of simple electrical circuits for 8 class hours over a period of 2 weeks. After the quantitative stage of the study, which was designed as a mixed method design, the qualitative stage was conducted in the study, a STEM process rubric was used as the quantitative data collection tool, while an observation form and interview form were used as the qualitative data collection tools. At the end of the study, it was determined through interviews that the STEM activities made a significant academic contribution to the participants, that they had a lot of fun while learning, and that they did not easily forget what they had learned. The participants, who stated that the activities benefited them academically in science and mathematics, also reported that they used the knowledge about science and mathematics they gained here in other subjects as well.
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Keywords: STEM, learning disability, science education, primary school

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INTRODUCTION

In the world of the 21st century, in which rapid changes are being experienced through the effect of globalisation, countries are in constant competition in the fields of production, design, invention and technology. This competition has encouraged countries to science, engineering and technology (Kaplan, 2019). For this reason, countries have abandoned educational approaches that employ the content transfer of information and have begun to adopt teaching approaches that produce, design and are based on creativity. In the teaching approach towards the fields of science, engineering, design and production, STEM comes to the fore. STEM is a teaching approach that is based on the integration of disciplines and adopts the model of learning by doing and experiencing. Bybee and Dugger (2010) defined STEM as a new educational approach that encompasses the disciplines of Science, Technology, Engineering and Mathematics in unity, increases learners' motivation to do research by developing their sense of curiosity, and develops their problem solving and creative thinking skills. The STEM educational approach is defined as the integration of the learning objective of one STEM discipline focused on by associating it with the objectives of the other STEM disciplines (Çorlu, et al., 2014). It has been reported in many studies that the STEM approach, which is design-based and includes learning by doing and experiencing, is effective in both enabling meaningful learning and in developing problem solving skills in education (Bryan, et al., 2016; Author, 2018; Corlu & Aydın, 2016; Ergün & Balçın, 2019; Gwon- Suk & Sun Young, 2012; McClain, 2015; Wosu, 2013). Furthermore, although STEM education is effective at all grade levels of education, its effect has been determined to be greater at primary school level (Becker & Park, 2011; Murphy & Mancini-Manuelson, 2012; Lamb, et al., 2015).

STEM and individuals with special needs (ISNs)

It has been determined that in the world population, the number of students who are at a lower educational level than their peers due to premature births, genetic factors, consanguineous marriages and accidents is increasing day by day (Batu & Kırcaali-İftar, 2006). In the Decree Law No. 573 on Special

Education of the Ministry of National Education (MoNE), these students are defined as: "Individuals with Special Needs (ISNs) who, for various reasons, differ significantly from the level expected from their peers in terms of educational qualifications" (MoNE, 1997) Ensuring that ISNs are not separated from social life and benefit from education and training activities according to the principle of the least restrictive environment is achieved through inclusion-integration education. However, while ISNs' social interaction skills with their peers increase thanks to inclusive education, problem solving skills are pushed into the background because appropriate learning methods for their level are not applied.

Theoretical Framework

In terms of equality of opportunity in education, it is very important that ISNs are trained like their peers by fostering 21st century skills with teaching approaches appropriate for their level in classes. STEM education, which is one of the approaches that foster these skills in individuals, is an important teaching approach in equipping individuals with 21st century skills such as innovation, analytical thinking, problem solving and cooperation (Kennedy & Odell, 2014). Despite such importance, the studies conducted on STEM education for ISNs are limited (Balçın & Yıldırım, 2021; Hwang & Taylor, 2016). However, teaching and learning STEM disciplines are especially valuable for these students in improving their quality of daily life, because STEM is intertwined with daily life situations (e.g., using technology, using electronic devices and programs such as smartphones and iPads, and using chemicals like soap, oil, and paraffin). Although research in STEM disciplines for students with disabilities is still increasing, very few practical guidelines for teachers in inclusive and non-inclusive environments have been proposed and developed in order to increase students' achievement and their accessibility to STEM (Basham & Marino, 2010; Dunn, et al., 2012; Ludlow, 2013). It can be said that ISNs face some obstacles to STEM education careers. One of these are characteristics related to teachers. For example, topics such as teachers' lack of adequate STEM knowledge, and their insufficient educational experience and readiness related to ISNs can be listed (Margot & Kettler, 2019). Other than these, the remaining obstacles can be listed as the lack of adequate infrastructure and educational opportunities for STEM education in schools, the lack of an integrated curriculum, as well as the lack of understanding of these barriers and their effects on employment. Common obstacles to accessing STEM education for all ISNs include (a) a lack of STEM role models (Hasse, 2011; Lee, 2011); (b) parents' and teachers' misconceptions that students with disabilities will not be successful in STEM, resulting in a lack of encouragement for them to take courses in these areas (National Science Foundation, 2002); (c) a lack of appropriate information and counselling (Alston, et al., 2002); (d) teachers' inadequate knowledge and skills on how to involve students with disabilities (Rule, et al., 2009); (e) technical barriers to science education (e.g., inaccessible laboratories) (Hasse, 2011); and (f) lower participation rates in structured and unstructured STEM-related activities (e.g., mathematics and science) (Eriksson, et al., 2007).

There are many disability groups among the aforementioned inclusion students. One of these is learning disability. In 1983, the United States National Joint Committee on Learning Disabilities (NJCLD) defined learning disability as "a general term that refers to a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, reading, writing, reasoning, or mathematical abilities".

The areas in which individuals experience learning difficulties may differ from each other. While some individuals have learning difficulties in verbal areas such as understanding and interpreting, other individuals have learning difficulties in subjects that require numerical reasoning, such as the disciplines of mathematics and science. STEM education, in which the disciplines of science and mathematics are integrated, contributes to Special Learning Disability (SLD)s' effective and permanent learning since it offers multiple learning environments by applying the doing-experiencing and active learning methods rather than the traditional educational approach. In their studies, Hwang and Taylor (2016) and Author (2017) stated that conducting STEM education activities for inclusion students with intellectual disabilities will increase their academic achievement in the disciplines of mathematics and science. Moreover, in the study conducted by Balçın and Yıldırım (2021), it was determined that due to STEM activities conducted for inclusion students with mild intellectual disabilities, there was an increase in the percentage of students' knowledge changes regarding the subject of science and in the students' interest in the subject. Bellman, et al. (2015) implemented STEM with inclusion students who had intellectual disabilities, and as a result of this study, it was concluded that STEM education increased the inclusion students' motivation, academic achievement and self-confidence. In the study carried out by Biçer (2019), STEM activities were conducted for inclusion students in support training rooms. In the findings obtained in this study, it was concluded that the STEM approach was effective in teaching science to inclusion students with intellectual disabilities. Yuen, et al. (2014), conducted STEM activities with two students with severe autism spectrum disorder in order to examine the effect of STEM activities on social communication. As a result of the study, it was observed that there was a significant improvement in the ability of the students with autism to communicate with their peers. Moreover, Akarsu, et. al. (2022) reported that the activity they developed for inclusion students with visual impairments was very effective on an electromagnet design in the science lesson for the students.

Based on the results of this study, it is seen that STEM education practices concretise abstract concepts, enable permanent learning with multiple learning environments, and develop individuals' psychomotor-social communication skills. When the relevant literature was scanned, however, it was concluded that the STEM approach has not been adequately implemented with SLDs. In this context, since the STEM approach has not been applied to SLDs, our study will contribute to the literature.

ACTIVITY IMPLEMENTATION

The students participating in the study were students with a diagnosis of learning disability, and the activity conducted with them was carried out during their lesson hours in the students' support training room. The reasons why the support training room hours were chosen were that in terms of the students' learning, the students could learn faster during the times they had one-to-one lessons, feedback could be obtained, and the things they learned were more permanent. Moreover, the activity was not detached from the curriculum and was designed in line with the individualised education plan (IEP). The implementation of the STEM approach within the scope of the IEP was preferred with the foresight that it could further increase the permanence of learning. It is possible that for SLDs, STEM's product-oriented, engineering-based make-up based on doing and experiencing will lead to permanent learning in them. Accordingly, in this study, a STEM activity for SLDs was designed and tested. This activity was prepared for teachers in order to enable the active participation in STEM activities of SLDs who are educated together with their peers (Figure 1).

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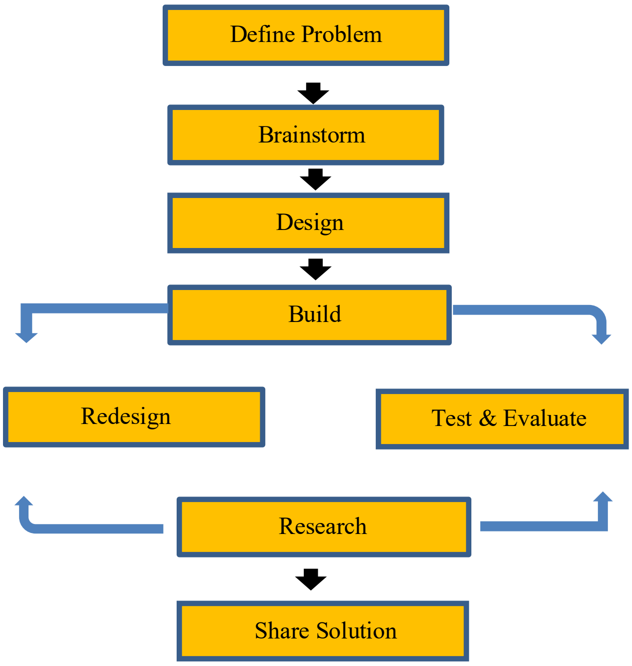

Figure 1. Teachers Exploring STEM Integration (Lesseig, et al., 2017, p.18)

Define Problem: Determining the problem. What kind of problem should be presented in which field with the students?

Brainstorm: What kind of path should be followed to solve the problem? Different solutions are explored with the students.

Design Process: The materials used in the activity to be conducted are specified, and how and where they will be used in the design is determined.

Construction phase: The construction of the design is begun. The accuracy of the design is tested on the students by guiding them (Test & Evaluate). They are also given the opportunity to do research by giving them time to redesign the designs which are wrong (Redesign and Research).

Share Solution: Individuals or groups who carry out their designs correctly share the solutions they find with their friends. At this stage, the teacher is the guide and director.

It will also serve as a guide to how learning objectives should be brought together for activities. The activity meets the education standard requirement for K-12 science education (Table 2).

Table 2. Application of education standards (MoNE , 2018; NGSS, 2022)

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts	Turkish MoNE Learning Objectives
4.PS3-2.Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents	PS3.A: Definitions of Energy The faster a given object is moving, the more energy it possesses.	Energy and Matter Energy can be transferred in various ways and between objects.	F.4.7.1.1. The student can recognise the circuit elements that make up a simple electrical circuit with their functions.
3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved	(4-PS3-1) Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (4-PS3-2),(4-PS3-3)	(4-PS3-1), (4-PS3-2), (4-PS3-3) (4-PS3-4)	F.4.7.1.2. The student can set up a working electrical circuit

This study has been designed around the following research question: What is the impact of a STEM activity designed for SLDs on their learning outcomes?

The studey was carried out over a period of 2 weeks in the form of extracurricular activities focused on science. The STEM activity was conducted under the supervision of the researchers. The activity was evaluated with the STEM process rubric that was checked by science and special areas expertise (Appendix 1), and observation form.

Before beginning the STEM process, a rubric for the STEM activity was created by the researchers based on the literature (Amaya et al., 2015; Author, 2020; STEM School Progress Rubric, 2019; STEM Implementation Rubric, 2017). During the activity, the student's performance was observed and evaluated. The rubric was designed by 2 STEM experts, 1 classroom instructor and 1 special educator. In addition, the participants were followed by the researchers throughout the application. For this, an observation form that was checked by expertise (science and special areas) was created based on the literature on STEM skills (Duygu, 2018; Gökbayrak & Karışan, 2017). Observations were noted with the help of this form (Appendix 2). With the help of this observation form, it was aimed to determine the level of skills that inclusive students use during STEM studies and to reveal their needs. The participants were four 4th grade students attending the same school who were diagnosed with learning disabilities by the Guidance and Research Centre. While selecting the participants, support was obtained from the school administration and the guidance service, and care was taken to ensure that they had the same diagnosis and they were studying at the same level. Permission for the activity was obtained from the school administration and from the classroom teachers and parents of the participants, consisting of 2 girls and 2 boys. They were told the activities and they were included in the activities on a voluntary basis. STEM was expressed in its simplest form to them. During the activities, it was stated that science, technology, engineering and mathematics would be used together. The activities were carried out after school under the supervision of the researchers in the school psychological counselling service. The activities focusing on the subject of science were designed in the context of the learning objectives of the Next Generation Science Standards (NGSS) and the Turkish Ministry of National Education (MoNE). In addition, the activities were planned in a way that allowed the participants to collaborate and engage in peer learning.

The stages of the STEM activity are as follows:

1. Science Stage: “What are the elements that make up a circuit?” and “Can the dough that you will make really be used in a circuit?” In this context, the experts gave the students preliminary information about conductive and insulating materials and circuits and stated that they expected them to test this. With the question, “What are conductors and insulators?” their preparedness for the subject was tested. Again, when they were asked for examples of conductors and insulators, they gave answers such as “sea water” and “pool water”, and based on this, they were questioned why pool water and sea water conduct electricity. Similarly, they were asked to find answers to the question, “Can this process be done with play dough?”.

2. Mathematics Stage: The students used 4 process skills in the stage of mixing the play dough by weighing it in certain sizes. They also used mathematics intensively in the processes of boiling and cooling to a certain temperature and using the dough as a cable in the circuit.

3. Technology Stage: Technology, which is also expressed as everything that makes life easier, was used by the students throughout the activity. They continued their activities by using technological tools such as a beaker, precision balance, graduated cylinder, spirit stove, battery, LED lamp, and switch.

4. Engineering/design process: The students produced designs to make the play dough they had prepared a part of the circuit. They brainstormed about where to use the play dough in the circuit and discovered that it could be used instead of wires. At this stage, the participants discovered how they could use play dough correctly in the circuit. For example, with brainstorming such as “Seeing that play dough can be a conductive battery…” (participant A), “Let’s make play dough like a cable, okay?” (participant B), and “Where should the play dough stick to the bulb?” Participant D) they were able to predict how a correct circuit arrangement should be. Those who saw that the lamps did not light or that the DC motor did not work in the circuit construction decided that their designs were wrong. Designs that were unsuitable were redesigned and reintegrated into the circuit.

When they realised the inaccuracy of their designs in the engineering design cycle, they updated their designs again and tested whether or not they had achieved the result. In this process, the researchers made observations on the one hand and carried out their guidance duties on the other.

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METHODOLOGY AND MATERIALS

Methodology of Research

This study was carried out with 4 students (two girls, two boys) diagnosed with learning disabilities and was designed in a mixed design. According to Creswell (2012), a mixed method design refers to the collection and analysis of quantitative and qualitative data together. In this study, explanatory sequential mixed method design was selected because it is aimed to determine the effectiveness of STEM approach among the participants. In order to evaluate the effectiveness of the STEM activities carried out in the first stage in the context of the process and the product, separate semi-rubrics were applied for each participant. The second stage consisted of the qualitative part where opinions were taken and observations were made within the scope of the activity. At this stage, one-on-one interviews were held with the students and the processes and products were observed by the researchers.

Material and Procedure

The students kneaded mixtures of certain sizes (1 cup[240ml] of water, 1 cup[120gr] of flour, ¼ cup [75gr] of salt, 3 tablespoons of cream of tartar, 1 tablespoon of vegetable oil, and a few drops of food colouring) in a bowl (Figure 2). The students were informed about what the materials were, and where and how much they would use at which stage, and the use of materials was left up to them to use in a controlled manner.

Photograph 1. Materials used in the activity

Conductive Play Dough

Brightly coloured and extremely soft play dough, which has been the main material used in handicrafts for generations, is a material that encourages children to produce things. It can stimulate their imaginations while playing and allow us to explore their creativity. It was thought that by making some changes to the materials that made up the play dough, it could be used for different purposes, and it was imagined, “Why not make more than just insects, towers or dinosaurs?” Considering that the salt that is added can transform it into conductive circuits and that it can turn into a fun activity, the way to a science-oriented activity was also opened by enlivening the participants’ imaginations. Science is not too complicated for children as long as the aim is not to teach scientific concepts, principles or explanations. Providing opportunities for children to work on the materials and seeing how they react to the materials are among the priorities of science education (NGSS, 2022).

First of all, how to make a conductive play dough was explained. It was elicited how play dough can be conductive with examples such as sea water and pool water. It was understood that after salt dissolves, it enables the transfer of electrical energy in its medium. Then, the mixing, kneading and cooking process for the conductive play dough was begun (Photograph 2).

Photograph2a. Conductive play dough cooking process

Photograph2b. Conductive play dough making process

The students cooked the play dough on a medium heat. They boiled the mixture until it thickened well, and then they left it to cool. They were given time to shape it by kneading it on a floured surface. Next, they identified the elements of an electrical circuit. They discussed the function of materials such as a LED lamp, DC motor, switch, wires, and battery in the circuit and their role in the conversion of energy (Photograph 3).

Photograph 3. Discussing the function of materials

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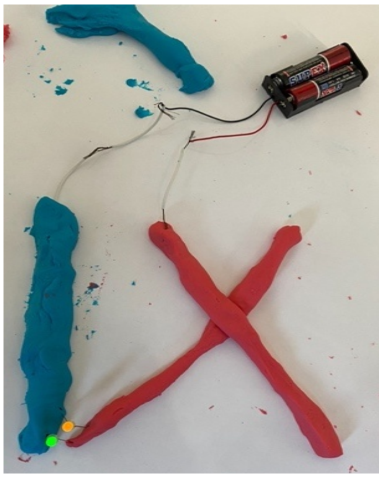
By making a connection with daily life, they tried to understand and analyse the questions, “How does the electric current from the power supply operate the circuit elements? For example, the light bulb” and “So, when we build a circuit, how can we transfer the electrical energy to another circuit element without wires?” This was when they realised that the play dough would come into play, and they began their designs (Photograph 4).

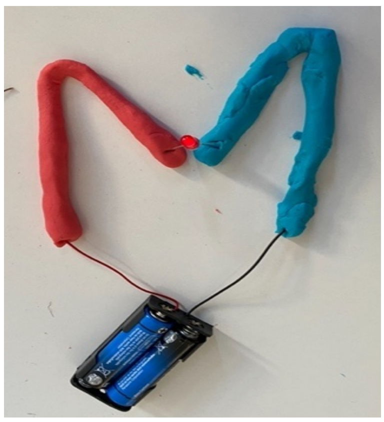
Photograph 4a. Examples of conductive play dough circuits



Photograph 4b. Examples of conductive play dough circuits

In the activity, the children designed simple electrical circuits using the dough they had mixed, kneaded, thickened and coloured. With the activity, they both had fun and constructed knowledge, and by using the disciplines of science, technology, engineering/design and mathematics together, the knowledge they learned was made more meaningful and permanent (Photograph 5).

Photograph 5a. Conductive play dough DC motor circuits



Photograph 5b. Conductive play dough LED lamp circuits

CONCLUSIONS and SUGGESTIONS

STEM activities in which students with learning disabilities actively participate can be effective in their learning. The rubrics and observation notes that the researchers received throughout the activity, and the feedback received from the students, show that the activities they designed by doing and experiencing contributed to them. A maximum score of twenty-four can be obtained from the STEM rubric used in the activity. Participant A received a total of twenty-two points, participant B received a total of twenty points, participant D received a total of twenty-four points, and participant C received a total of twenty-one points. The participants received maximum scores from the parts using scientific and mathematical knowledge. It was determined that among the rubrics, the participants used their science and mathematics knowledge the most. This situation reveals that the use of collaborative approaches, especially with small groups, as a teaching-learning tool can be effective in fostering science learning outcomes in SLDs in the literature (Akarsu, et al., 2022). Therefore, while creating learning environments and planning instruction, individuals with special needs should be enabled to exhibit and develop their knowledge and skills, by taking their individual differences into account (Zorluoğlu & Sözbilir, 2017; Villanueva et al., 2012). In this context, performing STEM activities in a student-centred way and considering students' differences can enable permanent learning, particularly in subjects such as science and mathematics.

Especially for learning objectives to be given with integrated disciplinary approaches such as STEM, 1. pre-planning 2. the teacher's having a background related to STEM, and 3. a suitable learning environment are essential. When the literature was reviewed, it was determined that while teaching with SLDs, science teachers had problems in making adaptations in the curriculum, method and activities conducted during the lesson (Caseau & Norman, 1997). Moreover, special education teachers stated that the content and hours of the courses they took in undergraduate science teaching were insufficient, that they had problems in the adaptations to be made while teaching science concepts to ISNs due to the fact that the courses were mostly theory-oriented, that there were insufficient materials for the science course, and that the physical conditions of the classroom were unfavourable (Dedeoğlu et al., 2004; Tarhan, 2019). Similarly, special education teachers stated that due to the complexity of the concepts they encountered during science teaching, they experienced inability in terms of how to present these concepts (Smith et al., 2013; Tarhan, 2019). Therefore, in implementing effective teaching methods while presenting the curriculum set for SLDs, it is necessary to increase the competencies of both special education and science teachers who teach science to these students (Lynch et al., 2007). In their studies, Apanasionok et al. (2019), Taylor et al. (2019) and Therrien et al. (2011) emphasised that systematic and inquiry-based methods are effective in enabling permanent learning, especially in SLDs. In this context, it can be said that the STEM activity carried out was effective in terms of being systematic, problem-based, design-based and inquiry-based. Moreover, teaching approaches such as collaborative, video-based learning, STEM, and graphic editors for SLDs increased both students' science achievement and their attitudes towards science, and contributed to the development of their skills in reading and analysing science concepts (Botsas, 2017; Boyle, 2011; Thornton et al., 2015). This finding is in parallel with the result of the research. The fact that the researchers had STEM backgrounds, that the physical conditions were suitable, and that a pre-planning was made also enabled the teaching to be more effective. The rubrics and observation forms made while investigating the effectiveness of the instruction are evidence of this. By means of the process rubric, it was concluded that among the STEM disciplines in which they activated their analytical thinking skills, albeit partially, during the activity, the students were effective at an adequate level in all areas except for engineering design skills, and that they carried out the implementation step at a sufficient level. The deficient engineering design skills could have been rectified by giving students more time and providing them with a more comfortable environment. However, since the main purpose of the research was to enable permanent learning, not much emphasis was placed on this part. Three weeks after the activity, the students were interviewed one by one by one of the researchers (the special educator) and were asked questions about the STEM disciplines related to the activity, and it was determined that the students had not forgotten any of the information they had learned. It is significant that some of the students described this activity as "the most enjoyable activity in our lives" and also gave their feedback as "I remember every step performed and all the materials used in the activity". The responses given were recorded. This STEM-based teaching strategy, whose aim is to enable students to learn by doing and experiencing science and engineering activities as much as possible, supports the learning objectives of the Next Generation Science Standards in the following ways:

It encourages students to participate in science activities independently by providing equal learning opportunities within peer groups.

- It helps students become familiar with scientific knowledge and understanding through the use of tactile observation and physical models.
- It enables students to continue their conversations, demonstrate their curiosity and participate actively in collaborative problem solving, and to pose new research questions for future extended scientific research.

LIMITATIONS

This study was carried out with four students with SLDs. The activities were carried out in the guidance service outside of the classroom and could have been carried out in a more equipped environment over a longer part of time. For example, a support training room or a special training room. Morever, the effects of the activities carried out on the acedemic success of the students can also be observed. Thus, the effectiveness and permanence of the activities can also be measured.

RECOMMENDATIONS

Researchers who will carry out similar studies can be recommended to prepare the designed activities in the light of the IEP plan, more appropriate for the level of the student and in parallel with the curriculum. In addition, different activities can be designed in the context of providing students with desired behaviors.

Ethical Rules: Ethics committee approval was obtained from Karamanoglu Mehmetbey University Ethics Committee with the document dated 03.11.2021 and numbered E-95728670-020-10067.

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Conflict of Interest: There is no conflict of interest between the authors and other parties during the planning, conducting, data collection, analysis and reporting of the study.

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REFERENCES

Akarsu, M., Kızılaslan, A., & Şimşek, Ö. (2022). An inclusive tactile based STEM activity for students with visual impairment: an electromagnet design, *Science Activities,* Online First, https://doi.org/10.1080/00368121.2021.2025026

Alston, R., Bell, T., & Hampton, J. (2002). Learning disability and career entry into the sciences: A critical analysis of attitudinal factors. *Journal of Career Development, 28*(4), 263–275.

Apanasionok, M. M., Hastings, R. P., Grindle, C. F., Watkins, R. C., & Paris, A. (2019). Teaching science skills and knowledge to students with developmental disabilities: A systematic review. *Journal of Research in Science Teaching, 56*(7), 847-880. https://doi.org/10.1002/tea.21531.

Balçın, M. D., & Yıldırım, M. (2021). Evaluation of the STEM Practices: The science courses of inclusive students. *Ankara University Faculty of Educational Sciences Journal of Special Education, 22*(2), 307-341. https://doi.org/10.21565/ozelegitimdergisi.660695

Basham, J. D., & Marino, M. T. (2010). Introduction to the topical issue: Shaping STEM education for all students. *Journal of Special Education Technology*, *25*(3), 1.

Batu, S., & Kırcaali-İftar, G. (2006). *Kaynaştırma [Inclusion]*. KÖK Publishing.

Becker, K. & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: *A preliminary meta-analysis. Journal of STEM Education, Volume 12.*

Bellman, S., Burgstahler, S., & Hinke, P. (2015). Academic coaching: outcomes from a pilot group of postsecondary stem students with disabilities. *Journal of Postsecondary Education and Disability, 28*(1), 103-108.

Biçer, A., (2019). *STEM yaklaşımına dayalı elektrik devre elemanları konusu öğretiminin 5. sınıf özel öğrenme güçlüğü olan öğrencilerin akademik başarılarına ve kalıcılığına etkisi[The effect of STEM approach based electrical circuit elements teaching on the academic achievement of 5th grade students with specific learning disabilities.* [Unpublished Master's Thesis], Aksaray University.

Botsas, G. (2017). Differences in strategy use in the reading comprehension of narrative and science texts among students with and without learning disabilities. Learning Disabilities: *A Contemporary Journal, 15*(1), 139-162.

Boyle, J. R. (2011). Strategic note-taking for inclusive middle school science classrooms. *Remedial and Special Education, 34*(2), 78-90. https://doi.org/10.1177/0741932511410862

Bryan, L.A., Moore, T.J., Johnson, C.C., & Roehrig, G.H. (2016). Integrated STEM education. In C.C. Johnson, E.E. Peters-Burton & T.J. Moore (Eds.), *In STEM road map a framework for integrated STEM education* (pp. 23- 37). New York: Routledge.

Bybee, R. W. (2010). What is STEM education? *Science, 329*(5995), 996.

Caseau, D., & Norman, K. (1997). Special education teachers use science-technology-society (STS) themes to teach science to students with learning disabilities. *Journal of Science Teacher Education, 8*(1), 55-68. https://doi.org/10.1023/A:1009453403131

Corlu, M. A., & Aydin, E. (2016). Evaluation of learning gains through integrated STEM projects. *International Journal of Education in Mathematics, Science and Technology, 4*(1), 20-29.

Creswell, J. W. (2012). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Thousand Oaks, CA: Sage.

Çevik, M. (2017, May). Effects of the project based STEM (science, technology, engineering and mathematics) approach on academic achievement and attitude of students with intellectual disability in vision arts course. The Ninth International Congress of Educational Research.

Çevik, M. (2018). Impacts of the project based (PBL) science, technology, engineering and mathematics (STEM) education on academic achievement and career interests of vocational high school students. *Pegem Eğitim ve Öğretim Dergisi, 8*(2), 281-306, http://dx.doi.org/10.14527/pegegog.2018.012

Çevik, M. (2020). Proje tabanlı öğrenme yaklaşımı ile STEM Eğitimi[STEM education with project-based learning approach]. Çevik, M. (Ed.) *Ders planları kurgusunda öğretme öğrenme yaklaşımlarıyla uygulamalı STEM eğitimi[Applied STEM education with teaching-learning approaches in lesson plans]*. Nobel Akademik Yayıncılık.

Çevik, M., Düzgün, M., & Öztaş, E. B. (2016). *Effects of the intelligence games approaches on academic achievement and attitude of students with mild mental retardation in mathematics course.* In 8th World Conference on Educational Sciences.

Çorlu, M. S., Capraro, R. M., & Capraro, M. M. (2014). Introducing STEM education: Implications for educating our teachers in the age of innovation. *Education and Science*, *39*(171),74-85.

Dedeoğlu, S., Durali, S. & Tanrıverdi-Kış, A. (2004). The thoughts and suggestions of the 3rd and 4th undergraduates students and graduated students of the Special Education Department about special education programs, teacher training and education faculties. *Ankara University Faculty of Educational Sciences Journal of Special Education, 5*(1), 47-55. https://doi.org/10.1501/Ozlegt_0000000074

Dugger, E. W. (2010). *Evolution of STEM in the United States. 6th Biennial International Conference on Technology Education Research*, Australia.

Dunn, C., Rabren, K. S., Taylor, S. L., & Dotson, C. K. (2012). Assisting students with high-incidence disabilities to pursue careers in science, technology, engineering, and mathematics. *Intervention in School and Clinic*, *48*(1), 47-54.

Duygu, E. (2018). Simülasyon tabanlı sorgulayıcı öğrenme ortamında fetemm eğitiminin bilimsel süreç becerileri ve fetemm farkındalıklarına etkisi [The effect of STEM education on science process skills and STEM awareness in simulation based inquiry learning environment] [Unpublished Master's Thesis], Kırıkkale University.

Ergün, A., & Balçın, M. D. (2019). The effects of problem-based STEM applications on academic success. *The Journal of Limitless Education and Research, 4*(1), 40-63.

Eriksson, L., Welander, J., & Granlund, M. (2007). Participation in everyday school activities for children with and without disabilities. *Journal of Developmental and Physical Disabilities, 19*(5), 485–502.

Gökbayrak, S., & Karışan, D. (2017). STEM etkinliklerinin fen bilgisi öğretmen adaylarının bilimsel süreç becerilerine etkisi [An investigation of the effects of STEM based activities on preservice science teacher's science process skills]. *Batı Anadolu Eğitim Bilimleri Dergisi*, 8(2), 63-84.

Gwon- Suk, K., & Sun Young, C. (2012). The effects of the creative problem solving ability and scientific attitude through the science-based STEM program in the elementary gifted students. *Journal of Korean Elementary Science Education, 31*(2), 216- 226.

Hasse, J. (2011). *How to develop a STEM career when you have a disability. Careers and communities for talented people with disabilities.* Retrieved from http://community.gettinghired. com/blogs/perfectlyable/archive/2011/03/14/how-to-developa-stem-career-when-you-have-a-disability.aspx

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.

Kaplan, S. (2019). *Dezavantajlı STEM uygulamalarına ilişkin öğrenci görüşleri.* [Student views on disadvantaged STEM practices]. [Unpublished Master's Thesis], Dicle University.

Kennedy, T., & Odell, M. (2014). Engaging students in STEM education. *Science Education International, 25*(3), 246-258.

Lamb, R., Akmal, T., & Petrie, K. (2015). Development of a cognition-priming model describing learning in a STEM classroom. *Journal of Research in Science Teaching, 52*(3), 410–437. https://doi.org/10.1002/tea.21200

Lee, A. (2011). Postsecondary science, engineering, and mathematics (STEM) enrollment comparisons for students with and without disabilities. *Career Development for Exceptional Individuals, 34*(2), 72–82.

Lesseig, K., Slavit, D., & Nelson, T. H. (2017). Jumping on the STEM bandwagon: How middle grades students and teachers can benefit from STEM experiences. *Middle School Journal*, 48(3), 15-24. https://doi.org/10.1080/00940771.2017.1297663

Ludlow, B. (2013). Growing STEM as a pathway to the future. *Teaching Exceptional Children, 45*(4), 4.

Lynch, S., Taymans, J., Watson, W. A., Ochsendorf, R. J., Pyke, C., & Szesze, M. J. (2007). Effectiveness of a highly rated science curriculum unit for students with disabilities in general education classrooms. *Exceptional Children, 73*(2), 202-223. https://doi.org/10.1177/001440290707300205

Margot, K. C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. *International Journal of STEM Education, 6(2),1-16. https://doi.org/10.1186/s40594-018-0151-2*

McClain, M. L. (2015). *The effect of STEM education on mathematics achievement of fourth-grade underrepresented minority students*. Doctoral Dissertation, Capella University, Minneapolis.

MoNE [Ministry of National Education] (1997*). 573 Sayılı özel eğitim hakkında kanun hükmünde kararname [Decree Law No. 573 on Special education].*

MoNE [Ministry of National Education] (2018). Primary education institutions (primary schools and secondary schools) science course curriculum (3rd, 4th, 5th, 6th, 7th and 8th grades). Board of Education and Discipline. Ankara.

Murphy, T. P., & Mancini- Samuelson, G. J. (2012). Graduating STEM component and confident teachers: The creation of a STEM certificate for elementary education majors. *Journal of College Science Teaching, 42*(2), 18- 23.

National Joint Committee on Learning Disabilities. (1983). *Learning disabilities: Issues on definition*. A Position Paper of the National Joint Committee on Learning Disabilities, January 30, 1981. Learning Disability Quarterly, 42-44.

National Science Foundation. (2002). *NSF's program for persons with disabilities: A decade of innovation and progress.* Retrieved from http://www.nsf.gov/pubs/2002/nsf02094/nsf02094.pdf.

Next Generation Science Standards [NGSS] (2013*). https://www.nextgenscience.org/*

Rule, A., Stefanich, G., Hadelhuhn, C., & Peiffer, B. (2009). *A working conference on students with disabilities in STEM coursework and careers.* Retrieved from ERIC database. (ED505568)

Smith, B. R., Spooner, F., Jimenez, B. A., & Browder, D. (2013). Using an early science curriculum to teach science vocabulary and concepts to students with severe developmental disabilities. *Education and Treatment of Children, 36*(1), 1-31. http://dx.doi.org/10.1353/etc.2013.0002

STEM Implementation Rubric. (2017). Retrieved from: https://www.calstate.edu/impact-of-the-csu/teacher-education/ngei/Documents/technical-supplements/3.1%20Monterey%20Bay%20STEM%20Rubric.pdf

STEM School Progress Rubric. (2019). Retrieved from: https://www.dpi.nc.gov/media/8397/download

Tarhan, R. (2019). *The problems faced by special education teachers in science education for students with intellectual disabilities and the examination of these problems in terms of various variables* (Thesis Number: 573695) [Master's Thesis, Ağrı İbrahim Çeçen University].

Taylor, J. C., Rizzo, K. L., Hwang, J., & Hill, D. (2019). A review of research on science instruction for students with autism spectrum disorder. *School Science and Mathematics, 120*(2),116-125. https://doi.org/10.1111/ssm.12388

Therrien, W. J., Taylor, J. C., Hosp, J. L., Kaldenberg, E. R., & Gorsh, J. (2011). Science instruction for students with learning disabilities: *A meta.analysis. Learning Disabilities Research & Practice, 26*(4), 188-203. https://doi.org/10.1111/j.1540-5826.2011.00340.x

Thornton, A., McKissick, B. R., Spooner, F., Lo, Y. Y., & Anderson, A. L. (2015). Effects of collaborative preteaching on science performance of high school students with specific learning disabilities. *Education and Treatment of Children, 38*(3), 277-304.

Villanueva, M. G., Taylor, J., Therrien, W., & Hand, B. (2012). Science education for students with special needs. *Studies in Science Education, 48*(2), 187-215. https://doi.org/10.1080/14703297.2012.737117

Wosu, S. N. (2013, June). Impact of academic performance improvement (API) skills on math and science achievement gains. *In 2013 ASEE Annual Conference & Exposition* (pp. 23-683).

Yuen, T. T., Mason, L. L., & Gomez, A. (2014). Collaborative robotics projects for adolescents with autism spectrum disorders. *Journal of Special Education Technology, 29*(1), 51–62.

Zorluoğlu, S., & Sözbilir, M. (2017). Görme yetersizliği olan öğrencilerin öğrenmelerini destekleyici ihtiyaçlar [The needs that support the learning of visually impaired students]. *Trakya Üniversitesi Eğitim Fakültesi Dergisi,* 7(2), 659-682. https://doi.org/10.24315/trkefd.279369

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Appendix 1
STEM EDUCATION PROCESS RUBRIC

Evaluation criteria	4	3	2	1
Analytical Thinking Skills	He/she performed the activity in accordance with scientific processes.	He/she performed the activity partially in accordance with scientific processes.	He/she performed a very small part of the activity in accordance with scientific processes.	He/she did not perform the activity in accordance with scientific processes.
Using Scientific Knowledge	He/she used his/her scientific knowledge completely in the process.	He/she partially used his/her scientific knowledge in the process.	He/she used very little scientific knowledge in the process.	He/she did not use his/her scientific knowledge at all in the process.
Technology Usage Skills	He/she used technological tools adequately.	He/she partially used technological tools.	He/she made very little use of technological tools.	He/she did not use technological tools.
Engineering /Design Skills	His/her design skills were adequate for the activity.	His/her design skills were partially adequate for the activity.	His/her design skills were barely adequate for the activity.	His/her design skills were inadequate for the activity.
Using Mathematical Knowledge	He/she used his/her mathematical knowledge completely in the process.	He/she partially used his/her mathematical knowledge in the process.	He/she used very little mathematical knowledge in the process.	He/she did not use his/her mathematical knowledge at all in the process.
Application	All applications were made in a creative way.	All applications were made in accordance with the procedures.	All applications were partially made.	Problems were experienced in all applications.

Appendix 2
OBSERVATION FORM

	Questions	**Yes**	**No**
1.	She/he actively participated in group work.		
2.	She/he carried out the tasks.		
3.	She/he didn't shy away from taking responsibility.		
4.	She/he worked in collaboration.		
5.	She/he wasn't distracted throughout the activity.		
6.	She/he was in touch throughout the activity.		
7.	She/he did not exhibit any negative behaviour during the event.		
8.	At the end of the activity, she/he turned the design into a product.		

Appendix 3
STEM INTERVIEW FORM

Student Code: A/B/C/D
1. Do you think that the STEM activity we carried out contributed to your lessons?
If your answer is Yes, which subject do you think it contributed to?
2. Which STEM field did you use most in the activities we carried out?
Science, Mathematics, Technology, Engineering or Art
3. How did you feel during the activity??
Excitement, happiness, worry, sadness, or surpris