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The Effectiveness of the Science Experimental Guidebook on the Conceptual Understanding of Students with Learning Disabilities

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ABSTRACT This study aimed to develop a science experiments guidebook (based on discussion method and enriched worksheet) for fourth grade mainstreamed students with learning disabilities and to investigate its effect on their conceptual understanding of the "Matter and its Nature", "Living Things and Life", "Physical Events" and "Earth and The Universe" learning domains. Furthermore, mixtures, sieving, filtration, magnetism (Matter and its Nature), recycling (Living Things and Life), simple electrical circuit (Physical Events), and fossil (Earth and The Universe) concepts/issues were determined. Since the aim is to investigate the conceptual understanding of five 4th grade students with learning disabilities, the case study method was used. Conceptual understanding tests, drawing tests, and semi-structured interviews were used as data collection tools. The science experiments guidebook was presented to the students in worksheet format. Besides, worksheets were enriched with avatar images, mobile applications (QR codes), hands-on experiments, and active learning techniques (brainstorming, buzz 22, aquarium, and snowball). As a result of the research, it can be said that the science experiments guidebook had a positive effect on the conceptual understanding of students with learning disabilities.

Keywords Conceptual understanding, Learning disabilities, Science education, Science experiments guidebook

1. INTRODUCTION

Learning disabilities are among the most common problems experienced by school-age children (Lerner, 2000). The intelligence levels of the students with learning disabilities are normal or abnormal. Furthermore, their inadequacy in the field of literacy negatively affects their success and performance. When we investigated in depth the related literature, we found that researchers focused students' reading (Baydık, 2002; Bingöl, 2003; Chard, Vaughn, & Tyler 2002; Fidan & Akyol, 2011; Gilbert, Williams, & Mclaughlin 1996; Görgün & Melekoğlu 2019; Özmen, 2005; Sezgin & Akyol 2015) and writing skills (Akçin, 2009; Hallenbeck, 2002; İlker & Melekoğlu 2017; Kaya, 2016; Maki, Vauras, & Vainio 2002; Saddler, Behforooz, & Asaro, 2008; Saddler, 2006; Temur, Şahin, & Özdemir, 2019). The students with learning disabilities experience reading and writing problems and other areas of disciplines such as math, reading comprehension, social skills, and generalization of the concepts (Therrien, Taylor, Hosp, Kaldenberg, & Gorsh, 2011). Thus, it can be said that the problems they experience in these areas are the main factors that affect academic success in other disciplines. Especially problems in literacy lead to academic failures in the acquisition of essential academic skills in the first years of school life such as science and the other courses (Er-Nas, Şenel-Çoruhlu, Çalık, Ergül, & Gülay 2019).

Significantly, the science course is one of the most valuable courses that can be given to students with special needs (Brigham, Scruggs, & Mastropieri, 2011). Science covers many topics such as understanding nature and becoming aware of various environmental and energy efficiency problems. Karaer & Melekoğlu (2020) carried out a literature review on 20 studies published between 2008-2017, on the intervention studies to science education to the students with learning disabilities. The review revealed that studies conducted in foreign countries and there is no intervention studies in Turkey (Aydeniz, Cihak, Graham, & Retinger, 2012; Boyle, 2011; Bulgren, Ellis, & Marquis, 2014; Gaddy, Bakken, & Fulk, 2008; Kim & Linan Thompson, 2013; Lam, Doverspike, Zhao, Zhe, & Menzemer, 2008; Scruggs & Mastropieri, 2007; Therrien,

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Taylor, Hosp, Kaldenberg, & Gorsh, 2011). In Turkey, it is seen that intervention studies aimed at teaching science to the students with learning disabilities have just begun to be carried out (Emir, 2019; Nas, Çoruhlu, Çalık, Ergül, & Gülay, 2019; Yilmaz, 2018). Nas, Çoruhlu, Çalık, Ergül, & Gülay, 2019 have determined that the science experiments guidebook for 5, 6, 7, and 8 grades students with learning disabilities had a positive effect on students' conceptual understanding, and students were found to be more successful in expressing their thoughts with drawings. In the research they carried out on 5-6-7 and 8th graders, Yılmaz (2018) have identified science experiments guidebook had positive effects on conceptual understanding of the students with learning disabilities. The samples involved in these studies focus mostly on secondary schools (Emir, 2019; Nas, Çoruhlu, Çalık, Ergül, & Gülay, 2019; Yılmaz, 2018). Therefore, the related literature points to a need for studies at primary level, since no studies have been carried out at elementary schools.

In this study, science experiments guidebook was associated with; mixtures, sieving, filtration, magnetism (Matter and its Nature), recycling (Living Things and Life), simple electrical circuit (Physical Events) and fossil (Earth and The Universe) concepts/issues. Aspects that distinguish the science experiment guide from other guides can be listed as including hands on experiments, QR codes and active teaching techniques. Moreover, QR codes allow students to reinforce individual experiments by repeating them, while active teaching techniques ensure students' active participation in the process. However, examining the existing literature shows that students have alternative concepts on these concepts. Sökmen & Bayram (2000) have identified the alternative concepts of 5th, 8th and 9th graders on "pure substance" and "mixtures". In this research, it has been concluded that students had misconceptions such as "air is pure matter" and "water is a mixture". Besides, Uyanık & Dindar (2016) have determined that students find it challenging to learn the "Let's get to know matter" unit and have alternative concepts at fourth grade. Moreover, Kör (2006) investigated the misconceptions of 5th-grade students in Turkey had about electricity. The research also revealed that the students do not have sufficient knowledge about simple electrical circuits and misconceptions. Similarly, Keleş & Keleş (2018) researched to understand 3rd and 4th students' perceptions and found that they do not have sufficient knowledge about recycling. Furthermore, in research they carried out on 4th graders, Çelik & Tekbıyık (2016) have identified "fossil" as the concept on which students' understanding levels are the lowest. As a result of the research, they have concluded that students do not know the importance of fossils for today's world. Therefore, the inability to learn these concepts negatively affects the students' learning in later years. It is crucial for students with learning disabilities to practice that will enable them to understand science concepts and students with normal development, both in the development of their academic success and life skills (Brigham, Scruggs, & Mastropieri, 2011). Thus, it is stated that students with learning disabilities experience difficulties in middle and high school years, especially in primary school, if their learning needs for science concepts are not addressed correctly (Aydeniz, Cihak, Graham, & Retinger, 2012). When the relevant literature was examined, it was stated that research-based activities significantly increased the understanding and learning of science concepts by the students with learning disabilities (Mastropieri & Scruggs, 1992; Scruggs, Mastropieri, Bakken, & Brigham 1993). In the intervention process, it was aimed for the students to do the experiments themselves. Using techniques such as discussion and brainstorming allows students to increase their social and academic performance (Dalton, Morocco, Tivnan, & Rawson–Mead, 1997). Furthermore, it is believed that this research will be a pioneer in the development of awareness on the education of students with learning disabilities by ensuring enriched worksheets. It is believed that the science experiment guidebook will contribute to the conceptual understanding of students and indirectly contribute to the development of their social skills by working in groups and gaining the ability to generalize concepts. There have been numerous studies that have found the positive effects of intervention process on normal students' understanding of concepts such as; fossils (e.g. Çoruhlu, & Nas, (2018), recycling (e.g. Şenel Çoruhlu & Er Nas, 2018), electric (e.g. Çoruhlu, Çalık, & Çepni 2012). The literature, however, lacks intervention studies supported by enriched learning environments at elementary school students with learning disabilities, therefore, underlining the need for such studies.

This study aimed to develop a science experiments guidebook (based on discussion method and enriched worksheet) for fourth grade mainstreamed students with learning disabilities and to investigate its effect on their conceptual understanding of the "Matter and its Nature", "Living Things and Life", "Physical Events" and "Earth and The Universe" learning domains.

2. METHOD

The case study method was used in the study. In as much as case studies are one of the unique ways to observe any natural phenomenon existing in a dataset (Yin, 1984). Many researchers preferred this method (Thomas, 2011; Hyett, Kenny & Dickson-Swift, 2014). Furthermore, case studies can be classified as single or multiple. Multiple case studies are needed when focusing on more than one single case. Moreover, multiple cases allow research questions and theoretical evolution to be explored in a broader perspective (Eisenhardt & Graebner, 2007). In multiple case studies, researchers examine multiple cases to understand the similarities-differences between cases and

Table 1 Interview, conceptual understanding, and drawing test's questions

Learning Domains	Conceptual understanding test	Interview*	Drawing test
Matter and its nature	1. By what methods can we separate mixtures? Please Explain. 2. Ayşe's mother accidentally poured rice into the flour while making a cake. What kind of way should Ayşe's mother follow to separate the rice from the flour? Please explain.	1. In what ways do you think we can separate the mixtures? Explain by giving an example."	1. Please draw a mixture and write how you can separate it.
Living things and Life	1. What do you think about the recycling concept? Please explain. 2. Which materials do you think can be recycled? Explain by giving an example.	1. How can you define the concept of recycling? Please explain. 2. Which materials do you think can be recycled? Can you explain why you think so?"	Please write a recycling object and draw it.
Earth and Universe	1. What do you think about a fossil? Please explain. 2. How are fossils formed? Please explain.	1. How can you define the concept of fossil? Please explain. 2. How are fossils forms? Please explain it with an example.	Please draw a fossil.
Physical Events	1.What circuit elements are included in a simple electrical circuit? Please explain. 2. What should the circuit be too light the bulb? Please explain.	2. What circuit elements are included in a simple electrical circuit? Please explain. 3. Without a battery, would a bulb in a simple electrical circuit light? Why is that? Please explain.	Please draw a simple electric circuit.

*Researchers asked some other questions in the semi-structured interview process.

contribute to the literature by discovering the differences and similarities. Thus, the effects of science experiments guidebooks on the students' conceptual understanding were investigated in depth. That's why the development of each student was examined individually. Since each student in the study group was evaluated as a whole and considered independent cases, the case study method's holistic multi-case pattern was preferred (Cohen & Manion, 1994).

2.1. Subject

This multi-case study investigates the effect of the science experiments guidebook (based on discussion method and enriched worksheet) on 5 mainstreamed students' conceptual understanding. Ethical issues have been emphasized. The researchers used pseudonym names for the students, such as Ahmet, Can, Zeynep, Emre, and Serkan. Students had been attending inclusive support education. For example, two of them (Can and Zeynep) had been taking it since 2016, Emre and Serkan had received it since 2015, and Ahmet had been attending it since 2017. All of the students started inclusive support education within the year of their diagnosis. While only one student (Emre) attended the science courses through their inclusive support education.

2.2. Data Collection

The researchers used conceptual understanding tests, drawing tests, and interview questions (See Table 1). The questions in all three data collection tools overlap with each other. For example; In the "Earth and The Universe" learning domain, "What do you think about a fossil? Please explain." and "How are fossils formed? Please explain." were asked in the conceptual understanding test, "How can you define the concept of fossil? Please explain." and "How the fossil forms? Please explain it with an example." were asked in the interview, while "Please draw a fossil" was asked in the drawing test. The conceptual understanding and drawing test were administered before the intervention as a pretest to the students. The same tests were employed as a post-test immediately after the enriched worksheet's intervention to the students. Semi-structured interview questions were administered before the intervention as a pre-interview to the students. Alike, the same questions were employed as a post-interview immediately after the intervention. To ensure content and face validities, a group of experts (two science, one special, one chemistry

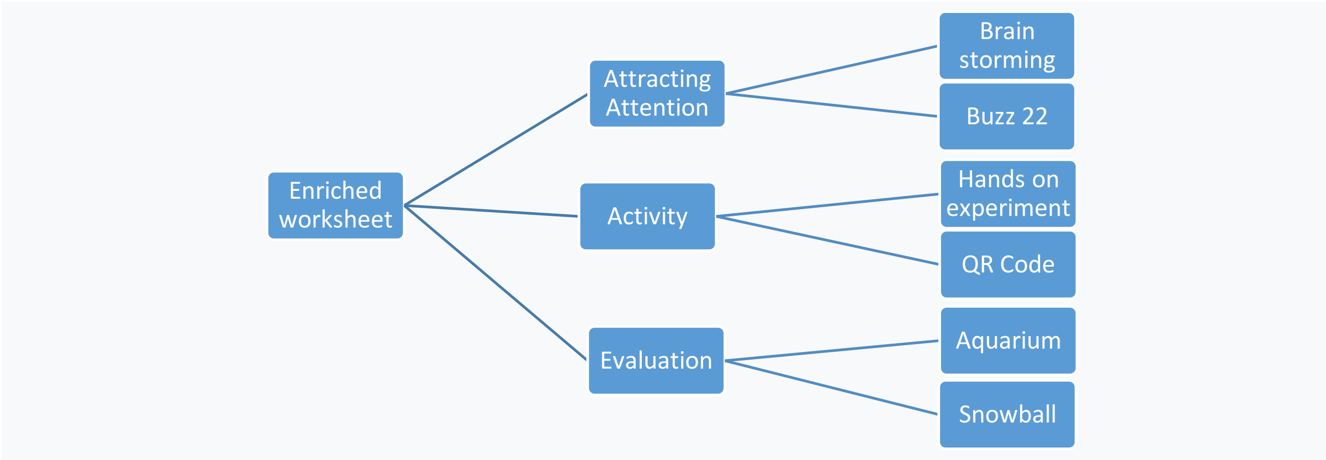


Figure 1 Techniques used in the enriched worksheet's phases

educators-one science, and a primary school teacher) examined the tests. Conceptual understanding, drawing, and interview questions were submitted to experts in science and special education for internal validity. The experts verified the validity of the test questions in terms of the objectives of the research. Interview, conceptual understanding, and drawing test questions have been presented in Table 1.

2.3. Data Analysis

"Sound understanding, partial understanding, alternative understanding and no understanding" suggested by Marek (1986) used in the data analysis process. Furthermore, evaluation schemes are charted in Table 2 and prepared for every learning domain. Obtained data were shown with graphics. Each graphic showed the students' individual conceptual understanding before and after the intervention. Samples from student's responses and drawings have been presented for each understanding level. The researchers determined critical concepts for every learning domain (See Table 3)

Table 2 Evaluation Scheme for the simple electric circuit

Categories	Code	Key Ideas of Responses
Complete understanding	CU	All of the above: "Battery, battery holder, wire, bulb, lamp holder, switch."
Partial understanding	PU	Includes at least one; "Lampholder, switch, wire, battery, battery holder."
Alternative concept	AU	Typical responses include; "Switch must be on."
No response or irrelevant responses	NU	Blank, repeated question or irrelevant responses; "I don't know."

Two of the researchers analyzed the data separately and unaware of each other. After that, the researchers came together and looked at inter- rater consistency. This value was found to be 0.85, which was higher than acceptable value (0.70) (Tavşancıl & Aslan, 2001). Disagreement between researchers was solved through negotiation.

2.4. Science Experiment Guidebook

Science experiments guidebook consisted of four enriched worksheets. Thus, students' enriched worksheet comprises the "attracting attention, activity and evaluation" phases (See figure 1)

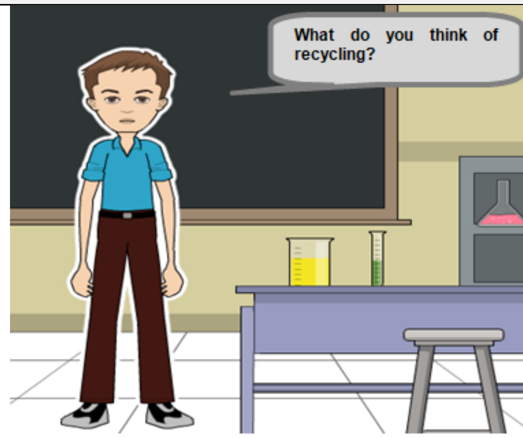
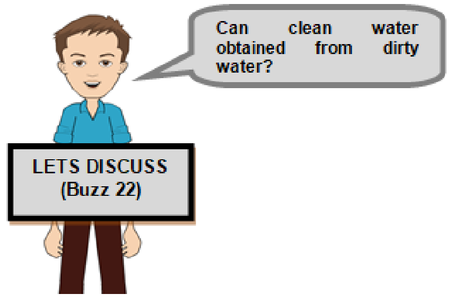
The 'attracting attention' phase covers brainstorming and buzz 22, the 'activity' phase includes hands-on experiments and QR-coded videos, whilst the 'evaluation' phase incorporates snowball and aquarium techniques. The intervention process consisted of 24 classes of 40 minutes (3 days a week, 2 hours every day, and finished in a 1 month). An enriched worksheet which name is "Let's Recycle Dirty Water," using in the "Living Things and Life" learning domain, was presented in Table 4-6

"Buzz 22" and "brain storming" techniques were used in the "attracting attention" phase. This phase started with "brainstorming" and ended with the "buzz 22" technique.

Table 3 Experimental names, experimental links, and fundamental concepts of learning areas

Learning Domain	Worksheet	Key concepts/issues	Links
Matter and its nature	Separating the mixes	mixtures, sieving, filtration, magnetism	https://youtu.be/t48in8pgUyw
Living things and life	Let's recycle dirty water	recycling	https://youtu.be/eybkDufXJdg
Physical Events	How to install a simple electrical circuit	circuit elements, simple electrical circuit	https://youtu.be/rj2AEfZ1rHg
Earth and the universe	How the fossil forms	Fossil	https://youtu.be/14m8gFqv3Y0

Table 4 "Attracting attention" phase of the worksheet

P.	T.	Worksheet
Attracting attention	Brain Storming	 Let your teacher write your ideas on the board. Vote for your ideas. Let's decide together what the concept of recycling can be and write it down below. …………………………………………………………………………
	Buzz 22	

P. Phase, T. Techniques

Firstly "What do you think of recycling?" asked the students. A discussion was started related to the "Can clean water obtained from dirty water?" and students discussed with groups.

The "Activity" phase covers hands-on experiments and QR codes. Then, the students completed their hands-on experiments on the worksheet, and students used their observations to fill in the gaps given in the worksheet. They answered t he questions on the worksheet. After completing the "Activity" phase, the evaluation section is passed (see Table 6).

Finally, "aquarium" and "snowball" techniques were used in the "evaluation" phase. "What substances can be recycled in nature?" was asked to the students to determine the students' associating the recycling concepts with daily life. Then, students were asked to discuss the answer to this question following the snowball technique.

3. RESULT AND DISCUSSION

The findings reached through the interviews, drawing test, and conceptual understanding test presented with tables (See Table 7, 8, 9, 10, and 11)

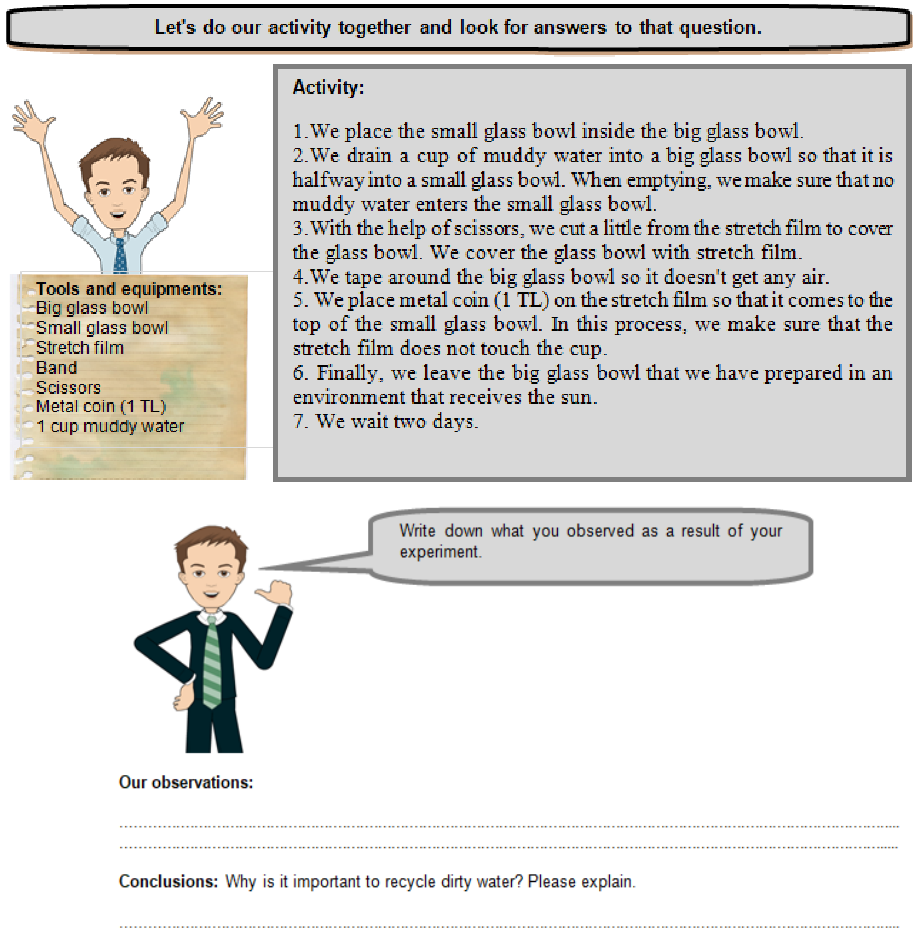
Table 7 shows students' pre-post test understanding levels related to the concepts. Examples from the students' answers for each concept were presented in Table 8, 9, 10, and 11.

As seen in Table 8, Zeynep, Ahmet, and Serkan's responses to the pre-conceptual understanding test, Serkan, Zeynep, and Can's explanations for pre-interview and pre-drawings fell into the "no understanding" category. When Table 8 is examined, it is observed that there has been an increase in the number of students answering in the "sound understanding" category after the intervention of the science experiments guidebook

When Table 9 is examined, it was observed that Emre and Serkan's explanations to the first question, Ahmet, Can, Emre and Zeynep's responses to the second question in the pre-conceptual understanding test, Ahmet, Emre, Serkan and Zeynep's pre-drawings were categorized under the "no understanding" category, whilst all of the students' explanations for pre-interview fell into the "partial understanding" category. All of the students' explanations to the post-conceptual understanding test were categorized under the "sound understanding" category. Emre and Serkan's post-interview and all of the students' post drawings were labeled under the "partial understanding" category.

As seen in Table 10, Ahmet and Can's explanations to the second question in the pre-conceptual understanding

Table 5 "Activity" phase of the worksheet

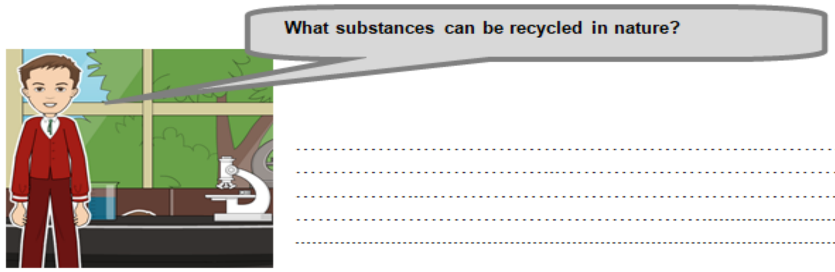
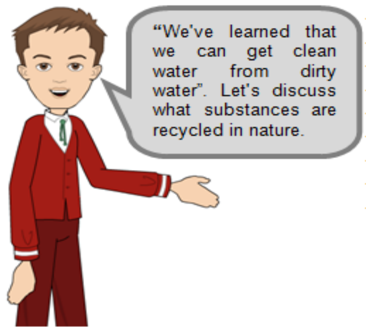
<table>
<tr><th>P.</th><th>T.</th><th>Worksheet</th></tr>
<tr><td>Activity</td><td>Hands on experiment</td><td>
</td></tr>
<tr><td></td><td>QR Code</td><td>
</td></tr>
</table>

test and Serkan's pre-drawing and responses to the second question in the pre-interview were categorized under the "alternative understanding" category. The students' responses for the post-interview, post-conceptual understanding, and post-drawing test fell into the "sound understanding" category.

When the answers students gave to the data collection tools are examined (see Table 11), it is observed that Zeynep's explanations to the first question for the pre-conceptual understanding test and Serkan's responses to the second question in the pre-interview were categorized under the "alternative understanding" category. All of the students' responses to the data collection tools in the post-tests were classified under the "partial and sound understanding" category (Excep t for Serkan).

When the students' conceptual understanding, drawing test, and interview data (see Table 7) were examined, whole students were observed to have given answers in the complete understanding category in the post-tests and interviews. However, some students had misconceptions in the pretests about simple electric circuits. As seen from Table 10, Ahmet, Serkan, and Can have alternative concepts about simple electric circuits in the pretests. The alternative concepts expressed among students were the statements of "no bulb lights on if the switch is off" and "bulb lights on if the switch is on." Further, electricity is

Table 6 "Evaluation" phase of the worksheet

P.	T.	Worksheet
Evaluation	Aquarium and snowball	**Question:**  **Let's discuss the above question and write down the points where we are agree to the below.** 

one of the complex topics to understand, where students have misconceptions.

Thus, electricity is an abstract subject, not easy to embody (Atılğanlar, 2014). Küçüközer & Kocakülah (2007) have identified the misconception that "no bulb lights on if the switch is off" as a result of their study. Besides, Bahçeci & Kaya (2010) stated that everyday language effectively misconceptions about electric circuits. When the origin of misconception was investigated, it was observed that "turn on the light" and "turn off the light" statements in the everyday language can lead to these misconceptions. However, all of the students' responses for post-interview, post-conceptual understanding, and post-drawing fell into the "sound understanding" category. This may stem from the science experiment guidebook (especially the use of hands-on activities embedded within the worksheets). As a matter of fact, the students gained an opportunity to do hands-on activities related to the simple electric circuit. That is, they installed a simple electric circuit and observed the switch position.

When the answers students gave to the first question, which was asked related to the circuit elements in the interview questions, were examined, it has been concluded that students have insufficient knowledge about electric circuits. Brigham, Scruggs, & Mastropieri, (2011) emphasized that learning by doing is more effective than reading complex science concepts for students with learning difficulties. In a similar vein, there have been numerous researches focused on hands-on experiments that facilitate remembering information, increases academic achievement, and makes the subject more understandable in science (Freedman, 1997; Kurnaz & Kutlu, 2016; Özdemir; 2004; Çoruhlu, Çalık & Çepni, 2012; Zhai, Jocz & Tan, 2014). Hands-on experiments contributed to the conceptual development of the students.

As seen from Table 8, their responses to the question "How are fossils forms? Please explain it with an example." were classified under partial or sound understanding for the post-test. It has been observed that students had difficulty making definitions of concepts; on the other hand, they could answer the questions in the post interviews more efficiently. In the pre-post interviews conducted with students code Serkan, this situation is observed in detail. He couldn't identify what the fossil was in the pre-post conceptual understanding test. Contrary, Serkan could identify the fossil concept in the post-interview. Similarly, the same findings can be seen in the "Matter and its nature" learning domain (see Table 9).

Language deficiency experienced in reading and writing is one reason that negatively affects students' science success with learning difficulties (Shepard & Adjogah 1994; Steele, 2004). It can be said that the small group discussions

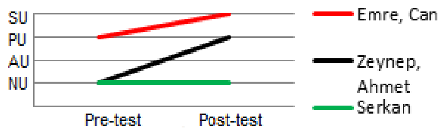
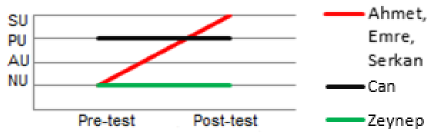
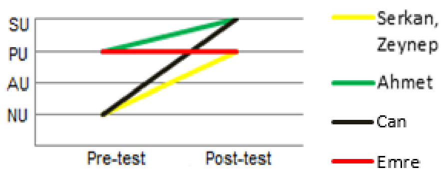
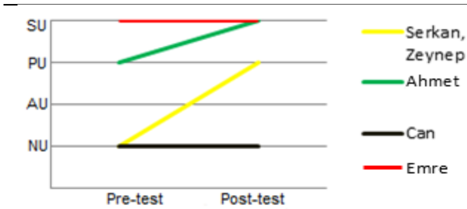
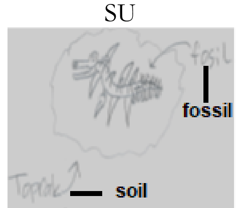
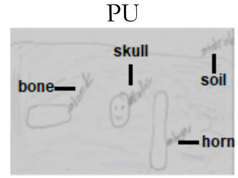
Table 7 Understanding levels of the students with learning disabilities about the concepts

Concepts	Tests		Q	Zeynep	Ahmet	Emre	Serkan	Can
Fossil	Pre-test	CUT	1	NU	NU	PU	NU	PU
			2	NU	NU	NU	NU	PU
		IQ	1	NU	PU	PU	NU	NU
			2	NU	PU	PU	NU	NU
		DrT	1	NU	PU	SU	NU	NU
	Post-test	CUT	1	PU	PU	SU	NU	SU
			2	NU	SU	SU	SU	PU
		IQ	1	PU	SU	PU	PU	SU
			2	SU	SU	SU	SU	PU
		DrT	1	PU	SU	SU	PU	NU
Mixtures	Pre-test	CUT	1	PU	PU	NU	NU	PU
			2	NU	NU	NU	SU	NU
		IQ	1	PU	PU	PU	PU	PU
		DrT	1	NU	NU	NU	NU	PU
	Post-test	CUT	1	SU	SU	SU	SU	SU
			2	SU	SU	SU	SU	SU
		IQ	1	SU	SU	PU	PU	SU
		DrT	1	PU	PU	PU	PU	PU
Simple electric circuit	Pre-test	CUT	1	NU	SU	PU	SU	NU
			2	NU	AU	PU	NU	AU
		IQ	1	NU	PU	PU	PU	NU
			2	SU	SU	SU	AU	SU
		CUT	1	NU	PU	SU	AU	NU
	Post-test	CUT	1	SU	SU	SU	SU	SU
			2	SU	SU	SU	SU	SU
		IQ	1	SU	SU	SU	SU	SU
			2	SU	SU	SU	SU	SU
		CUT	1	SU	SU	SU	SU	SU
Recycling	Pre-test	CUT	1	AU	NU	NU	PU	PU
			2	PU	PU	PU	PU	PU
		IQ	1	PU	PU	PU	PU	SU
			2	PU	PU	PU	AU	PU
		CUT	1	PU	PU	NU	PU	PU
	Post-test	CUT	1	PU	SU	SU	SU	SU
			2	SU	SU	SU	SU	SU
		IQ	1	PU	SU	SU	PU	SU
			2	SU	SU	PU	AU	SU
		CUT	1	PU	PU	SU	PU	PU

Note: C: Concepts, CUT: Conceptual understanding test, DrT: Drawing Test, IQ: Interview; SU: Sound Understanding; PU: Partial Understanding; AU: Alternative Understanding; NU: No Understanding, Q: Question number

increase mainstreamed students' (with learning disabilities) success in science (Cook & Friend, 1995). Discussion techniques (e.g. snowball, aquarium) used in the guidebook's intervention process contributed to students' conceptual understanding of the fossil concept. All of the student's explanations to the post-conceptual understanding test were categorized under the "sound understanding" category in the "matter and its nature" learning domain. In a similar vein, teachings designed based on context-based theory related to the "pure substance and mixture" effectively impact fourth-grade students' conceptual understanding (Derman & Badeli, 2017). Context-based interventions associated with everyday life facilitate students' understanding of the concepts. For example, when table 9 is examined, Zeynep gave examples of the methods used in separating mixtures from daily life. With the science experiment guidebook, students experienced hands-on experiments associated with daily life. For example, in the "Separating the mixes" worksheet, a mixture was given to the students, and then they separated the components of the mixture by using magnet and sieving methods. Indeed, giving examples from daily life in worksheets caused students to associate science

Table 8 Categorization of the mainstreamed students' responses to the concept of fossil

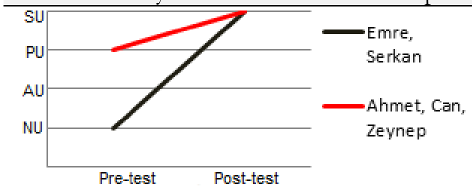
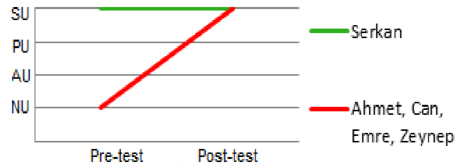
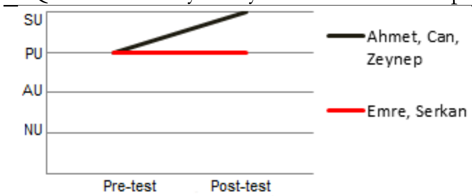
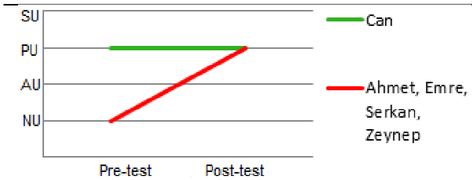
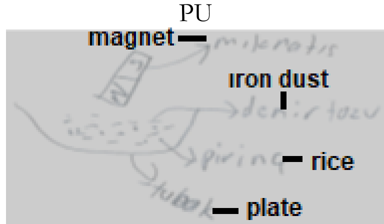
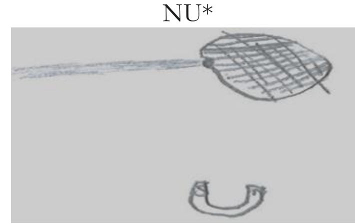
Graph	Category	Response
CUT 1: "What do you think about a fossil? Please explain."		
	SU	"The remaining dead creature within millions is called a fossil." (Can PostT)
	PU	"The skull under the ground." (Can PreT)
	NU*	"A food." (Zeynep PreT)
CUT 2: "How are fossils forms? Please explain."		
	SU	"Living things are buried under the ground when they die, it must take a long time." (Ahmet PostT)
	PU	"Dead squirrel is formed if it is too long under the ground." (Can PreT)
	NU*	"Fossils that came out when dinosaurs died." (Ahmet PreT)
IQ 1: "How can you define the concept of fossil? Please explain."		
	SU	"Fossils are formed when dead creatures remain under the ground for thousands of years. Like dinosaur…" (Can PostI)
	PU	"It is something in the soil made up of the bone of a living thing. The bones of dinosaurs remain under the ground for years and then they become fossils." (Zeynep PostI)
	NU*	(Serkan PreI): "I've never heard of." Resr: "Doesn't you think of anything?" (Serkan PreI): "Beans are coming, isn't it the same thing?" Resr: "Do you think it's the same?" (Serkan PreI): "Yes."
IQ 2: "How are fossils forms? Please explain it with an example."		
	SU	When bones remain in the ground, they form under the ground after a long time. For example a fish fossil… The fish dies, its bones remain under the ground for years, and then scientists find it. (Zeynep PostI)
	PU	(Ahmet PreI): "When the dinosaurs die, they remain under the ground and when they do, fossils form." Resr: "Can you give an example?" (Ahmet PreI): For example, the dinosaur foot.
	NU*	(Serkan PreI): "I will tell you how the beans grow." Resr: "Are fossil and beans the same thing?" (Serkan PreI): "Yes, they occur in the soil." Resr: "Well, you said that it occurs in the soil. Can you give an example?" (Serkan PreI): "I don't know."
DrT: "Please draw a fossil."		
	SU	 Emre PostD
	PU	 Zeynep PostD
	NU*	 Zeynep PreD

CUT: Conceptual understanding test, DrT: Drawing Test, IQ: Interview Question; I: PreT: Pretest; PostT: Post-test; PreInt: Pre-interview; PostInt: Post-interview; PreD: Pre-drawing; PostD: Post-drawing *Only these categories appeared at the drawing test; SU: Sound Understanding; PU: Partial Understanding; AU: Alternative Understanding; NU: No Understanding, Resr: Researcher

concepts with daily life and understand the relationship between life and science.

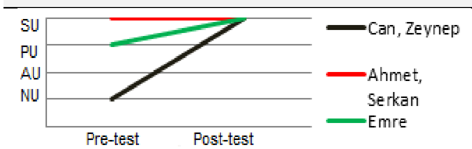
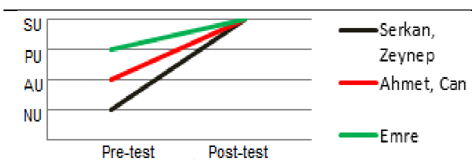
As observed in Table 11, Zeynep responded the question, "What do you think about the recycling concept? Please explain." and Serkan responded the question "Which materials do you think can be recycled? Can you explain why you think so?" at the "alternative understanding" categories. The post-test showed that Zeynep's misconceptions were eliminated, however, Serkan has the same misconception in the post-test. All alternative conceptions of "recycling" have not fully diminished. Phrased differently, some alternative conceptions, such as "everything can be recycled", are still persistent in changing with scientific ones. The student may have generalized the knowledge that many substances will be recycled to all substances by over-generalization. The student's responses to the data collection tools in the post-tests were categorized under the "partial and sound understanding" category (Except for Serkan). All students responded to the question, "Which materials do you think can be recycled? Explain by giving an example" at the "sound understanding" categories. It is believed that this

Table 9. Categorization of the mainstreamed students' responses to the concept of mixtures

CUT 1: "By what methods can we separate mixtures?" Please explain."		
	SU	"Magnet, sieving, filtration methods……" (Can PostT)
	PU	"Filtration methods, magnetization, sieving methods …" (Ahmet PreT)
	NU*	"I don't know." (Serkan PreT)
CUT 2: "Ayşe's mother accidentally poured rice into the flour while make a cake. What kind of way should Ayşe's mother follow to separate the rice from the flour? Please explain."		
	SU	"We use sieving method. We pour rice and flour into the sieve. Rice stays in the sieve and flour falls down." (Emre PostT)
	NU*	"I don't know." (Emre PreT)
IQ: "In what ways do you think we can separate the mixtures? Explain by giving an example."		
	SU	(Zeynep PostI): "Magnet, sieving, and filtration…" Resr: "Can you give an example of separation with a magnet?" (Zeynep PostI): "We put iron fillings on the magnet and the magnet pulls them…" Resr: "Well then can you give me an example of sieving? (Zeynep PostI): Flour and lentil. Flour falls down and lentil stays above." Resr: "Ok, can you give me an example of filtration? Are water and sand appropriate?" (Zeynep PostI): "Sand stays and waterfalls down."
	PU *	(Can PreI): "We separate with magnet" Resr: "How can we separate with a magnet?" (Can PreI): "I don't know. I guess magnet pulls these black things." Resr: "What else?" (Can PreI): "I don't know."
DrT: "Please draw a mixture and write how can you separate it. "		
	PU  Can PreD	NU*  Serkan PreD

CUT: Conceptual understanding test, DrT: Drawing Test, IQ: Interview Question; I: PreT: Pretest; PostT: Post-test; PreInt: Pre-interview; PostInt: Post-interview; PreD: Pre-drawing; PostD: Post-drawing *Only these categories appeared at the drawing test; SU: Sound Understanding; PU: Partial Understanding; AU: Alternative Understanding; NU: No Understanding, Resr: Researher

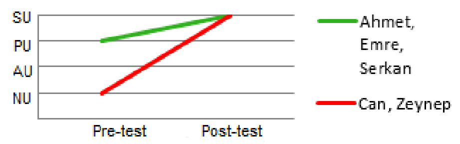
Table 10. Categorization of the mainstreamed students' responses to the concept of simple electric circuit

CUT 1: "What circuit elements are included in a simple electrical circuit? Please explain."		
	SU	"Battery, battery holder, wire, bulb, lampholder, switch…" Ahmet PostT
	PU	"Lampholder, switch, wire, Battary, battery holder, …" Emre PreT
	NU *	"I don't know." Can PostT
CUT 2: "What should the circuit be in order to light the bulb? Please explain."		
	SU	"Off, because electricity passes into the bulb." Ahmet PostT
	PU	"We have to push the switch." Emre PreT
	AU	"Switch must be on." CanPreT
	NU	"If you leave the light bulb on the stove, it will light up." Zeynep PreT

situation may stem from videos embedded in the QR code in the guidebook. The use of QR code applications, one of the critical software of technology, together with written documents, has been seen to increase students' interest and

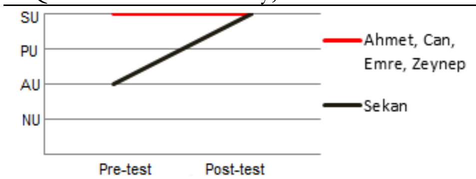
Table 10. Categorization of the mainstreamed students' responses to the concept of simple electric circuit (*Continued*)

IQ 1: "What circuit elements are included in a simple electrical circuit? Please explain."



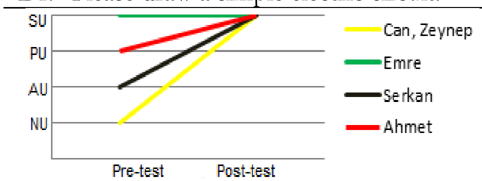
SU	"Battery, battery holder, bulb, lampholder, wire, switch…" (Ahmet PostI)
PU	(Serkan PreI): "Bulb, battery… Resr: "What else?" (Serkan PreI) "None more than these."
NU *	(Zeynep PreI): "Electrician does that thing. Electricity comes when you push something like this." Resr: "Well, what is needed for electricity's coming?" (Zeynep PreI): "Light bulb, I don't know another."

IQ 2: "Without a battery, would a bulb in a simple electrical circuit light? Why is that? Please explain."



PU	"It doesn't give light, because lights up thanks to the battery" (Emre PreI)
AU*	"Gives very little." (Serkan PreI)

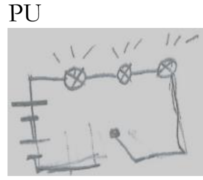
Dr: "Please draw a simple electric circuit."



SU

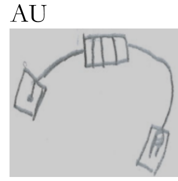
Emre PostD

PU



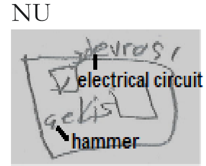
Ahmet PreD

AU



Serkan PreD

NU



Zeynep PreD

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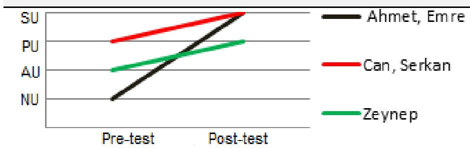
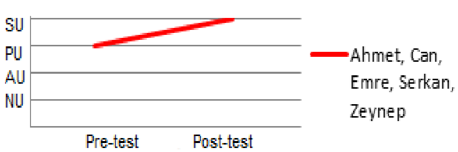
Table 11. Categorization of the mainstreamed students' responses to the concept of recycling

CUT 1: "What do you think about the recycling concept? Please explain."



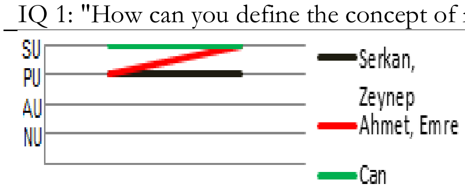
SU	"Waste material is becoming a new material by undergoing different processes." (Ahmet PostT)
PU	"Achieving new materials from waste materials again." (Zeynep PostT)
AU	"Recycling is the place throwing unnecessary materials." (Zeynep PreT)
NU	"I don't know." (Ahmet PreT)

CUT 2: "Which materials do you think can be recycled? Explain by giving an example."



SU	"Glass, battery, dirty water, paper, plastic, iron, food waste…" (Ahmet PostT)
PU*	"Paper, battery, plastic bottle…" (Can PreT)

IQ 1: "How can you define the concept of recycling? Please explain."

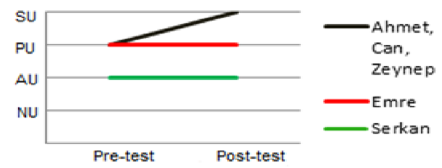
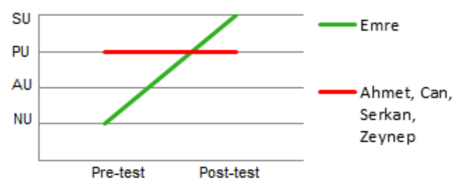
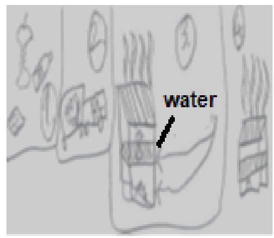
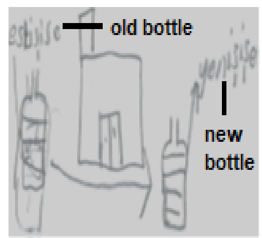
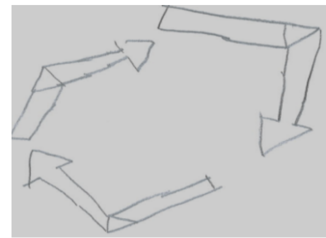


SU	(Can PostI): "Recycling is re-changing some waste materials with different methods." Resr: "Well, What kind of materials are become these changing materials?" (Can PostI): "They were old, they become new materials now. We reuse them."
PU	(Ahmet PreI): "Recycling machines recycle plastics and glass." Resr: "What happens after recycling?" (Ahmet PreI): "They become totally new glass, plastics, water bottles."

CUT: Conceptual understanding test, DrT: Drawing Test, IQ: Interview Question; I: PreT: Pretest; PostT: Post-test; PreInt: Pre-interview; PostInt: Post-interview; PreD: Pre-drawing; PostD: Post-drawing *Only these categories appeared at the drawing test; SU: Sound Understanding; PU: Partial Understanding; AU: Alternative Understanding; NU: No Understanding, Resr: Researcher

academic success (Chen, Chang & Wang, 2008; Kukulska-Hulme & Traxler, 2005; Kumar ve Wilson, 1997). In the results obtained for the "living things and life" learning area, it was seen that students were more likely to be in the category of partial understanding in the preliminary tests compared to other learning areas. Emphasizing the importance of environmental cleanliness and recycling in mass media such as television could have caused this situation. Likewise, adults and children's knowledge of the concept of recycling has increased due to written, oral or

Table 11. Categorization of the mainstreamed students' responses to the concept of recycling (*Continued*)

IQ 2: "Which materials do you think can be recycled? Can you explain why you think so?"		
	SU	(Zeynep $_{PostI}$): "Plastic bottle, paper, cardboard, water…" Resr: "What can be other materials?" (Zeynep $_{PostI}$): "Foods and battery…"
	PU	(Emre $_{PostI}$): "Glass, plastic, dirty water, paper…" Resr: "What can be other materials?" (Emre $_{PostI}$): "I don't know."
	AU*	(Serkan $_{PostI}$): "Pen, eraser. Everything can be recycled." Resr: "Is everything can be recycled?" (Serkan $_{PostI}$): "Yes, it is."
DrT: "Please write a recycling object and draw it."		
	SU  Emre $_{PostD}$	PU  Can $_{PostD}$
	NU*  Emre $_{PreD}$	

CUT: Conceptual understanding test, DrT: Drawing Test, IQ: Interview Question; I: PreT: Pretest; PostT: Post-test; PreInt: Pre-interview; PostInt: Post-interview; PreD: Pre-drawing; PostD: Post-drawing *Only these categories appeared at the drawing test; SU: Sound Understanding; PU: Partial Understanding; AU: Alternative Understanding; NU: No Understanding, Resr: Researcher

visual texts in schools and the media (Çimen & Yılmaz, 2012; Gürer & gum, 2018; Keleş & Keleş, 2018).

To sum up, science experiments guidebooks persuaded students to see the difference between the concepts and positively impacted mainstream students' conceptual understanding with learning disabilities. Active learning techniques such as aquarium and snowball techniques had led to the development of students' skills of expressing their thoughts and discussion skills about the concepts. Meanwhile, students worked together as a group while answering the worksheet's questions with Buzz 22 technique. Furthermore, a brainstorming technique has been effective in creating environments where students can express their thoughts freely. The students could access scientifically correct information about the concepts as a result of discussions and transfer their newly generated knowledge/conceptions to novel situations. Firstly, students had experience by hands-on experiments about the concepts, and then QR codes persuaded them to see the experiments repeatedly. That is, students had the opportunity to reinforce the concepts over and over again and overcome their misconceptions.

4. CONCLUSION

This study's results reveal that the science guidebook, including enriched worksheets, effectively affects students' conceptual understanding. Mobile apps (QR codes) and tablets offer students the opportunity to watch experiments repeatedly. Likewise, students had experienced with concepts through hands-on experiments. In a similar vein, students' active participation in the hands-on experiment has been effective in eliminating misconceptions.

Especially in preliminary conceptual understanding tests and preliminary interviews, it can be concluded that students with learning disabilities also experience difficulties in reading, writing, and understanding, in which case students had problems in interpreting the causes and consequences of events with science. Moreover, research can be enriched with different data collection tools such as drawing, clinical interviews.

As a result, it can be seen that enriched worksheets related to the concepts/issues such as; simple electric circuits, mixtures, separation methods, fossils, and recycling had positive effects on students' conceptual understanding. Overall, future studies should continue to prepare similar guidebooks for other science concepts/issues by students with learning disabilities.

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REFERENCES

Akçin, N. (2009). Characteristics of learning disabled children on the writing process. *Marmara Üniversitesi Atatürk Eğitim Fakültesi Eğitim Bilimleri Fakültesi Dergisi,* 29(29), 5-18.

Atılğanlar, N. (2014). Kavram karikatürlerinin ilköğretim yedinci sınıf öğrencilerinin basit elektrik devreleri konusundaki kavram yanılgıları üzerindeki etkisi [The effect of concept cartoons on seventh grade students' misconceptions about simple electrical circuits] [Unpublished master's thesis]. Hacettepe University (In Turkish).

Aydeniz, M., Cihak, D. F., Graham, S. C. & Retinger, L. (2012). Using inquiry-based instruction for teaching science to students with learning disabilities. *International Journal of Special Education*, 27(2), 189-206.

Bahçeci, D., & Kaya, V. H. (2010). Kavramsal algılamalar ve kavram yanılgıları. *Bilim ve Teknik Dergisi*, *515*, 30-33.Baydık, B. (2002). Okuma güçlüğü olan ve olmayan çocukların sözcük okuma becerilerinin karşılaştırılması [Comparison of the word reading skills children with and without reading disability] [Unpublished doctoral dissertation]. Ankara University (In Turkish).

Bingöl, A. (2003). The prevalence of developmental dyslexia among the 2. and 4. grade students in Ankara. *Ankara Üniversitesi Tıp Fakültesi Mecmuası, 56*(2), 67- 82.

Boyle, J. R. (2011). Strategic note-taking for inclusive middle school science classrooms. *Remedial and Special Education, 34*(2), 78-90.

Brigham, F. J., Scruggs, T. E. & Mastropieri, M. A. (2011). Science education and students with learning disabilities. *Learning Disabilities Research & Practice, 26*(4), 223-232.

Bulgren, J. A., Ellis, J. D. & Marquis, J. G. (2014). The use and effectiveness of an argumentation and evaluation intervention in science classes. *Journal of Science Education and Technology, 23*(1), 82-97.

Çelik, M. & Tekbıyık, A. (2016). The influence of activities based on gems with the theme of earth crust on the fourth grade students' conceptual understanding and scientific process skills. *Pegem Eğitim ve Öğretim Dergisi, 6*(3), 303-332.

Chard, D. J., Vaughn, S. & Tyler, B. J. (2002). A synthesis of research on effective interventions for building reading fluency with elementary students with learning disabilities. *Journal of learning disabilities, 35*(5), 386-406.

Chen, G. D., Chang, C. K. & Wang, C. Y. (2008). Ubiquitous learning website: Scaffold learners by mobile devices with ınformation-aware technologies. *Computers & Education, 50*(1), 77-90.

Çimen, O. & Yılmaz, M. (2012). Recycling knowledge, behaviors, and attitudes of primary school students. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi, 25*(1), 63-74.

Cohen, L., Manion, L., & Morrison, K. (1994). Educational research methodology. *Athens: Metaixmio.*

Cook, L. & Friend, M. (1995). Co-Teaching: Guidelines for creating effective practices. *Focus on Exceptional Children, 28*(3), 1-16.

Çoruhlu, T. Çalık, M. & Çepni, S. (2012). Effect of conceptual change pedagogies on students' alternative conceptions of electricity resistance and electricity current, *Energy Education Science and Technology, Part B Social and Educational Studies, 4*(1), 141-152.

Çoruhlu, T. Ş., & Nas, S. E. (2018). The impact of project-based learning environments on conceptual understanding: The" Recycling" concept. In *Asia-Pacific Forum on Science Learning and Teaching* (Vol. 19, No. 1, p. 1). The Education University of Hong Kong, Department of Science and Environmental Studies.

Dalton, B., Morocco, C. C., Tivnan, T. & Rawson-Mead, P. L. (1997). Supported inquiry science: Teaching for conceptual change in urban and suburban science classrooms. *Journal of Learning Disabilities, 30*(6), 670-684.

Derman, A. & Badeli, Ö. (2017). The investigation of the impact of the context based teaching method supported by the 5e model in teaching 4th grade students the "pure material and mixture" topic on the students' conceptual perceptions and their attitude towards science. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 17*(4), 1860-1881.

Eisenhardt, K. M., & Graebner, M. E. (2007). Theory building from cases: Opportunities and challenges. *The Academy of Management Journal, 50*(1), 25-32.

Emir, İ. M. (2019). Ortaokul öğrenme güçlüğü tanılı kaynaştırma öğrencilerine yönelik hazırlanan fen deneyleri kılavuzunun değerlendirilmesi: "fiziksel olaylar" örneği [Evaluating A science experiments guidebook prepared for mainstreamed students with learning disabilities: "physical events" sample] [Unpublished master's thesis]. Trabzon University (In Turkish).

Er-Nas, S., Şenel-Çoruhlu, T., Çalık, M., Ergül, C. & Gülay, A. (2019). Investigating the effectiveness of the science experiments guidebook for students with learning disabilities. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi, 20*(3), 501-534.

Fidan, N. K. & Akyol, H. (2011). The qualitative research on the improvements of the reading and comprehension skills of a student with mildly mental retardation. *Kuramsal Eğitimbilim Dergisi, 4*(2), 16-29.

Freedman, M. P. (1997). Relationship among laboratory ınstruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching, 34*(4), 343-357.

Gaddy, S. A., Bakken, J. P. & Fulk, B. M. (2008). The effects of teaching text-structure strategies to postsecondary students with learning disabilities to improve their reading comprehension on expository science text passages. *Journal of Postsecondary Education and Disability, 20*(2), 100-119.

Gilbert, L. M., Williams, R. L. & Mclaughlin, T. F. (1996). Use of assisted reading to increase correct reading rates and decrease error rates of students with learning disabilities. *Journal of Applied Behavior Analysis, 29*(2), 255-257.

Görgün, B. & Melekoğlu, M. A. (2019). Development of a reading support program for students with specific learning disabilities to improve reading fluency and comprehension skills. *İlköğretim Online, 18*(2), 698-713.

Gürer, A. & Sakız, G. (2018). Global warming knowledge levels and recycling awareness in adults. *İnsan ve Toplum Bilimleri Araştırmaları Dergisi, 7*(2), 1364-1391.

Hallenbeck, M. J. (2002). Taking charge: Adolescents with learning disabilities assume responsibility for their own writing. *Learning Disability Quarterly, 25*(4), 227-246.

Hyett, N., Kenny, A., & Dickson-Swift, V. (2014). Methodology or method? A critical review of qualitative case study reports. International Journal of Qualitative Studies on Health and Well-being,9, 23606.

İlker, Ö. & Melekoğlu, M. A. (2017). Review of the studies on writing skills of students with specific learning disabilities in elementary education. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi, 18*(3), 443-469.

Karaer, G & Melekoğlu, M. A. (2020). Review of studies on teaching science to students with specific learning disabilities. *Ankara Üniversitesi Eğitim Bilimleri Fakültesi Özel Eğitim Dergisi, 21*(4), 1-31.

Kaya, B. (2016). Teaching cursive slanted handwriting to the 4th grader primary school student with writing difficulty. *Electronic Turkish Studies, 11*(3), 1407-1434.

Keleş, P. U. & Keleş, M. İ. (2018). Perceptions of the 3rd and 4th grade students of elementary school about the concept of "recycling. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi, 20*(2), 481-498.

Kim, W. & Linan-Thompson, S. (2013). The effects of self-regulation on science vocabulary acquisition of English language learners with learning difficulties. *Remedial and Special Education, 34*(4), 225-236.

Kör, A. S. (2006). İlköğretim 5. sinif öğrencilerinde "yaşamimizda ki elektrik" ünitesinde görülen kavram yanilgilarinin giderilmesinde bütünleştirici öğrenme kuramina dayali geliştirilen materyallerin etkisi [Effects of materials developed according to the constructivist learning approach in removal of conceptual errors seen in unit "electricity in our life" by 5th grade students in primary school] [Unpublished master's thesis]. Trabzon University (In Turkish).

Küçüközer, H. & Kocakülah, S. 2007. Secondary school students' misconceptions about simple electric circuits. *Journal of Turkish Science Education, 4*(1), 101-115.

Kukulska-Hulme, A. & Traxler, J. (2005). *Mobile Learning: A Handbook for Educators and Trainers.* London: Psychology Press.

Kumar, D. & Wilson, C. L. (1997). Computer technology, science education, and students with learning disabilities. *Journal of Science Education and Technology, 6*(2), 155-160.

Kurnaz, F. B. & Kutlu, Ö. (2016). Determining the effectiveness of science process skills program prepared for elementary school grade 4. *İlköğretim Online,* 15(2), 529-547.

Lam, P., Doverspike, D., Zhao, J., Zhe, J. & Menzemer, C. (2008). An evaluation of a STEM program for middle school students on learning disability related IEPS. *Journal of STEM Education, 9*(1), 21-29.

Lerner, J. W. (2000). *Learning Disabilities: Theories, Diagnosis and Teaching Strategies* (8th ed.). Boston: Hougton and Mifflin Company.

Maki, H. S., Vauras, M. M. S. & Vainio, S. (2002). Reflective spelling strategies for elemantary school students with severe writing difficulties: A case study. *Learning Disability Quarterly, 25*(3), 189-207.

Marek, E. A. (1986). They misunderstand, but they'll pass. *Science Teacher, 53*(9), 32-35.

Mastropieri, M. A. & Scruggs, T. E. (1992). Science for students with disabilities. *Review of Educational Research, 62*(4), 377-411.

Nas, S. E., Çoruhlu, T. Ş., Çalık, M., Ergül, C., & Gülay, A. (2019). Öğrenme Güçlüğü Yaşayan Ortaokul Öğrencilerine Yönelik Fen Bilimleri Deneyleri Kılavuzunun Etkililiğinin İncelenmesi*. *Ozel Egitim Dergisi*, *20*(3), 501-528.

Özdemir, M. (2004). Fen eğitiminde bilimsel süreç becerilerine dayalı laboratuar yönteminin akademik başarı, tutum ve kalıcılığa etkisi [The effect of laboratory method based on scientific process skills on academic success, attitude and performance in science education] [Unpublished master's thesis]. Zonguldak Karaelmas University (In Turkish).

Özmen, H. (2005). Misconceptions in chemistry teaching: a literature review. *Gazi Üniversitesi Türk Eğitim Bilimleri Dergisi, 3*(19), 23-45.

Saddler, B. (2006). Increasing story-writing ability through self-regulated strategy development: Effects on young writers with learning disabilities. *Learning Disability Quarterly, 29*(4), 91-305.

Saddler, B., Behforooz, B. & Asaro, K. (2008). The effects of sentence-combining instruction on the writing of fourth-grade students with writing difficulties. *The Journal of Special Education, 42*(2), 79-90.

Scruggs, T. E. & Mastropieri, M. A. (2007). Science learning in special education: The case for constructed versus instructed learning. Exceptionality: *A Special Education Journal, 15*(2), 57-74.

Scruggs, T. E., Mastropieri, M. A., Bakken, J. P. & Brigham, F. J. (1993). Reading versus doing: The relative effects of textbook-based and inquiry-oriented approaches to science learning in special education classrooms. *Journal of Special Education, 27*(1), 1-15.

Sezgin, Z. Ç. & Akyol, H. (2015). Improving reading skills of fourth grade elementary student who has reading disability. *Turkish Journal of Education, 4*(2), 4-16.

Shepard, T. & Adjogah, S. (1994). Science performance of students with learning disabilities on language-based measures. *Learning Disabilities Research & Practice, 9*(4), 219–225.

Sökmen, N. & Bayram, H. (2000, Eylül). 5, 8 ve 9. sınıf öğrencilerinin saf madde, karışım, homojen ve heterojen karışım kavramlarını anlama seviyeleri ve kavram yanılgıları [5th, 8th and 9th grade students' level of understanding and misconceptions of pure substance, mixture, homogeneous and heterogeneous mixture concepts]. IV. Fen Bilimleri Eğitimi Kongresi'nde sunulan bildiri, Hacettepe Üniversitesi, Ankara.

Steele, M. (2004). Teaching science to middle school students with learning problems. *Preventing School Failure, 49*(1), 19–22.

Tavşancıl, E. & Aslan, E. (2001*). İçerik analizi ve uygulama örnekleri [Content analysis and application examples]*. İstanbul: Epsilon Publishing (In Turkish)

Temur, Ö. D., Şahin, H. K. & Özdemir, K. (2019). Investigation of 4th grade elementary students' levels of experiencing difficulty in mathematics learning and their writing quality levels. *Ahi Evran Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 5*(1), 65-80.

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.

Thomas, G. (2011). A typology for the case study in socialscience following a review of definition, discourse, and structure. Qualitative Inquiry, 17(6), 511-521.

Uyanık, G. & Dindar, H. (2016). The effect of the conceptual change texts on removing misconceptions in primary 4th grade science course. *Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi, 36*(2), 349-374.

Yılmaz, U. H. (2018). *Öğrenme Güçlüğü Tanılı Kaynaştırma Öğrencilerine Yönelik Hazırlanan Fen Deneyleri Kılavuzunun Değerlendirilmesi:"Madde ve Değişim" Örneği* (Doctoral dissertation, Lisansüstü Eğitim Enstitüsü (İlköğretim)).

Yin, R. (1984). *Case study research.* Beverly Hills: Sage Publications

Zhai, J., Jocz, J. A. & Tan, A. L. (2014). 'Am I Like a Scientist?': Primary children's images of doing science in school. *International Journal of Science Education, 36*(4), 553-576.