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# A Thematic Review of Studies on Specific Learning Disabilities in Science Education

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As part of science education/science courses, students with special needs can develop their skills such as observing the events occurring in nature, making predictions and inferences. Given the characteristics of students with specific learning disabilities, it is crucial to reveal the developments of specific learning disabilities in science education to see the overall effect(s) of the teaching methods, techniques and others. The current study aims to thematically review the studies on specific learning disabilities within the scope of science education from the year 2009 to 2021. Considering the 2009-2021 date range and the criteria for specific learning disabilities in science education, a total of 43 studies were obtained from the relevant databases. The Thematic Content Analysis method was preferred. The studies were examined by considering the parameters of "distribution by years, aim, method, sample group, data collection tools, results, and recommendation". The results indicate that a limited number of studies were conducted on specific learning disabilities in science education and the researchers generally focused on elementary school students' academic achievement and conceptual understanding levels employing quantitative methods. The results of the present study suggest carrying out studies in which in-depth analysis may be done selecting different sample groups (such as pre-service science teachers) for specific learning disabilities in science education and these may be conducted on the social and behavioral difficulties (loneliness, isolation and alike.) faced by students with specific learning disabilities in science education.

## Introduction

Science education focuses on a better understanding of the scientific knowledge that students need in the ever-changing world. Science provides the theories and principles demanded by modern technology for the use of knowledge to advance students' conceptual and theoretical understanding (Dela Fuente, 2019). Thus, Science course is among the most important courses taught at school in the 21st century (OECD, 2020). The National Science Education Standards (NSES) state that "science in our schools must be for all students … regardless of age, gender, cultural, ethnic origin, disability, or interest, desire, or motivation for science." (National Research Council [NRC], 1996, p.2). These standards aim for all

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students to benefit from science education, including students with disabilities. UNESCO's Education 2030 agenda considers the inclusion of all students, including those with disabilities to create safer and more accessible educational institutions by 2030 (UNESCO, 2017).

In order to support the physical, mental, and emotional development of students in a healthy way, the teaching environments should be adapted to the needs and developmental characteristics of the students. If the subject is students with special needs, it is very important to determine the educational needs of the students and make the necessary arrangements in science education. Functional science instruction can deepen students with disabilities' understanding of their own bodies and the natural world (Apanasionok, Hastings, Grindle, Watkins & Paris,2019) and provide them with future employment opportunities (Rizzo & Taylor, 2016). In addition, the skills gained during science lessons can help students with disabilities learn basic life skills together with their peers in general education classes (Spooner, Knight, Browder, Jimenez & DiBiase, 2011). In the science course, students with special needs have the opportunity to develop their skills such as observing the events occurring in nature, making predictions and inferences (Spektor Levy & Yifrach, 2019). Moreover, students with special needs can be interested and curious about the science lesson by establishing a cause-effect relationship with the events that occur in daily life and they can be more motivated towards the lesson (Gebbels, Evans & Murphy, 2010).

Students with specific learning disabilities (SLD) are the most common student group among students with special needs (Cortiella & Horowitz 2014; Çakıroğlu & Melekoğlu, 2014). Although defining SLD is complicated, this general term includes a heterogeneous group of problems that arise in the acquisition and use of speaking, listening, writing, reading, mathematical abilities, or reasoning (National Joint Committee on Learning Disabilities [NJCLD]), 2000). Regardless of the diversity in definitions, it is recognized that students with SLD have normal IQs but have difficulty in cognitive performance such as inductive and deductive thinking associated with scientific reasoning (Turkey Ministry of National Education [MoNE], 2006) or metacognitive thinking (Swanson 2001). These challenges create inconsistencies between students' abilities and achievements.

Students with SLD consistently show low academic achievement, therefore, they set low expectations for themselves and may have low self-esteem and self-confidence (Flogie, Aberšek, Aberšek, Lanyi & Pesek, 2020; Spektor Levy & Yifrach, 2019). In addition, this situation may cause them to feel uneasy in the classroom (Connolly, Boyle, MacArthur, Hainey & Boyle, 2012) and encounter peer pressure or social rejection (isolation). All these cause them to make fewer friends than their peers, feel lonely (Hogan, McLellan & Bauman, 2000), or exhibit weak social relations (such as difficulties in interpersonal communication, and less cooperative behavior) (Cortiella & Horowitz, 2014; Flogie et al., 2020). Studies have been carried out on SLD in science education with the creation of a specific field related to SLD, and different teaching methods are used in these studies considering the student's characteristics.

### *Specific learning disability studies in science education*

There have been varied studies examining the effect of different methods, guidebooks, units etc. such as the collaborative pre-teaching method (Thornton, McKissick, Spooner & Anderson, 2015), the keyword strategy (Aracı, 2019), interactive online science units (Terrazas-Arellanes, Gallard, Strycker, & Walden, 2018), video game-enhanced life science

units (Israel, Wang, & Marino, 2016), augmented reality technology (Turan & Atilla, 2021) or science experimental guidebook (Er Nas, İpek Akbulut, Çalik & Emir, 2021) on the science achievement of students with SLD. The effect of the inquiry-based teaching method on acquiring the students' scientific process knowledge (asking questions, identifying problems, making plans, doing research, analyzing data, etc.) (McGrath & Hughes, 2018) or how students with SLD used the strategic note-taking intervention in science classes were also investigated (Boyle, Rosen & Forchelli, 2016). Given the characteristics of students with SLD, it is crucial to reveal the developments of SLD in science education to see the overall effect(s) of the teaching methods, techniques, etc. For example, Karaer and Melekoğlu (2019) conducted a descriptive review of only intervention studies in science teaching for students with SLD. The reviewed studies in the study are only those that include interventions in science teaching with SLD in Turkey and in the world. However, it is necessary to investigate all studies (not only intervention studies) to identify trends in SLD studies in science education. From this point of view, it seems that a new extensive review is necessary to determine the trend in SLD studies in science education, which is the area of interest of the current study. Also, the fact that Karaer and Melekoğlu (2019) included four databases ("TÜBİTAK ULAKBİM", "EbscoHost", "SAGE", "Springer Link" and "ProQuest") between the years 2008-2017 necessitates a new review by including extensively databases and years. Karaer and Melekoğlu considered only intervention studies, presented the studies descriptively (no codes and themes were created), and scanned the limited database between the years 2008 and 2017. In addition, the recommendations of the intervention studies were not evaluated. A comprehensive new study is needed to determine the trends in SLD research in science education in recent years. In other words, a need for an extensive synthesis of the SLD studies in science education has resulted in the current study. Therefore, reviewing the distribution of SLD studies in science education according to years, aims, methods, sample groups, data collection tools, results, and recommendations can provide a holistic perspective on SLD studies in science education. This study aimed to thematically review the studies on specific learning disabilities in science education between 2009 and 2021. Moreover, there is no thematic review study handled in the field of SLD in science education. Therefore, the current study searched international and national well-known databases to go over SLD studies in science education from 2009-2021. For this purpose, the following questions guided:

(1) How is the distribution of the specific learning disabilities studies in science education by years?
(2) What were the aims of these studies?
(3) Which methods were used in these studies?
(4) Which sample groups were preferred in these studies?
(5) Which data collection tools were exploited in these studies?
(6) What results have been reached in these studies?
(7) What recommendations were represented in these studies?

### *Limitations of the study*

The present study is limited to specific learning disability studies in the field of science education. Also, this study is limited to studies and theses available using databases. National and international studies gathered in the context of study's aim were examined. Since the aim of examining current studies and determining a realistic trend increases the desire to focus on studies conducted in recent years, studies between 2009 and 2021 were taken into account in the current study. Therefore, this situation can be considered another

limitation of the study. Lastly, this study is limited to the databases mentioned in the data collection part.

## Method

The thematic content analysis method is employed in the study. It offers rich content to researchers who work in the related field but do not have the opportunity to access all studies (Çalık & Sözbilir, 2014). Because this study aimed to examine the studies on SLD in science education from a critical point of view by creating themes, thematic content analysis was preferred. This study aimed to examine the articles and theses on SLD in science education in a thematic way between the years 2009-2021. To be able to present the line of research through the relatively recent literature, the years 2009 and 2021 were chosen. Additionally, this timeline was selected because science education has recently studied special education.

### *Data collection*

In this study, international and national databases were searched in order to reach and examine specific learning disability studies in science education. To reach the publications in the relevant field between 2009-2021 in the national and international literature, respectively; "Academic Search Complete", "Education Research Complete", "ERIC (EBSCO)", "Springer LINK (ANKOS)", "Taylor & Francis (EKUAL)", "Wiley Online Library Full Collection", "Science Direct", "ProQuest Dissertations and Theses Global", "Emerald Premier eJournal", "Scopus (A&I)", "Web of Science Core Collection (WoS)", "Google Scholar" and "YOK National Thesis Center" databases were searched. Therefore, most of the databases were searched and well-known databases were selected to reach all SLD studies in the field of science education. The search was conducted in English including the keywords learning disability/disabilities, science education, mainstreaming, and special/specific learning disabilities. In the selection of the studies to be included in the study, the criteria of (I) publishing between 2009-2021, (II) publishing in peer-reviewed journals, and (III) inclusion of students with SLD and science education were taken into consideration. As a result of the search, 112 studies were found. After reviewing those studies, 43 studies, which serve the study criteria for inclusion and whose full text could be accessed, were discussed. These publications are referred to with the "*" sign in references.

### *Data analysis*

Each study included in the study was examined in detail with the thematic content analysis method, parameters related to the study questions were determined for the thematic content analysis. The parameters were (a) the year of publication, (b) the main aim, (c) method, (d) sample group, (d) data collection tool(s), (f) main result and (g) main recommendation. A sample of these parameters is presented in Table 1. The data obtained within the scope of these parameters were transferred to the computer and the findings were prepared in the Excel program. The studies were categorized and was coded separately according to the parameters (see Table 1). The analyzed studies are presented in tables and graphs in accordance with the parameters. Since some of the studies included more than a sample group (such as studying with both $7^{th}$-grade and $8^{th}$-grade students) or data collection tool (such as preferring both interview and observation as data collection tools), they were coded more than once under the specified parameter. This situation caused the frequency of the investigated parameter to be higher than the total number of studies.

Table 1. A sample data analysis of the parameters

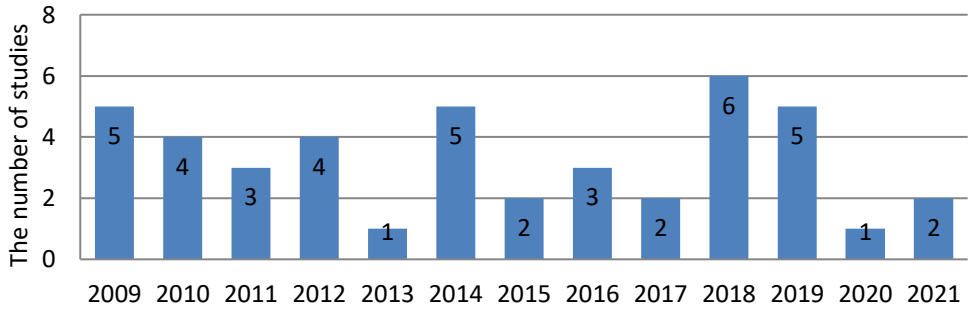
| | Study Code | S8 |
|---|---|---|
| a | Year | 2018 |
| b | Main Aim | "To reveal the instructional process of science and nature activities of special education teachers with mainstreaming students diagnosed learning disabilities" |
| c | Method | Qualitative (Case study) |
| d | Sample group | Special education teachers |
| e | Data collection tool(s) | Semi-structured interviews |
| f | Main result | "It was determined that the special education teachers take into consideration of the performance level of the student, developmental characteristics, concrete and understandable activities in designing science and nature activities." |
| g | Main recommendation | "It is recommended that special education teachers be given in-service training on the development of science and nature activities." |

### *Validity and reliability*

The reliability of descriptive and content analysis in qualitative research is especially dependent on the coding process. One of the most important features that categories should have is that another researcher using the same document for the same purpose can achieve similar results to a large extent (Tavşancıl & Aslan, 2001). Therefore, the interpretation of categories could not vary from researcher to researcher or change over time. Thus, within the scope of this study, coding reliability was examined to determine how consistently the researcher (coder) coded into the categories. The coder may get lost in different situations or remove such important concepts from the analysis. Therefore, iterative analysis is recommended as they provide a more saturated and deep analysis of the data set (Baltacı, 2017). For this purpose, the coder returned to the data at another time. All the studies examined within the scope of the study were coded twice by the coder with three weeks intervals. The analysis was carried out twice with at three weeks intervals to remain on the analysis but not to be familiar the analysis during this time. The researcher's internal consistency was checked. Coding reliability was calculated to determine how the researcher's response words were consistent. Coding reliability was calculated using the answer word agreement ratio index. The agreement ratio is an index found by calculating the coding where consensus was reached. By using the agreement ratio index, the coding reliability value was found as 0.91. $\Delta = C \div (C + \partial) \times 100$ is a formula for calculating the agreement ratio ($\Delta$ : Reliability coefficient, $C$: Number of codes on which agreement was reached, $\partial$: Number of codes on which agreement was not reached). According to Tavşancıl and Aslan (2001), the percentage of agreement is expected to be higher than 0.70 as an inter-rater or intra-rater reliability. As a result, the value was provided at an acceptable level of reliability.

### *Findings*

In this section, the findings obtained within the scope of the study are presented with the help of themes, codes, and frequency. The frequency distributions created for the publication year of the studies are given in Graph 1.




Graph 1. Frequency distribution of the examined studies for the year of publication

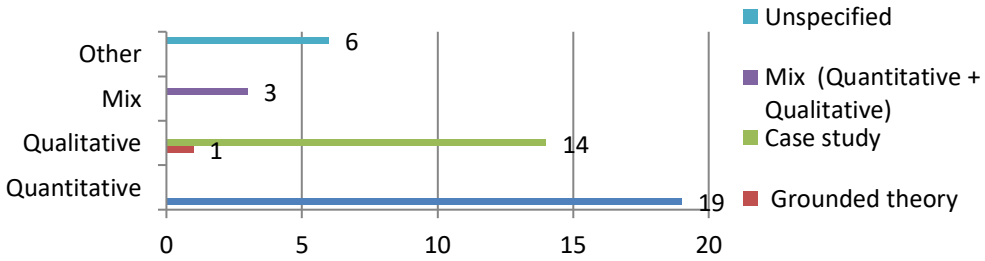
According to Graph 1, one study was conducted in 2013 and 2020, two studies in 2015, 2017 and 2021, three studies in 2011 and 2016, four studies in 2010 and 2012, five studies in 2009, 2014 and 2019, six studies in 2018. The themes, codes, frequency distributions and study codes created for the main aim of the studies are presented in Table 2.

Table 2. Distribution of frequencies and study codes for the main aim of the studies

| Themes | Codes | f | |
|---|---|---|---|
| Examining the effect of different methods /techniques etc. on the determined variable | • The effect of different methods (discussion method and enriched worksheets / Inquiry-based science instruction / journals in guided inquiry-based science education / three different science teaching methods ("engineering teaching kit (ETK)", "explicit instruction (EI)", and "a combination of the two methods (ETK+EI)" / a science experimental guidebook) / a science experimental guidebook) on conceptual understanding | 8 | 30 |
| | • The effect of different methods ("keyword strategy" / "science education supported by video games" / "direct teaching technique"/ "self-regulation strategy"/ "augmented reality technology") on learning science concepts | 5 | |
| | • The effect of different methods ("a technology-enhanced STEM curricula"/ "collaborative pre-teaching method"/ "video games and alternative print-based texts" / "strategic note-taking method"/ "interactive online units") on academic achievement | 4 | |
| | • The effect of different methods ("Argumentation and Evaluation Intervention (AEI) and associated graphic organizer" / "science lessons supported by video games and alternative print-based texts" / "problem based learning unit" / "strategic note taking intervention") on improving students' performance ("identifying important information, listening , interpreting and using that information; organizing the information they were hearing") | 4 | |
| | • The effect of three types of reading methods ("text reading, vocabulary learning, and text reading plus vocabulary learning / repeated readings") on reading science texts | 2 | |
| | • The effect of inquiry-based teaching method on acquiring scientific process knowledge | 1 | |
| | • The effect of self-regulation strategy development teaching method on fast writing skills | 1 | |
| | • The effect of self-monitoring strategy on class participation behaviors | 1 | |
| | • The effect of strategic note-taking method on note-taking skills | 1 | |
| | • The effect of strategic note-taking method on remembering science concepts | 1 | |
| | • The effect of inquiry-based science teaching program on interest, attitude and motivation towards science | 1 | |
| | • To measure the extent to which The Lesson Study for Accessible Science (LSAS) improve both science and special education teachers' instruction in inclusive classrooms | 1 | |
| Identifying | • Determining the special education/science teachers' teaching process/their | 5 | 9 |

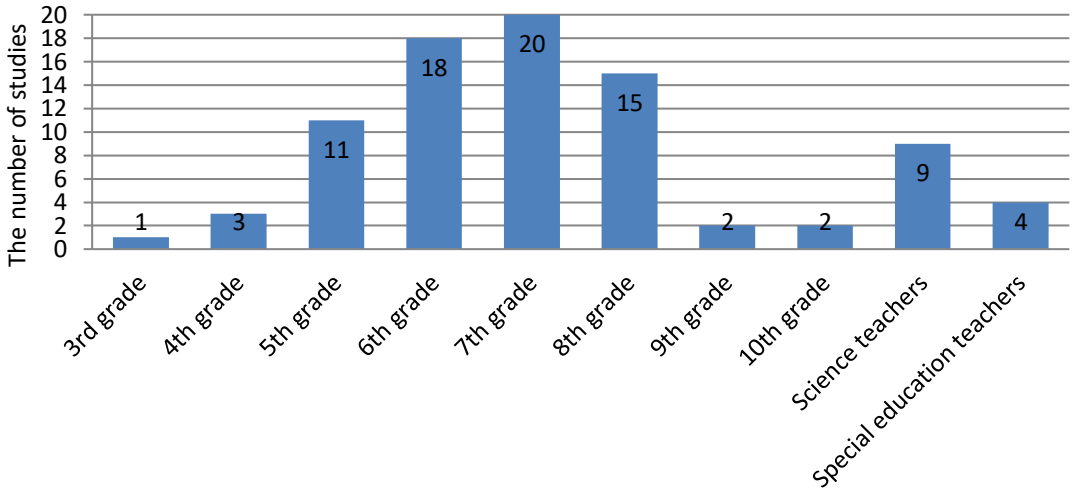
| | | | |
|---|---|---|---|
| the case | beliefs concerning providing equitable opportunities for students with learning disabilities | | |
| | • Determining the views of science teachers about the obstacles they encounter in the teaching process with students with learning difficulties | 1 | |
| | • Examining the use of audio technology in the context of science vocabulary learning and conceptual understanding | 1 | |
| | • Understanding learning experiences with both academic and behavioral exceptions for the 7th grader in life sciences | 1 | |
| | • Documenting whether inclusive classes with two teachers is better than solo-teaching | 1 | |
| Comparing different variables | • Comparing the academic achievement of students with and without SLD in terms of the traditional teaching method and the differentiated science curriculum with various activities | 1 | 4 |
| | • Comparing notetaking and perception skills of students with and without SLD | 1 | |
| | • Comparing cognitive and metacognitive strategies ("in terms of narrative and explanatory texts") of students with and without SLD | 1 | |
| | • Comparing inquiry-based teaching and teacher-centered teaching method | 1 | |
| Total | | 43 | |

According to Table 2, 21 different codes were determined under three different themes: "examining the effect of different methods and techniques on the determined variable", "identifying the case" and "comparing different variables". The codes created for the main aim of the studies are mostly under the theme of "examining the effect of different methods and techniques on the determined variable". Under this theme, codes were created regarding the effect of students with SLD on their conceptual understanding. The themes, codes and frequency distributions created for the method of the studies are presented in Graph 2.



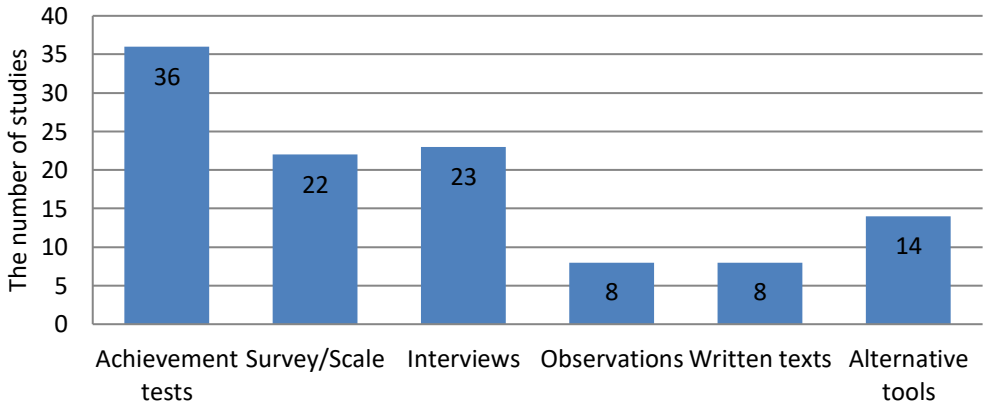

Graph 2. Frequency distribution for the method of the studies

According to Graph 2; in six studies, no method or pattern was clearly specified. Three of the examined studies were conducted with mixed methods (quantitative and qualitative), 15 of the studies were carried out with qualitative methods (case study and grounded theory) and 19 with quantitative methods. 14 of the qualitative studies were labeled under case studies while one of them adopted grounded theory. The frequency distributions created for the sample group of the studies are presented in Graph 3.




Graph 3. Frequency distribution for the sample group of the studies

According to the frequency distribution for the sample group of the studies, studies were one for 3rd grade, three for 4th grade, 11 for 5th grade, 18 for 6th grade, 20 for 7th grade, 15 for 8th grade, two for 9th grade and 10th grade, 9 for science teachers and four for special education teachers. It is seen that the studies were mostly conducted with elementary school students (5th, 6th, 7th, and 8th grade), a limited number of studies were conducted with science teachers (f= 9), special education teachers (f=4), primary school students (1st, 2nd, 3rd, and 4th grade) and high school students. The frequency distributions for the data collection tools of the studies are presented in Graph 4.




Graph 4. The frequency distributions for the data collection tools of the studies

According to Graph 4, the researchers used achievement tests (f=36), survey/scales (f=22), interview technique (f=23), observation technique (f=8), written texts (f=8), and alternative data collection tools (f=14, portfolio, video games, I connect application, electrical circuits kit, supporting activities, quiz, student notes, field notes). The themes, codes frequency, and study codes distributions created for the main result of the studies are presented in Table 3.

Table 3. Distribution of Frequencies and Study Codes for the Main Results of the Studies

| Themes | | Codes | f | |
|---|---|---|---|---|
| Results for the effect of the determined variable | Positive effect | • Conceptual understanding | 8 | 29 |
| | | • Science vocabulary learning | 5 | |
| | | • Students' performance | 4 | |
| | | • Academic achievement | 3 | |
| | | • Scientific process knowledge | 1 | |
| | | • Quick writing skills | 1 | |
| | | • Class participation behaviors | 1 | |
| | | • Reading fluency and vocabulary knowledge | 2 | |
| | | • Note-taking performance | 1 | |
| | | • Remembering science concepts | 1 | |
| | | • Interest, attitude and motivation towards science | 1 | |
| | | • Science and special education teachers' instructional ability | 1 | |
| | Neutral effect | • Academic achievement | 1 | 1 |
| Descriptive results | | • Science teachers and special education teachers felt a lack of support and ongoing guidance in providing the appropriate pedagogy to meet the needs of students with LD | 2 | 9 |
| | | • Special education teachers prefer students' performance level, developmental characteristics, and concrete and understandable activities when designing science and nature activities. | 1 | |
| | | • Failure of science teachers to prepare an adequate and applicable "Individualized Education Program" | 1 | |
| | | • The majority of the obstacles faced by science teachers in the teaching process are outside the teachers. | 1 | |
| | | • Audio technology offers an opportunity to better grasp science vocabulary and better understand science topics | 1 | |
| | | • Science teachers and special educators revealed a limited understanding of how to teach students to ask questions, construct explanations, or argue from evidence. | 1 | |
| | | • The process of learning is fragmented for Wizard because it is underscored by an emerging disciplinary literacy. | 1 | |
| | | • Students usually did not receive a science education that met their needs in inclusive classes with two teachers | 1 | |
| Results for comparing different variables | | • There is a significant difference in favor of students without SLD in terms of notetaking and perception skills/academic success. | 2 | 4 |
| | | • Students with SLD use cognitive strategy more than metacognitive strategy when reading narrative texts compared to explanatory texts. | 1 | |
| | | • Students who receive inquiry-based teaching and teacher-centered teaching method are more successful than students who receive teacher-centered education | 1 | |
| Total | | | 43 | |

Codes for the main results of the studies were created for each study. These codes are then combined with those that are close to each other and 3 themes were produced with the combined codes. According to Table 3, 24 different codes appeared, and these codes were gathered under 3 different themes: "results for the effect of the determined variable", "descriptive results", and "results for comparing different variables". The codes created under the theme of "results on the effect of the determined variable" have a positive effect and the resulting codes are more than the codes under other themes. The frequency distributions for the main recommendation of the studies are presented in Table 4.

Tablo 4. Distribution of frequencies and study codes for the main recommendation of the studies

| Themes | Codes | f | |
|---|---|---|---|
| Recommendations for in-class practice | The learning process should be supported with continuous repetitions, and the subjects should be summarized and reminded after the subject is explained. | 1 | 14 |
| | Students may be asked to create keywords themselves. | 1 | |
| | Peer education, group work | 2 | |
| | Adopting alternative approaches, such as the drawing method | 1 | |
| | Guidance for strategies such as answering questions and summarizing | 1 | |
| | Supporting students in generalizing information learned in video games | 1 | |
| | Using the collaborative pre-teaching method for students to generalize information | 1 | |
| | Giving students enough opportunities to write | 1 | |
| | Using instructional strategies that will enable student participation in inquiry-based science instruction | 1 | |
| | Using the direct teaching technique | 1 | |
| | Giving students advance organizers that offer them clues about what will be covered in the lecture. | 1 | |
| | Focusing on student strengths, intentional use of disciplinary literacy strategies | 1 | |
| | Providing students with the opportunity to apply what they have learned to solve real-life problems using the engineering problem-solving process. | 1 | |
| Recommendations for program development | Adopting the STEM approach while preparing IEP in science teaching | 1 | 5 |
| | Incorporating video games and alternative print-based design learning technologies into the curriculum | 1 | |
| | Preparing a science curriculum supported by digital resources and technology | 1 | |
| | Due to the special interest of students with learning disabilities in personalized avatars and videos with QR and codes, sensors, digital materials should be designed in science activities for inclusive education. | 1 | |
| | Include opportunities for teachers to reflect on their beliefs about how students with learning disabilities learn and provide them with a variety of validated teaching practices in teacher education programs and professional development programs. | 1 | |
| Recommendations for experts | Providing in-service training to science teachers | 2 | 5 |
| | Providing in-service training to special education teachers on the development of science and nature activities | 1 | |
| | Considering how special education and science teachers integrate teaching core ideas and scientific practices. | 1 | |
| | Devoting attention and resources to providing professional training and appropriate instructional materials | 1 | |
| Recommendations for future research | Conduct different studies of argumentation and evaluation intervention | 1 | 19 |
| | Examining technology-based self-monitoring research in the context of academic achievement | 1 | |
| | Examining the effects of self-regulation strategy on other skills such as academic language or comprehension | 1 | |
| | Examining the effects of developments in vocabulary and fluent reading on understanding the text. | 1 | |
| | Examining the strategic note-taking technique within the context of various science subjects and different courses | 1 | |
| | Further investigation of learning differences between students with and without SLD | 1 | |

| | | |
|---|---|---|
| | Examination of other strategic note-taking techniques | 1 |
| | Implementing an inquiry-based science teaching program for students of diverse abilities | 1 |
| | Investigation of the effect of science teacher's technological literacy rate on student achievement | 1 |
| | Examining the use of journals in the context of maintaining a conceptual understanding | 1 |
| | Further work to compare teacher-centered instruction with inquiry-based instruction | 1 |
| | The systematic replication of repeated readings to a fluency criterion (RRFC) procedure with different science texts, different aged students both with and without special needs | 1 |
| | New quality teaching strategies are needed to enhance science learning | 1 |
| | Types of scaffolds that could support mainstreamed students during PBL units | 1 |
| | Future research for student learning resulting from the teacher-collaborative planning process. | 1 |
| | Voice in the implementation of the co-teaching model | 1 |
| | Carrying out technology-integrated studies that support reading and writing skills in the inclusive education of the Turkish lesson | 1 |
| | Implementing interdisciplinary approaches that intertwine special education with science education, mathematics education, and reading-writing practices | 1 |
| | Investigating the impacts of augmented reality technology on students' emotional processes | 1 |
| Total | | 43 |

According to Table 4, 19 recommendations were made for future research, 14 recommendations were made for in-class practice, five recommendations were made for program development and five recommendations were made for experts.

## Discussion and conclusion

Given the goal of training everyone to be literate in science (MoNE, 2018; NRC, 1996, p.2), it may be claimed that there isn't much research on students with SLD. According to the results of the scientific education journals scanned in the SSCI/SCI indexes ("Social Sciences Citation Index/ Science Citation Index") within the scope of special education research, only five papers were published in the field of special education between 2011 and 2016 in this respect (Martin, 2018). In particular, the findings of Martin (2018)'s study are consistent with those of the current study. The lack of research in the literature might mean that scientific education for students with SLD is not given the proper priority. On the other hand, the lack of research in science education may be a result of the fact that studies tend to concentrate on a single subject, such as the native language or mathematics, due to the various challenges that students with SLD face in their ability to read, write, speak, listen, reason, and perform calculations.

Such studies may be more desirable since researchers want to know how various teaching methods or strategies impact the researched variable. Studies on the impact on students' conceptual comprehension are more numerous than studies on the impact on student performance, classroom involvement, or other abilities like taking notes, writing quickly, or recalling scientific topics. This demonstrates that the academic accomplishment and conceptual comprehension of pupils are the main study interests. Although it is promising that research on students' conceptual comprehension and academic accomplishment is strong,

this finding also demonstrates that there aren't enough studies on diverse abilities, students' conduct, or performance. Considering the general characteristics of students with SLD are taken into account, it shows a lack of study about heterogeneous skills such as higher order thinking skills (critical thinking, problem-solving etc.) or social skills (interaction with peers, working with groups, participating in discussions etc.) in science education. It reveals a gap that needs to be filled in this area.

The preference of methods based on quantitative approaches in mathematics and science education (Adıgüzel, Şimşir, Çubukluöz & Özdemir, 2018) may come from the researchers' thought that science studies more appropriate to quantitative methods (Bağ & Çalık, 2017). A low number of studies with qualitative and mixed methods are another study result. The fact that the mixed method requires using different data collection tools or data analysis may have caused this result. Further, in-depth examination of the investigated phenomenon, event, situation, etc. in the qualitative method may require a long time or more concern about the validity and reliability of the studies. That is, researchers may not have preferred these methods because of its requirements and possible workloads (time, a lack of knowledge of these methods etc.)

The minority of the studies were carried out with preschool, primary school, and high school students and teachers. Moreover, no study was found with pre-service science teachers. It is absolutely necessary to work with people who are likely to be teachers in order to be aware of students with SLD, to know the general characteristics of students, and to be able to conduct an effective science teaching process with this student group. Likewise, it is fundamentally important to work with teachers, considering various dimensions, such as minimizing the obstacles of teachers with these student group in the education process, obtaining deeper information about the educational needs of these students or exploring how students evolve in a science course. Because teachers who choose the right method and technique and enable students with SLD to reach their educational goals can form a basis for students with SLD to achieve academic success and enhance social behaviors (Williams, 2013). The limited number of studies conducted with teachers or pre-service teachers may have resulted from the need to focus on specifically students with SLD and to identify or minimize the difficulties they faced. The late recognition of the students with SLD due to the deficiencies in their diagnosis may have caused the studies with mainly secondary school student group not to be started in the preschool period. In other words, this result may have been caused by the late diagnosis of students with SLD due to the fact that both parents and teachers do not have enough information about specific learning disabilities. However, it is extremely important for students with SLD to be identified and studied as early as possible in order to catch up with their peers (Stage, Abbott, Jenkins & Berninger., 2003). This situation prevents students' needs from being considered earlier and minimizing the problems that may be encountered in the future. In addition, the lack of studies in the field of science education with students with SLD at an early age may be due to the fact that more attention is paid to the difficulties (such as the acquisition and use of listening, speaking, writing, reading, mathematical abilities or reasoning) that student with SLD faced rather than science education in the early period.

The reason why tests are preferred may be that the experimental design is chosen based on the quantitative approach. Another reason can be shown as the convenience of the tests in data collection and the accessibility of a large amount of data in a short time. Moreover, these tests were mostly used to examine the effect of various methods/techniques on independent variables (e.g., academic achievement, conceptual understanding, note-taking skills). As a matter of fact, this result differs from the result that there were very few tests to evaluate the

academic success in Güngörmüş Özkardeş (2013)'s study, which carried out a descriptive analysis of studies on SLD in Turkey between 1972 and 2011. This difference can be interpreted as the use of tests to collect data in science education being preferred more than other disciplines. On the other hand, the low number and variety of data collection tools such as observations and written texts are remarkable. This can be explained by the fact that the choice of data collection tool in the studies may be parallel to the research model and aim. More clearly, the low number of studies in which the qualitative approach was adopted may have resulted in less preference for data collection tools that require qualitative analysis. Students with SLD are a special group, thus alternative data collection tools (portfolio, video games, field notes, student notes, electrical circuit kit, quizzes) may be preferred because richer data is needed to meet and understand their educational needs.

If the methods and results of the studies are examined together, the high number of results related to the effect of the determined variable may be due to the fact that researchers prefer more experimental studies in the relevant field. Although it is pleasing that there are noticeable frequencies of results on the effect of conceptual understanding, the results obtained in areas such as cognitive skills, life skills (communication, teamwork, creativity etc.), or interest and attitude towards science are limited in number. Similarly, the descriptive results and comparing different variables were limited. In addition, the fact that an event, situation, or phenomenon in specific learning disability literature not only requires in-depth analysis and description but also needs a long time may have caused the researchers to carry out fewer studies under the mentioned themes.

More recommendations for future research can be interpreted as the researchers think that more research should be done in the future on SLD in science education. Additionally, this may come from a need for examining the relationship between different variables and the methods/techniques/strategies they used in their studies or generalizing the effectiveness of discussed methods/techniques/strategies by different studies. Further, this recommendation shows that more work should be done with students with SLD and there is a gap that needs to be filled in this area. Similarly, making recommendations for in-class practice indicates the necessity of working with these students.

## Recommendations

Due to the limited number of studies related to SLD in science education, it can be said that we need new studies in this field. The current study addresses the following recommendations within the scope of the results.

- Students with SLD in science education may be studied starting from the pre-school period, as much as possible.
- Given the influence of the teacher on students, further studies may be done with both science teachers and pre-service science teachers to minimize the obstacles of teachers with SLD student groups in the education process, obtain deeper information about the educational needs of these students or explore how students evolve in a science course.
- In addition to studies examining the effects of different methods, techniques, and strategies on academic achievement or conceptual understanding in science education, further studies may also be conducted on the social and behavioral difficulties (loneliness, isolation, and others) faced by students with SLD in science education.

- Students' cognitive skills, life skills (communication, teamwork, creativity etc.), or interest and attitude towards science may be evaluated by authors. Similarly, future research may be carried out in the descriptive results (such as an investigation of learning differences between students with and without SLD, etc.) by comparing different variables (such as teacher-centered instruction with inquiry-based instruction, and so on).
- Since students with SLD are in the inclusive student group, science education studies may be done not only in the classroom but also in the support education rooms.
- Considering the readiness, needs, and individual differences of students with SLD, each student is a special case in itself. Therefore, it is necessary to increase studies based on qualitative (action research, and alike) and mixed approaches by conducting in-depth studies on SLD in science education.
- Students with SLD are a special group, thus alternative data collection tools (portfolio, video games, field notes, student notes, electrical circuit kit, quizzes) may be preferred in future research because richer data is needed to meet and understand their educational needs.

## References


Adıgüzel, T., Şimşir, F., Çubukluöz, Ö., & Özdemir, B. G. (2018). Master's theses and doctoral dissertations on misconceptions in mathematics and science education in Turkey: A thematic analysis. *Journal of Bayburt Education Faculty 13*(25), 57-92.

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.

*Aracı, N. (2019). *The impact of a mnemonic strategy, the keyword strategy, on learning elementary science concepts of students with specific learning disabilities* [Unpublished master's thesis]. Bolu İzzet Baysal University.

Au, W. (2007). High-stakes testing and curricular control: A qualitative metasynthesis. *Educational Researcher, 36*(5), 258-267.

*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.

Bağ, H., & Çalık, M. (2017). A thematic review of science education studies on 4th grade. *Elementary Education Online, 2018; 17(3*), 1353-1377.

*Barabasz, K. M. (2018). *Supporting students with learning disabilities in ınclusive middle school science classrooms* [Unpublished doctoral dissertation]. University of Illinois at Chicago.

*Belland, B. R., Glazewski, K. D., & Ertmer, P. A. (2009). Inclusion and problem-based learning: Roles of students in a mixed-ability group. *RMLE Online, 32*(9), 1-19.

*Benedek-Wood, E., Mason, L. H., Wood, P. H., Hoffman, K. E., & McGuire, A. (2014). An experimental examination of quick writing in the middle school science classroom. *Learning Disabilities: A Contemporary Journal, 12*(1), 69-92.

*Biçer, A. (2019). *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., Rosen, S. M., & Forchelli, G. (2016). Exploring metacognitive strategy use during note-taking for students with learning disabilities. *Education 3-13, 44*(2), 161-180. https://doi.org/10.1080/03004279.2014.929722

*Boyle, J. R. (2010a). Note-taking skills of middle school students with and without learning disabilities. *Journal of Learning Disabilities, 43*(6), 530-540. https://doi.org/10.1177/0022219410371679

*Boyle, J. R. (2010b). Strategic note taking for middle-school students with learning disabilities in science classes. *Learning Disability Quarterly, 33*, 93-109. https://doi.org/10.1177/073194871003300203

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

*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. https://doi.org/10.1007/s10956-013-9452-x

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & education, 59*(2), 661-686.

Cortiella, C., & Horowitz, S. H. (2014). *The state of learning disabilities: facts, trends and emerging issues.* National Center for Learning Disabilities.

Çakıroğlu, O., & Melekoğlu, M. A. (2014). Statistical trends and developments within inclusive education in Turkey. *International Journal of Inclusive Education, 18*(8), 798-808.

Çalık, M., & Sözbilir, M. (2014). Parameters of content analysis. *Education and Science, 39*(174), 33-38.

*Dilber, Y. (2017). *Examination of the instructional process carried out by the science teachers with mainstreaming students diagnosed learning disabilities* [Unpublished master's thesis]. Karadeniz Teknik University.

Doğru, M., Gençosman, T., Ataalkın, A.N., & Şeker, F. (2012). Analysis of master's and doctoral theses studied in science education. *Turkish Science Education, 9*(1), 49-64.

*Emir M., İ. (2019). *Evaluating a science experiments guidebook prepared for mainstreamed students with learning disabilities: "physical events" sample* [Unpublished master's thesis]. Trabzon University.

*Er Nas, S., İpek Akbulut, H., Çalik, M., & Emir, M. İ. (2021). Facilitating conceptual growth of the mainstreamed students with learning disabilities via a science experimental guidebook: A case of physical events. *International Journal of Science and Mathematics Education*, 1-23.

*Er-Nas, S., Gülay, A., Pehlevan, M., & Delimehmet-Dada Ş. (2018). Investigation of the science and nature activities instructional process carried out by special education teachers. *Journal of Kazım Karabekir Education Faculty, 36*, 60-77.

*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 University Faculty of Educational Sciences Journal of Special Education, 20*(3), 501-534.

Flogie, A., Aberšek, B., Aberšek, M. K., Lanyi, C. S., & Pesek, I. (2020). Development and evaluation of intelligent serious games for children with learning difficulties: observational study. *JMIR Serious Games, 8*(2), e13190.

*Gebbels, S., Evans, S. M., & Murphy, L. A. (2010). Making science special for pupils with learning difficulties. *British Journal of Special Education, 37*(3), 139-147.

*Gokool-Baurhoo, N., & Asghar, A. (2018). "I can't tell you what the learning difficulty is": Barriers experienced by college science instructors in teaching and supporting students with learning disabilities. *Teaching and Teacher Education, 79*, 17-27.

*Gomes C. V. (2014). *Sounding out science: Incorporating audio technology to assist students with learning differences in science education* [Unpublished doctoral dissertation]. Columbia University.

*Grigg, G. S. (2009). *An analysis of science conceptual knowledge in journals of students with disabilities and normally achieving students* [Unpublished doctoral dissertation]. State University of New York.

Güngörmüş Özkardeş, O. (2013). Descriptive analysis of studies on special learning disability in Turkey. *Bogazici University Journal of Education*, *30*(2), 123-153.

Hogan A., McLellan L., & Bauman, A. (2000). Health promotion needs of young people with disabilities-a population study. *Disability and Rehabilitation*, *22*(8), 352-357.

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

*İlik, Ş. Ş. (2009). *Evaluation of the effectiveness of direct teaching method in teaching concepts relating to science and technology for students with mild learning difficulties* [Unpublished master's thesis]. Selçuk University.

Juodaitytė, A., & Kazlauskienė, A. (2008). Research methods applied in doctoral dissertations in education science (1995-2005): Theoretical and empirical analysis. *Vocational Education: Research& Reality*, 15, 36-45.

Karaer, G., & Melekoğlu, M. A. (2019). Review of studies on teaching science to students with specific learning disabilities. *Ankara University Faculty of Educational Sciences Journal of Special Education*, *21* (4), 1-31.

*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. https://doi.org/10.1177/0741932513476956

*Koomen, M. H. (2016). Inclusive science education: learning from Wizard. *Cultural Studies of Science Education*, *11*(2), 293-325.

*Kostewicz, D. E., & Kubina Jr, R. M. (2011). Building science reading fluency for students with disabilities with repeated reading to a fluency criterion. *Learning disabilities: A multidisciplinary journal*, *17*(3), 89-104.

Kuruyer, H. G., & Çakıroğlu, A. (2017). Primary school teachers' opinions and practices in educational evaluation and intervention in process of specific learning difficulties. *Electronic Turkish Studies*, *12*(28), 539-555.

*Marino, M. T., Black, A. C., Hayes, M. T., & Beecher, C. C. (2010). An analysis of factors that affect struggling readers' achievement during a technology-enhanced stem astronomy curriculum. *Journal of Special Education Technology, 25*(3), 35-42. https://doi.org/10.1177/016264341002500305

*Marino, M. T., Gotch, C. M., Israel, M., Vasquez, E., Basham, J. D., & Becht, K. (2014). UDL in the middle school science classroom: Can video games and alternative text heighten engagement and learning for students with learning disabilities? *Learning Disability Quarterly, 37*(2) 87-99. https://doi.org/10.1177/0731948713503963

Martin, S. (2018, Mar 10–13). Invited presentation for the ethics and equity committee sponsored symposium entitled, Re-centering science education for all. [Conference presentation]. The National Association for Research in Science Teaching (NARST), Atlanta.

*McCrea Simpkins, P., Mastropieri, M. A., & Scruggs, T. E. (2009). Differentiated curriculum enhancements in inclusive fifth-grade science classes. *Remedial and Special Education, 30*(5), 300-308. https://doi.org/10.1177/0741932508321011

McDermott, R. (2001). The acquisition of a child by a learning disability. *Understanding Learning: Influences and Outcomes*, *2*, 60-70.

*McGrath, A. L., & Hughes, M. T. (2018). Students with learning disabilities in inquiry-based science classrooms: A cross-case analysis. *Learning Disability Quarterly*, *41*(3), 131-143. https://doi.org/10.1177/0731948717736007

MoNE [Turkey Ministry of National Education] (2018). S*cience course curriculum (Primary and secondary 3, 4, 5, 6, 7, & 8. Grades).* http://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=325

MoNE [Turkey Ministry of National Education] (2006, May 5). *Özel eğitim hizmetleri yönetmeliği [Special education services regulation]* [Press release]. http://orgm.meb.gov.tr/alt_sayfalar/mevzuat/Ozel_Egitim_Hizmetleri_Yonetmeligi_son.pdf

*Moin, L. J., Magiera K. & Zigmond, N. (2009). Instructional activities and group work in the US ınclusive high school co-taught science class. *International Journal of Science and Mathematics Education 7*, 677–697.

*Morales, M. (2011). *An exploration of equitable science teaching practices for students with learning disabilities* [Unpublished doctoral dissertation]. The Florida State University.

*Mutch-Jones, K., Puttick, G., & Minner, D. (2012). Lesson study for accessible science: Building expertise to improve practice in inclusive science classrooms. *Journal of Research in Science Teaching*, *49*(8), 1012-1034.

National Joint Committee on Learning Disabilities [NJCLD]. (2000). Professional development for teachers. *Learning Disability Quarterly, 23*, 2-6.

National Science Education Standards [NRC]. (1996). *National academy of sciences.* National Academy Press.

*Pehlevan, M. (2020). *Preparation, implementation and evoluation of a science experiments guidebook prepared for fourth grade mainstreamed students with learning disabilities* [Unpublished master's thesis]. Trabzon University.

Rizzo, K. L., & Taylor, J. C. (2016). Effects of inquiry-based instruction on science achievement for students with disabilities: An analysis of the literature. *Journal of Science Education for Students with Disabilities*, *19*(1), 2.

*Seifert, K., & Espin, C. (2012). Improving reading of science text for secondary students with learning disabilities: Effects of text reading, vocabulary learning, and combined approaches to instruction. *Learning Disability Quarterly*, *35*(4), 236-247. https://doi.org/10.1177/0731948712444275

Shin, M., & Bryant, D. P. (2015). A synthesis of mathematical and cognitive performances of students with mathematics learning disabilities. *Journal of learning disabilities*, *48*(1), 96-112.

Shonfeld, M., & Ronen, I. (2015). Online learning for students from diverse backgrounds: learning disability students, excellent students and average students. *IAFOR Journal of Education*, *3*(2), 13-29.

*Spektor Levy, O., & Yifrach, M. (2019). If science teachers are positively inclined toward inclusive education, why is it so difficult?. *Research in Science Education*, *49*(3), 737-766.

Spooner, F., Knight, V., Browder, D., Jimenez, B., & DiBiase, W. (2011). Evaluating evidence-based practice in teaching science content to students with severe

developmental disabilities. *Research & Practice for Persons with Severe Disabilities, 36*(1–2), 62–75.

Stage, S.A., Abbott, R.D., Jenkins, J.R. & Berninger, V.W. (2003). Predicting response to early reading intervention from verbal IQ, reading-related language abilities, attention ratings, and verbal IQ-word reading discrepancy: Failure to validate discrepancy method. *Journal of Learning Disabilities, 36*(1), 24-33.

*Starling, A., Lo, Y. Y., & Rivera, C. J. (2015). Improving science scores of middle school students with learning disabilities through engineering problem solving activities. *Journal of the American Academy of Special Education Professionals*, *98*, 113.

Swanson, H. L. (2001). Research on intervention for adolescent with learning disabilities: a meta-analysis of outcomes related to higher-order processing. *The Elementary School Journal, 101*(3), 331–348.

*Terrazas-Arellanes, F. E., Gallard M, A. J., Strycker, L. A., & Walden, E. D. (2018). Impact of interactive online units on learning science among students with learning disabilities and English learners. *International Journal of Science Education*, *40*(5), 498-518.

*Thornton, A., McKissick, B. R., Spooner, F., Lo, 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.

*Turan, Z., & Atila, G. (2021). Augmented reality technology in science education for students with specific learning difficulties: its effect on students' learning and views. *Research in Science & Technological Education*, 1-19. https://doi.org/10.1080/02635143.2021.1901682

United Nations Educational, Scientific and Cultural Organization [UNESCO]. (2017). *A guide for ensuring inclusion and equity in education.* UNESCO.

*Usta Yılmaz, H. (2018). *Evaluating a science experiments guidebook prepared for mainstreamed students with learning disabilities: "Matter and change" sample* [Unpublished master's thesis]. Trabzon University.

Williams, A. (2013). A teacher's perspective of dyscalculia: Who counts? An interdisciplinary overview. *Australian Journal of Learning Difficulties*, *18*(1), 1-16.

*Wills, H. T., & Mason, B. A. (2014). Implementation of a self-monitoring application to improve on-task behavior: A high-school pilot study. *Journal of Behavioral Education*, *23*(4), 421-434. https://doi.org/10.1007/s10864-014-9204-x

*Yorke Servis, J. (2012). *A comparison study on teacher-centered and inquirybased instruction in science education of middle school students with learning disabilities: what is effective?* [Unpublished master's thesis]. Rowan University.