LONG PAPER

An analysis of the utility of digital materials for high school students with intellectual disability and their effects on academic success

Arzu Deveci Topal[1] · Aynur Kolburan Geçer[2] · Esra Çoban Budak[1]

Abstract

This study thoroughly examines the usability of digital materials, to establish a classroom environment in which technology is integrated into teaching practices using tablet computers and interactive smart boards. The study was conducted at a special education vocational school, where students with intellectual disability receive training. The integration of technology was made to the Natural Disasters unit (erosion, landslide, flood, earthquake, and digital story developed on the subject of flood) in the Social Science syllabus. This study also aims to develop multimedia applications and apply these to teaching activities, and additionally to increase the learning competencies of students in the subject of Social Sciences. This study involved eight students who have mild intellectual disability at a vocational high school. A thorough multiple probe design was used among single-subject research models. Comparison of the results revealed that students' post-test scores increased significantly when compared to the pre-test scores, and that the teaching materials had a significantly positive impact on their learning process. Moreover, the effect of the prepared digitalized materials on learning was determined to be high in terms of its application in special education schools. Students indicated that they liked these activities which they engaged on computers, as well as the interactive multiple choices questions, and wished to have such creative applications made available for other subjects such as Turkish, Mathematics, Music, and Art.

Keywords Special education · Computer applications · Single-subject research models · Students with intellectual disability · And digital materials

1 Introduction

The fast growth and development of information and communication technology impacts the field of education, as well as other fields, providing potential innovation for both instructors and students in teaching and learning processes. Güngör et al. [1] argue that the independence, flexibility, and improvement of quality of life in certain areas which technology provides for the whole of society are also true for people with disabilities. Learning and/or teaching environments which are designed with information technologies can and will provide essential opportunities for students with intellectual disability in special education schools. Using computers in learning environments enriches these environments and allows for teaching to be customized according to the needs of students Tekinarslan [2]. Wehmeyer [3] has also stated that content presented through particularly graphics-based videos with sound established using multimedia components may increase students' participation in class and improve motivation, thus customizing the learning experience. Jeffs, Behrmann and Bannan-Ritland [4] state that when students read books with the support of technology and the Internet, they find reading books more enjoyable and consequently read more.

Instructors at special education practice schools have claimed that effective use of digital technologies in schools which teach students using intellectual disability materials is going to be beneficial for them in various ways Arpacık,

✉ Arzu Deveci Topal
arzudevecit@gmail.com

Aynur Kolburan Geçer
aynurgecer@hotmail.com

Esra Çoban Budak
esra@kocaeli.edu.tr

[1] Informatics Department, Kocaeli University, Umuttepe Campus, 41380 İzmit-Kocaeli, Turkey

[2] Department of Computer and Instructional Technologies Education, Faculty of Education, Kocaeli University, Kocaeli, Turkey

Kurşun and Göktaş [5]. Some of these benefits are as follows: as a result of technology-supported educational applications and research carried out for mentally disabled individuals, information and communication technologies increase students' motivation and interest in the lesson, improve their learning skills and make students more successful [6–12]. Ramdoss et al. [13] argue that using computer-based applications to develop the daily life skills of students with intellectual disability is a successful approach. According to Li et al. [14] teaching materials ought to be prepared in visual and audio format and ought to be used as much as possible to help educate students with intellectual disability Li, Chen, Yin and Li, [14].

Some of the advantages of digital materials compared to traditional materials is that they can be developed in a way to meet the needs of students with different characteristics Avcı [15], and that the materials used to develop the listening comprehension skills of individuals with intellectual disabilities make it easier to understand because they affect many sensory organs and enable the concretization of abstract concepts Sümer and Çetin, [16]. In addition, digital products enable both the presentation of the audio-visual content in the courses in the desired environment and the design of enriched lessons such as those with audio-visual pictures in a blended structure Taşkıran [17]. Bates [18] has stated that digital products come to the fore in improving learners' ability to learn independently, as well as promoting the acquisition of communication, thinking, and digital skills.

Although the use of technology in educational environments has increased significantly along with the fast growth and development of modern-day technologies, it is noticed that technologically supported teaching materials are not applied in teaching activities in special education institutions for reasons that include but are not limited to insufficient technological hardware and content, and the limited ability of instructors to use such technology Özgüç & Cavkaytar [9], Budak, Topal and Geçer, [19]. In interviews with elementary school teachers of students with intellectual disability, they stated that there was a lack of digital materials for teaching the syllabus, and that there was a crucial need for more teaching technologies particularly for physical sciences and Social Science subjects Güleç-Aslan et al. [20].

There have been several studies conducted in Turkey which investigate the use of technology in special education schools. Acungil [21], Özgüç and Cavkaytar [9] argue that many of these studies increasingly emphasize the need for planning new studies about the use of technology and its efficacy in special education. This study is significant in terms of its contribution to relevant literature and in serving as a model for future studies.

In a study carried out on teaching of academic skills with the support of technology, Martin [22] stated that those

conducted with students with intellectual disability focused mostly on reading, writing, and Mathematics, and that there is a need for studies focusing on physical and Social Science. Sola-Özgüç [10], in a study conducted with Turkish middle school students with intellectual disability, developed technology-supported teaching activities related to the "Let's get to know the substance" unit of the science and technology course and examined the results. According to the results, it has been determined that the teaching provided through technology made a positive contribution to students' learning of the subject. It was observed that students made improvements in generalizing the learned information and transferring it to daily life.

Among the studies which have been carried out in Turkey on students with intellectual disability, the numbers of high school level studies are perceived to be limited. Instructors have argued that there is a lack of digital materials which could be used in teaching students with mild intellectual disability, and that they could not find enough digital materials teaching Turkish, Mathematics and Social Science subjects. They have been facing multiple difficulties in the classroom in establishing, presenting, or using materials they collect online. Over and above this, they could not use materials from websites such as YouTube, for instance, because using such materials was prohibited at high school level by the Ministry of Education Budak, Topal and Geçer, [19]. Furthermore, the problems they faced in classrooms and the insufficiency of interactive digitalized materials for disabled students have become an even more important issue during the COVID-19 pandemic.

In light of the data obtained from the relevant literature, this study conducted preliminary research to determine what can be done for the education of students with intellectual disability who are currently enrolled in special education high schools. In this preliminary research, special education teachers who work at a special education school indicated that materials for all classes were insufficient, particularly in Social Sciences classes. This study has been carried out within the scope of the Social Sciences subject, as it contains information which will provide more help in the daily life of students with intellectual disability, and because this information is not taught in daily life other than through direct experience? The issue of natural disasters discussed in this study is natural phenomena which often occur in real life, and individuals with intellectual disabilities need to be enlightened and taught the precautions they should take if they experience natural disasters. Accordingly, this study was established to lay the foundations for a class supported by technological tools (tablet computer and interactive smart board) in a special education vocational high school where students have intellectual disability, to integrate technology into the Natural Disasters unit of the Social Sciences syllabus (erosion, landslide, flood, and earthquake, as well as

a digital story prepared particularly for the flood subject). In this regard, the aim was to develop multimedia applications and to apply technology-supported teaching activities in order to identify and solve the problems which might arise during this process, and to increase the learning competencies of students in the Social Sciences subject. In accordance with these aims, the research questions were established as follows:

1. Does the use of technology in the learning process affect the academic success of students?
2. How are teaching activities utilizing technology?
3. How has the use of technology in the learning activities of the Social Science course affected students?

2 Method

The mixed method (which unifies the results of the study using quantitative and qualitative data collection methods) was used in this study. Thus, both quantitative and qualitative data were collected at the same time and more reliable results were consequently obtained. The findings of both quantitative and qualitative measurement tools were compared and their consistency was determined.

This study used a single-subject design with a multiple baseline model and probe conditions across participants. In this design, basic sessions are applied to interpret threats to internal validity and to assure experimental control. According to Tekin-Iftar [23, 24], multiple probe design is an adaptation of multilevel modelling that aims to evaluate the effectiveness of a teaching or behaviour modification program on more than one occasion. In this model, experimental control is established for each participant and data were collected continuously along with measurements taken multiple times. Single-subject studies are considered experimental research, however, due to the inability to determine the impartially, they are also categorized as quasi-experimental. Additionally, they are studies in which the effectiveness of an application is evaluated under standard conditions with repeated measurements for each participant Sönmez, Kot, & Sazak Pınar, [25]. To achieve maximum efficiency according to this design, individuals with similar learning backgrounds who exhibited similar behaviours under similar environmental conditions were consecutively exposed to the same independent variable Yeni, Çağıltay and Karasu, [26]. The multiple probe design consists of two phases: (a) starting level phase and (b) application phase. Establishing the experimental control in the multiple probe design is subject to two prerequisites: first, cases shall be independent, meaning that the start of teaching in one situation should not cause a change in the starting levels of other situations,

secondly, cases shall be functionally similar. The procedure of the study is shown in Fig. 1.

2.1 Participants

The study was carried out at a vocational school for students with mild intellectual disability in Kocaeli, Turkey. Necessary permission was granted by the Kocaeli Provincial Directorate of National Education and Governorship. Eight students in the ninth grade, three females and five males, and a special education instructor participated in the study. Their class was selected because the instructor volunteered to participate in the study. The instructor is thirty-seven years old and has fifteen years occupational experience. The researchers of the study include two experts in the field of Computer and Teaching Technologies Education and one expert in the field of Computer Teaching Education, all of whom are employed at a university and have occupational experience of at least 19 years.

According to the World Health Organization [27], Intelligence quotient (IQ) mental retardation can be classified in four grades: mild (IQ = 50–70), moderate (IQ = 35–49), severe (IQ = 20–34), and profound (IQ = < 20) [28]. According to this classification, individuals with mild disability can be classified as 'trainable', and individuals with moderate disability can be classified as 'teachable'. The demographic information of students who participated in the study is given in Table 1. The data in the Wisc R and diagnostic columns in Table 1 are based on the results of the health reports obtained from the child psychiatry services of medical faculties or full-fledged hospitals in Turkey. This information was obtained from the school administration, in accordance with the confidentiality rules, only for use in the research. The data on the skills of the students were obtained from the class teacher and branch teachers.

2.2 Materials preparation

An interview was conducted with the school teachers six months before starting this study, in which they stated the problems encountered in the use of instructional technologies at a public vocational high school for intellectually disabled students and which had also been determined by the researchers who carried out. Afterwards, an analysis of their opinions was established stating that digital materials used to teach Turkish, Social Science, and Mathematics subjects to students with mild intellectual disability were ineffective and insufficient. Moreover, while their teaching ought to be supported by two- or three-dimensional digital visuals Budak, Deveci-Topal and Geçer, [19], the available animations and videos were inadequate. Therefore, the number of digital materials, particularly for the Social Science course,
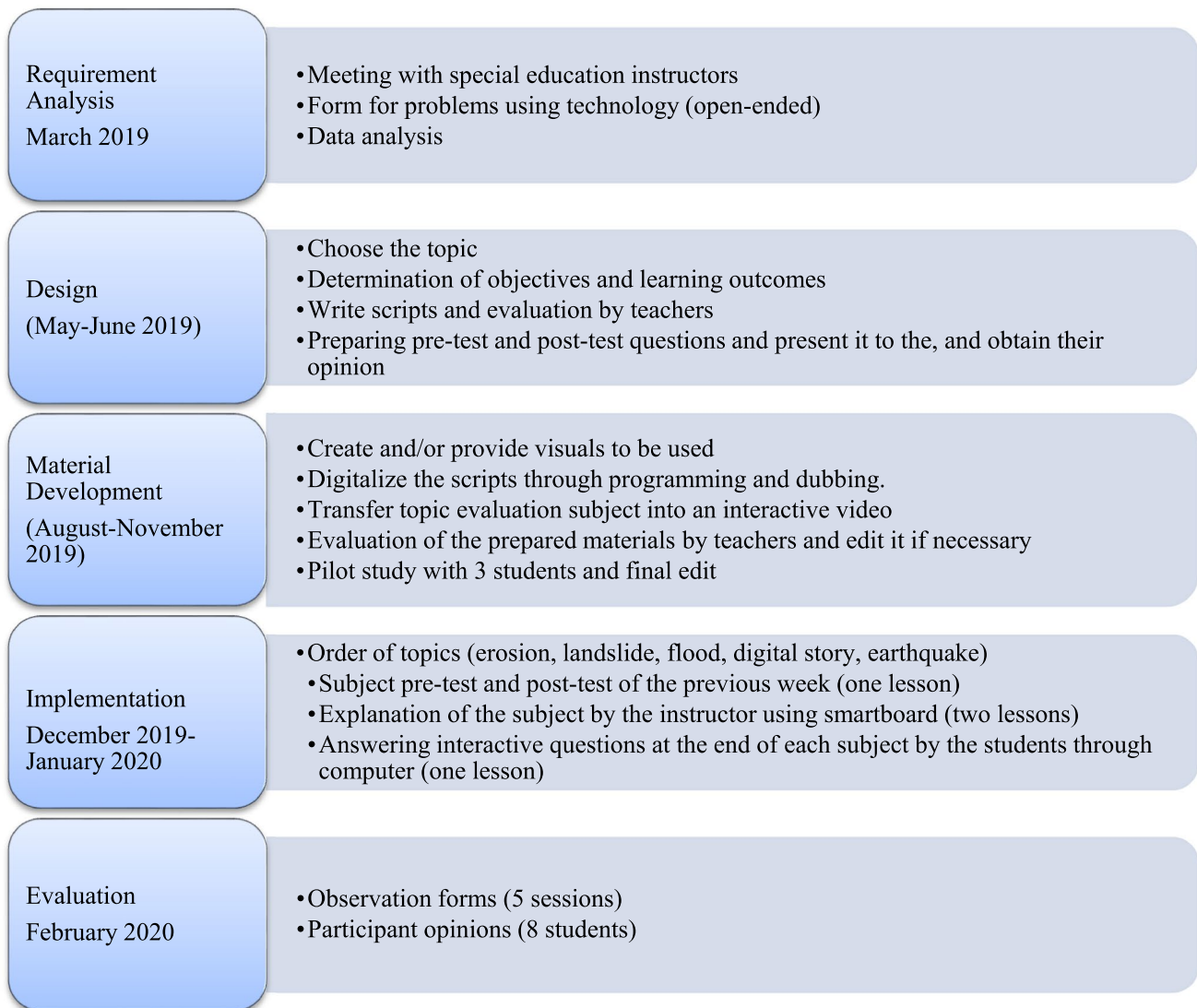
Requirement Analysis March 2019	• Meeting with special education instructors • Form for problems using technology (open-ended) • Data analysis
Design (May-June 2019)	• Choose the topic • Determination of objectives and learning outcomes • Write scripts and evaluation by teachers • Preparing pre-test and post-test questions and present it to the, and obtain their opinion
Material Development (August-November 2019)	• Create and/or provide visuals to be used • Digitalize the scripts through programming and dubbing. • Transfer topic evaluation subject into an interactive video • Evaluation of the prepared materials by teachers and edit it if necessary • Pilot study with 3 students and final edit

Implementation December 2019-January 2020	• Order of topics (erosion, landslide, flood, digital story, earthquake)
	  • Subject pre-test and post-test of the previous week (one lesson)
	  • Explanation of the subject by the instructor using smartboard (two lessons)
	  • Answering interactive questions at the end of each subject by the students through computer (one lesson)

Evaluation February 2020	• Observation forms (5 sessions) • Participant opinions (8 students)

Fig. 1 Study procedure

was determined to be insufficient and digital materials for the subject of natural disasters were therefore prepared.

While the materials were being prepared, the purposes and learning outcomes of the Social Science syllabus, particularly for students with mild intellectual disability, were examined along with script for learning outcomes. These scripts were duly reviewed by special instructors who worked at the high school where the digital materials prepared for the study were applied. The scripts were organized according to the advice of experts then digitalized by the two authors of this research using Scratch and graphic design programs and recorded. The materials for this study were prepared according to Mayer's [29] multimedia design principles. Pictures were supported by simultaneous vocalization and accompanied by sub-titles to attract the attention of students, and in order for students to see the action in concrete

form, the words and the related pictures in the animations prepared for them were placed close to each other. Unnecessary pictures, texts, or vocalizations did not feature in the media. Since the target audience were a group of students without prior knowledge about the subject, the aim was to make it easier for them to organize and learn the information through pictures and words presented in a multimedia format compared to learning with words only. The materials were relatively interactive since they had forward, backward, and replay buttons for students to use them unaided.

According to the visual design evaluation principles form, six instructors who work in the field of special education conducted an evaluation of the materials. This initial evaluation indicated that these materials were suitable for students with mild intellectual disability and could be used in their classrooms. As suggested by the instructors, a few changes

Table 1 Demographic information of the students participating in the study

Students	Gender	Age	Wisc R	Diagnosis	The skills the student has						
					Sf	Fa	Mi	Hf	Rpv	Ar	Spt
Nehir	Female	16	60	Mild	+	+	+	+	+	+	+
Seyit	Male	15	74	Mild	+	−	+	+	+	+	+
Yusuf	Male	15	60	Mild	+	+	+	+	+	+	+
Muhammed	Male	16	50	Mild	+	+	+	+	+	+	+
Hafize	Female	16	55	Mild	+	+	+	+	+	−	+
Eren	Male	16	65	Mild	+	+	+	+	+	+	+
Eray	Male	16	50	Mild	+	−	+	+	+	+	−
Selmanur	Female	14	55	Mild	+	+	+	+	+	−	+

Sf: Simple verbal instruction follow-up

Fa: Focusing attention on an activity for 10 min

Mi: Being able to imitate motor skills

Hf: Using hands and fingers

Rpv: Being able to respond to a question by pointing or verbally

Ar: Being able to attend school regularly

Spt: Being able to perform the skill planned to be taught

and corrections were made to the materials (for instance, a slower lecture in the video and more frequent placement of next and back buttons of the given information). A pilot study involving three students with intellectual disability was conducted in a class other than the experiment group, and materials were arranged according to students' reactions.

An interactive evaluation activity was prepared for students to measure their comprehension. In addition, multiple-choice questions were added to the activities which included games, including but not limited to, dragging and hiding images when clicked. Students received positive reinforcement with messages such as "congratulations", "bravo", "you are wonderful", "well done", and "carry on" for questions they answered correctly; on the other hand, incorrect answers received instant feedback such as "it is OK, you could not guess correctly", "I'm sorry", "you can do this", and "you should take another look at the topic". For some questions, students were provided with clues and the correct answers if they could not answer correctly.

A digital story about floods and landslides in the Social Sciences course was prepared in order to ensure the comprehension and reinforcement of the subjects. At the end of the story, the students were asked interactive questions (7 items) about what they understood from what they had seen and heard. Students received a point according to the short, written answers they provided to the questions. As Sümer and Çetin [16] have stated, digital story activities activate both the senses of hearing and seeing and facilitate comprehension in individuals with intellectual disability as they materialize abstract notions.

According to Hathorn (2005), a digital story is a program innovation that integrates technology with communication, language, and literacy skills. According to Robin (2006), digital stories are short stories useful for transferring information about individual stories and historical events by combining elements such as video, music, text, voice-over, and graphics.

When the scores students received was below 70 in all evaluations, they were asked to repeat the lesson topic; whereas when they were 70 and above, and in order to increase their motivation, they received positive reinforcement with audio responses such as "very good" and "congratulations", which were also supported by visual effects. Screenshots of some materials are given in Fig. 2.

2.3 Experimental process

Within the scope of this study, the erosion, landslide, flood, digital story, and earthquake lesson topics were reviewed. The materials were explained to students step by step by the special education instructor using a smart board. During the lecture, videos and photographs were taken, and the three researchers conducting this study simultaneously observed the lecture. Pre-tests were established before the lecture. A week after the lecture, a post-test was carried out. At the end of each lecture, students completed an interactive lesson exercise with at least six questions on the computer. The experiment process lasted 6 weeks. Figure 3 shows two photographs of the experimental process from the classroom. After all the lesson topics were covered, a team of three people scored the objectives on the observation form for each student separately over three weeks which covered five different sessions. Students were first asked to watch the lesson topics on a computer, and they were then asked questions about these lesson topics according to target behaviours. While students were answering the questions, three
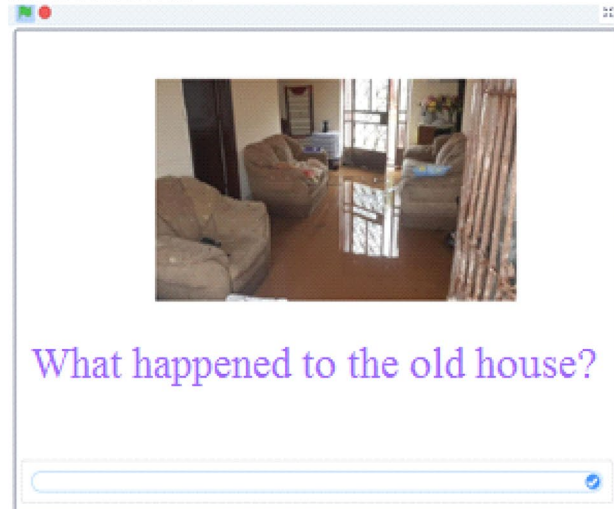
a. Landslide subject
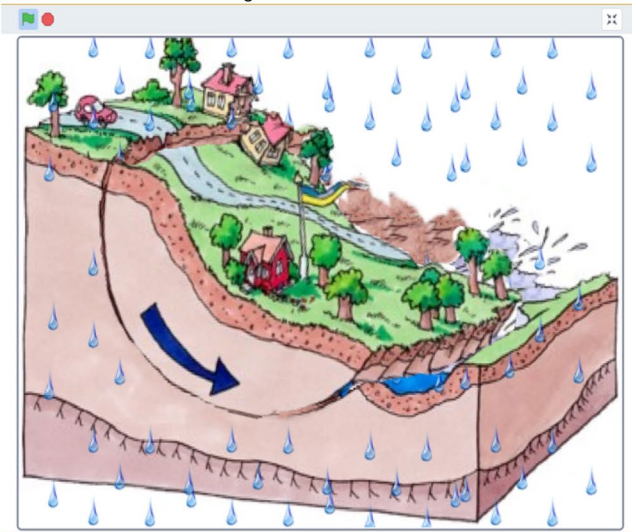
b. Game for Earthquake Emergency Bag
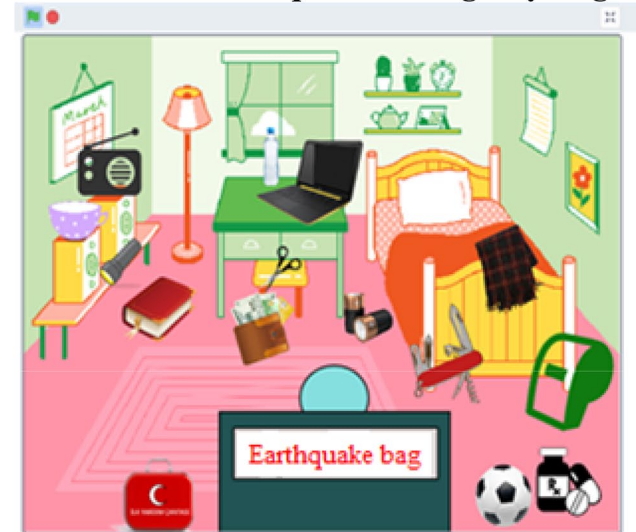
c. Example of digital story question with short answer

d. Example of question about erosion (drag and drop)

Fig. 2 Screenshots of some materials: **a** Animation explaining the subject; **b**, **c**, **d** End-of-subject reinforcement work

different observers scored students' responses between 1 and 5 as per the observation form.

2.4 Data collection tools

2.4.1 Observation form

Target learning outcomes of lesson topics prepared for the natural disaster were determined according to the goals and topic content indicated in the curriculum, and an observation form was also prepared. Two instructors, who are experts in special education, suggested an edit to the form, and upon applying this format of the form was finalized. At the end of the experiment process, the scores from the observers' forms were analysed and the reliability of the raters was calculated. In the sample of the observation form in Table 2, the target achievements to be scored in the teaching of erosion are seen. Observations were carried out for five separate activities, where after students were scored between 1 and 5 for every step they accomplished, and the average of these scores was calculated. One of the students could not be observed during the erosion lesson because he/she could not attend classes regularly.
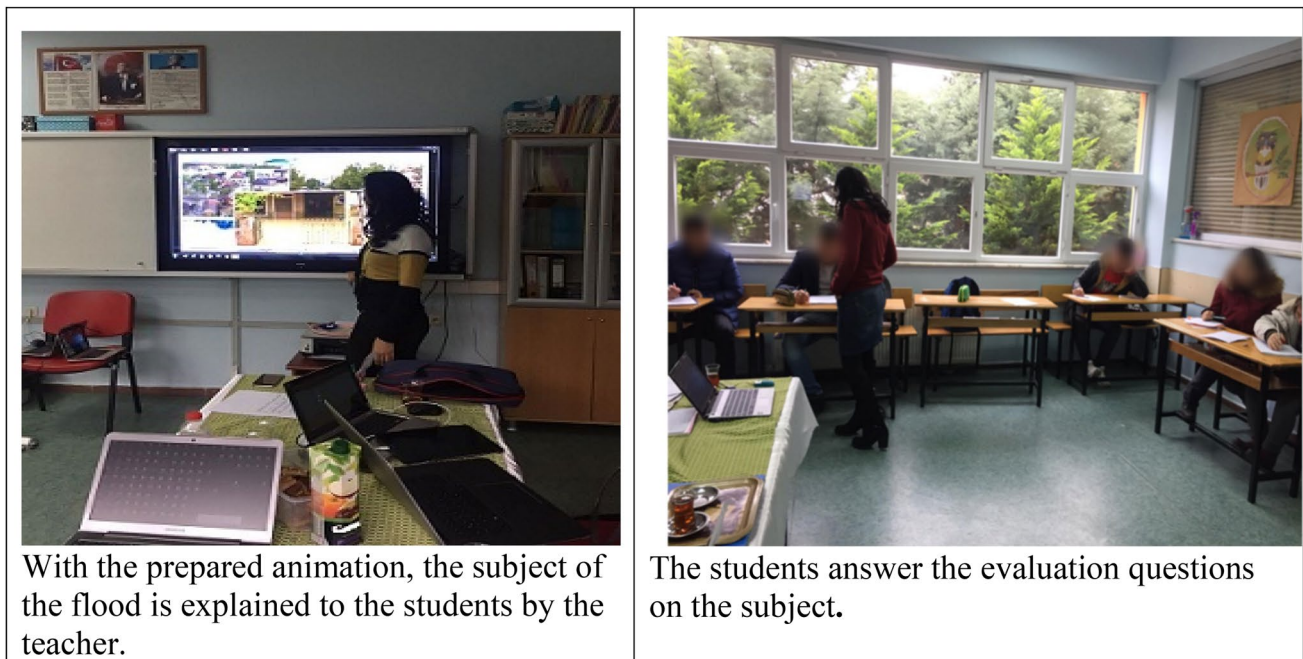
With the prepared animation, the subject of the flood is explained to the students by the teacher.

The students answer the evaluation questions on the subject.

Fig. 3 Photographs of the experimental process from the classroom

Table 2 Sample observation form for the subject of erosion

Target behaviour (Erosion)	Nehir	Eren	Seyit	Hafize	Eray	Yusuf	Muhammed
He/she articulates what erosion is	1	5	4	2	1	3	2
He/she describes how erosion occurs	0	5	3	2	1	3	3
He/she articulates why we should protect the soil	1	5	5	4	2	4	3
He/she articulates in which regions erosion is common	3	5	2	3	1	4	3
He/she articulates why erosion occurs	1	5	3	1	0	3	3
He/she says that urbanization is important factor in the occurrence of erosion	4	5	5	2	0	3	3
He/she describes the effect of excess water on the soil	1	5	4	2	0	3	3
He/she articulates forest fires and mining activities are important reasons for the occurrence of erosion	3	5	5	3	0	3	3
He/she can tell overgrazing animals cause erosion	5	5	5	2	0	3	2
He/she describes what to do to prevent erosion	0	5	4	3	0	4	3
He/she states afforestation protects the soil	4	5	5	3	0	3	4
He/she states pastures should be preserved to prevent erosion	0	5	1	2	0	4	3
He/she states vegetation should be preserved to prevent erosion	1	5	4	3	0	4	4
Means	1.83	5	3.82	2.47	0.33	3.36	3

2.4.2 Academic success test

Based on the relevant literature, a ten-question test form was prepared for each subject according to the target learning outcomes of the course, as to be presented for the approval of validity and reliability of the academic success test. These were presented to teachers and instructors who work in the special education field for approval for validity and reliability.

Once adjustments had been made according to the advice of the experts the finalized form included ratings such as "appropriate", "needs to be corrected", "not appropriate", and "explanation". Table 3 includes only questions and teachers' evaluations of earthquake lessons. After the questions were corrected as advised by the teachers, the first five questions were reorganized to constitute the pre-test questions, and the last five questions were reorganized

Table 3 Academic success test used for the evaluation of the earthquake lesson, and instructors' opinions about the suitability of the questions for the students' level

Earthquake questions	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Appropriate(3) %	Needs to be corrected (2) %	Not appropriate (1) %
Construct low-rise and solid buildings is minimize the damage of which natural disaster? (A) Landslide (B) Flood (C) Earthquake (D) Erosion	3	3	3	2	3	2	3	3	3	3	80	20	0
Which of the following is not included in earthquake an emergency bag? (A) Camera (B) Radio (C) Whistle (D) First aid kit	3	3	2	3	3	3	3	2	3	3	80	20	0
Which place is safer when we are caught in an earthquake in our house? (A) Near the window (B) Under the table (C) Ladders (D) Elevator	2	3	3	3	3	3	3	3	3	2	80	20	0
Which of the following actions should be carried out regarding earthquake is correct? (A) We must build our houses to be sturdy (B) We must attach the furniture to the wall with screws (C) We should prepare an earthquake emergency bag (D) All of the above	3	2	3	3	3	3	3	3	3	2	80	20	0
Which of the following should we not do during earthquake? (A) We should sit and crouch to protect our head (B) We should prepare an earthquake emergency bag for urgent needs (C) We should shut off electricity and natural gas against fire hazard (D) We should wait in the house for the tremor to end	2	3	3	3	2	3	3	1	2	2	50	40	10
Which of the below is not included among measures that can be taken before an earthquake? (A) Preparing an earthquake emergency bag (B) Preparing an earthquake evacuation plan (C) Fixing items such as cabinets and shelves to the wall (D) Staying away from places such as windows and stairs	2	3	3	3	2	2	3	1	3	3	60	30	10
What is the jolt caused by rupture in the Earth's crust? (A) Landslide (B) Tsunami (C) Earthquake (D) Erosion	1	3	3	3	3	3	3	3	3	3	90	0	10
If we are in a classroom during an earthquake, which of the following should we do? (A) We should crouch down on the ground next to the desks (B) We must jump out of the window (C) We should lie on the floor (D) We should get to the corridor	1	3	3	3	3	3	3	3	3	3	90	0	10
Which of the following is the first measure which should be taken to deal with earthquakes? (A) Building earthquake resistant houses (B) Doing research on earthquakes (C) To include the subject of earthquakes in the school curriculum (D) Informing ourselves about earthquakes	2	3	2	2	2	3	3	2	2	3	40	60	0
Which of the following items should be secured so as not to pose a danger during an earthquake? (A) Kitchen table (B) Chair (C) Large cabinet with glass (D) Beds	2	3	3	3	3	2	3	2	2	3	60	40	0

to constitute the post-test questions. Moreover, instructors were coded as T1, T2, etc.

2.4.3 Social validity form

Researchers developed a form with open-ended questions to collect students' opinions regarding the study based on the relevant literature. Three experts (an academic from the department of computer and educational technologies, an instructor of intellectually disabled students, and an academic in the field of assessment and evaluation) amended the questions so that their final form was as follows:

- Do you like the teaching materials?
- What did you like the most while studying the material?
- What did you dislike most while studying the material?
- Would you like similar technological tools (materials) to be used in other lessons? Which lessons would you like to have them in?

2.5 Data analysis

A Wilcoxon signed-rank test was performed to reveal the significance of the difference between the pre-test and post-test. Students' pre-tests, post-tests, and observation results were established using Spreadsheet; moreover, the interviews conducted by researchers were transcribed. A frequency analysis was conducted on the teachers' opinions regarding the academic test for a better understanding of similarity variations. To analyse the observation form, a Krippendorff reliability test was used to determine accuracy among observers. Students' observation score for each lesson was calculated according to the average of the scores noted by the observers.

3 Findings

3.1 Observation results of monitored sessions

Three observers evaluated the students individually at the end of each lesson, and they were given a score which varied between 1 and 5. Due to the fact that there were more than two raters, Krippendorff's Alpha reliability analysis was applied. The Krippendorff Alpha coefficient was calculated to be 0.795, which means agreement between researchers was at a high level (threshold value 0.8 and over) Krippendorff, [30], p: 242.

3.2 Pre-test, post-test, and observation scores of academic success

The graphics of the academic success pre-test and post-test scores and observation scores stated were given in this part.

At the end of the study, the researchers asked each student semi-structured questions in a 10-min conversation. Both the verbal and non-verbal responses of the students were noted by the researchers and expressed in a regular sentence. The related findings after examination are given in what follows.

Nehir: Nehir's results were analysed, and it has been noticed that her success rate in the erosion and landslide lessons increased significantly. To discern students' learning outcomes and how successful they have been, an individual observation has been conducted, the findings of which revealed that students' performance in the erosion lessons was low, yet was average in other lessons. Accordingly, and to be able to choose the correct answers, the student watched the scenes not less than two times while listening carefully; in addition, she responded to the hints and tips provided. Nevertheless, the student's concentration level was low, and a lack of self-confidence which led to multiple changes to her answers, which she had made based on the instructor's facial expressions, and difficulty in remembering the lesson itself were duly perceived (Fig. 4). Below is a statement by the student explaining her opinion regarding the digitalized material which she used in the lesson.

> *The student stated that she liked this activity on the computer that it was so much fun to learn via the computer, she liked that the questions had multiple choices and were interactive and expressed that she wanted similar activities in Turkish, Mathematics, Music, and Painting lessons.*

Seyit: It was determined that Seyit got full points in all subjects from the post-tests, his success was higher than the pre-tests, and the observation results were found to overlap these result. Seyit was able to read well but had difficulty in understanding the subject, was easily distracted, and answered questions with the help of clues after listening to most of the scenes twice because he was unable to concentrate enough for some topics in the observation session (Fig. 4). Seyit was asked about his opinions regarding the digitalized material which he used in the lesson.

> *Seyit stated that he liked these activities on computers, that he had learned better with the visuals presented by the computer, that he liked to answer questions directly, and that there should be such applications in Turkish and Mathematics lessons.*

Yusuf: Findings showed that his post-test grades increased compared to his pre-test grades, yet apart from the Landslide lesson, Yusuf's observation grades in other lessons were average. Additionally, during the follow-up session, it was noticed that Yusuf was able to read well and listened to the instructor carefully, but at some point, he got bored and lost concentration in the lesson and eventually started to answer the questions randomly. Thus, Yusuf was given a
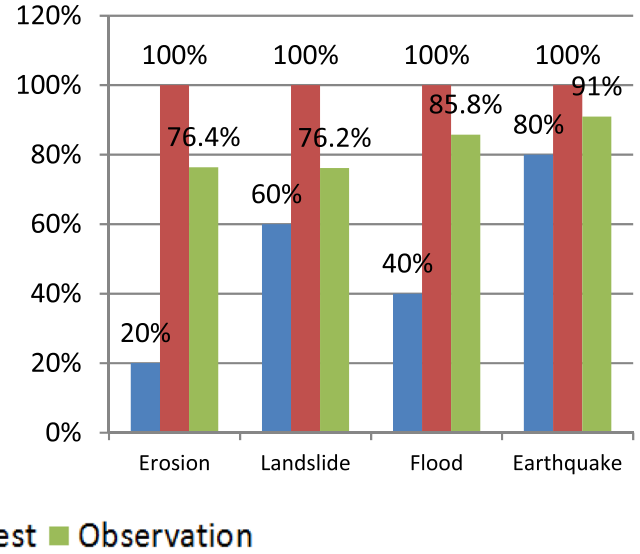
Nehir
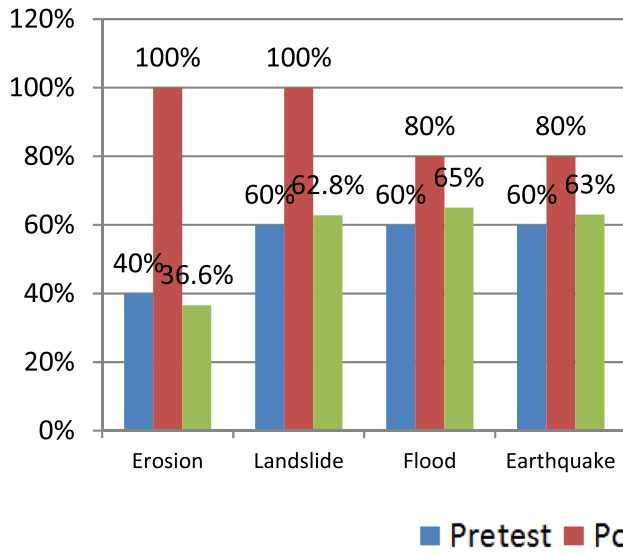
Seyit

Fig. 4 Graph representing Nehir and Seyit's learning accomplishment and results of the observation

short break and after which he carried on where he had left off (Fig. 5). Yusuf's thoughts on the material he worked on can be summarized as follows.

Yusuf stated that he liked this way of learning, liked to answer multiple-choice questions and work on the computer, but didn't like studying the erosion and

landslide subjects, and wanted such activities to be applied/made available for Mathematics and Turkish lessons.

Muhammed: The erosion lesson pre-test and post-test grades were quite different. During the lesson, not only did he get bored easily and lose his concentration level but he

Yusuf
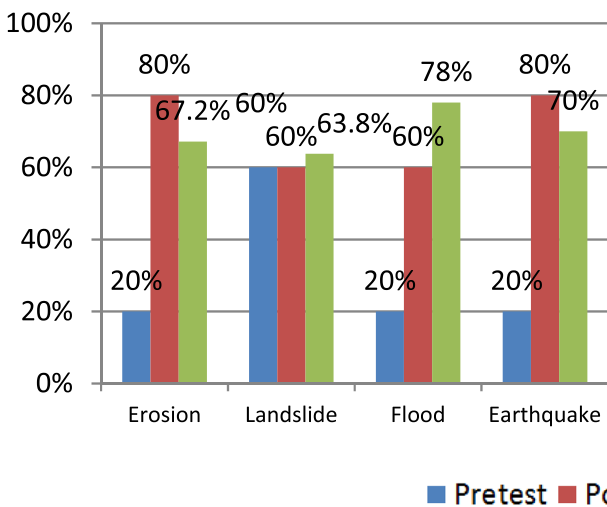
Muhammed
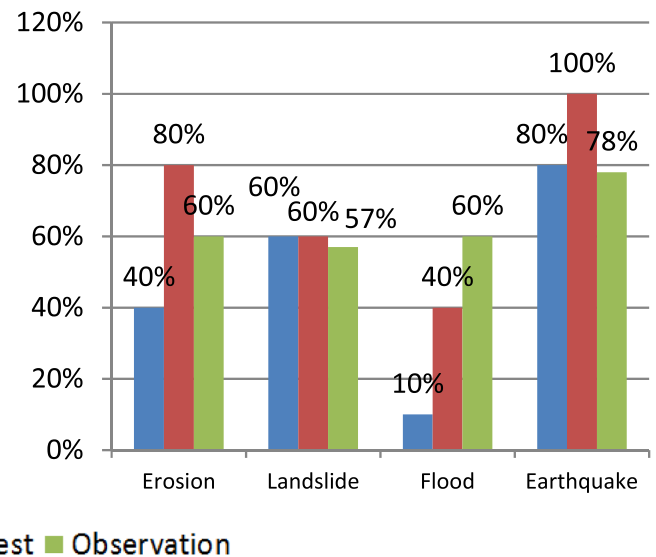
Fig. 5 Graph representing Yusuf and Muhammed's learning accomplishment and results of the observation

was also unable to answer the questions unless clues or hints were provided. His opinions about the material can be summarized as follows.

> *Muhammad could not decide whether he liked this kind of learning experience or not. He stated that it was good to learn from both the computer and paper material (digitalized and non-digitalized), and that he liked to be able to watch the lessons over and over. Moreover, he also liked that the materials were dubbed.*

Hafize: Her post-test grades were noticeably high compared to her pre-test grades, but her observation scores were average. She showed interest towards the digitalized material, but despite watching the scenes not less than twice, it was observed that her perception and expressive power were a little low, lacked the ability to express herself and her ideas. When she was asked about her opinions regarding the digitalized material she used in the lesson (Fig. 6), her response can be summarized as follows.

> *Hafize stated that she liked to participate in this type of activity, it was more useful to learn with the computer, she liked to learn with interactive exercises such as throwing in the basket, feedback, and pictures, and that these should be used in Mathematics and Turkish lessons as well.*

Eren: His grades in the post-test were higher compared to the pre-test, yet it was noticed that his pre-test grades were also relatively high. His observation scores were high because it was noticed that his concentration level and comprehension were good. Eren could answer

the questions correctly after listening to them only once. Aside from this, he was able to use the computer quite well. It was observed that Eren frequently squeezed and played with his fingers while answering the questions. Eren's opinions about the material are as follows.

> *Eren said that he liked this activity, liked multiple-choice questions and features such as drag and drop, voice narration, and other digitalized items; he thought learning on the computer was fun, and that there should be such activities in Turkish lessons and laboratory experiments as well.*

Eray: It was noticed that his post-test grades were higher than his pre-test grades. Eray did not want to conclude the erosion lesson observation session until the end of study; therefore, his erosion lesson grades were low. Yet, aside from erosion lesson, Eray's observation scores were good. He participated in the studies more carefully, as he was warned by the class teacher in the next sessions. Nevertheless, he had to read the topic many times over and had to listen to the track more than once because he kept forgetting what he was being taught during the class (Fig. 7). Eray's views on the material can be summarized as follows.

> *Eray said that he liked this learning methodology and, moreover, liked interactive exercises, multiple-choice questions, receiving feedback when he answered correctly. He liked features such as the next button, but didn't like to watch lectures again. He would like to study Mathematics and Turkish les-*
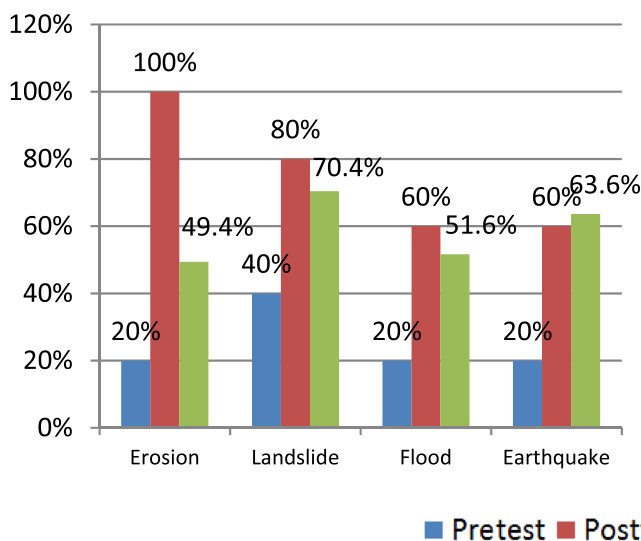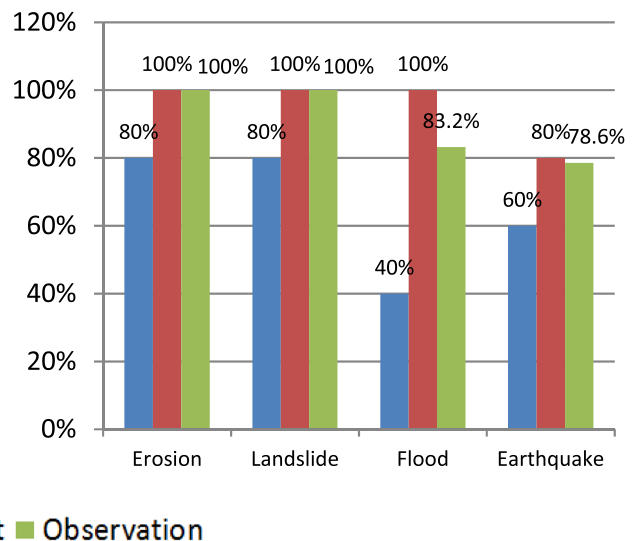

Fig. 6 Graph representing Hafize and Eren's learning accomplishment and results of the observation
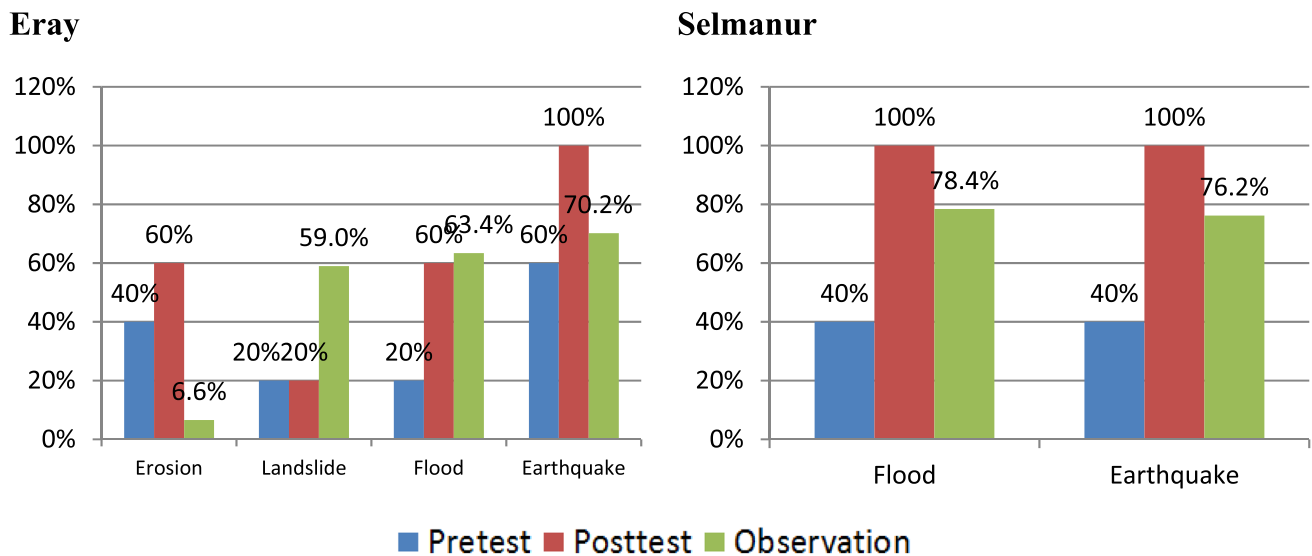
Eray

Selmanur

Fig. 7 Graph representing Eray and Selmanur's learning accomplishment and results of the observation

sons using the same methodology, and with the same digitalized activities on computer.

Selmanur: Since Selmanur did not attend classes regularly, she only attended the lessons for the flood and earthquake subjects and succeeded in these. It was observed that she was successful in the observation sessions, listened better if she focused, and could easily answer the questions. Selmanur's views on the material she worked on are as follows.

Selmanur stated that she liked this type of learning methodology, preferred the material used in teaching the earthquake lesson, learning by listening, flashcards, pictures, and interactive exercises; for instance, throwing in the basket, the sounds accompanying the digitalized exercises and the reinforcing comments she heard when the questions were answered. She wanted this learning method applied in Mathematics and Turkish courses as well.

To evaluate the efficacy of what the students had watched and listened to, students watched a digitalized story explaining the flood and landslide lessons which was presented on the smartboard. The observers then asked them questions which had been prepared earlier, where after their tests were graded. At the end of lesson, students answered the questions as interactive in the digitalized materials. Figure 8 shows the students' observation and academic success grades.

In general, the students understood the story which they watched during the observation session, but what we have noticed is they could not remember it. On the other hand, students generally answered the questions related to the story correctly in digitalized material. When the story activity grades were checked and either evaluation were concluded, and only Eray and Seyit were required to repeat the lessons as per the feedback they received from the digitalized material for the lesson due to the grades they received through digital material- grades were less than 70—among all other participants.

3.3 Findings related to pre-test and post-test results measuring students' academic success

A pre-test and post-test were carried out at the beginning and at the end of each lesson in order to evaluate the efficacy of the prepared materials for students' academic success. It has been deduced that students' pre-test and post-test scores can be compared, since their mental retardation scores, despite being mild, were close to each other.

To establish the significance of the difference between pre-test and post-test scores, Wilcoxon signed-rank test results were based on the total points scored by the students, which are shown in Table 4. This test was used due to the fact that the number of participants was low. According to Table 4, students' post-test success grades ($X = 15.25$; sd $= 3.5$) showed a significant increase compared to the pre-test grades ($X = 8.25$; sd $= 3.2$,) and the creative teaching materials positively affected their learning ($z = 2.53$; $p < 0.05$.) The effect of the prepared materials on learning was determined to be high ($r = 0.89$).
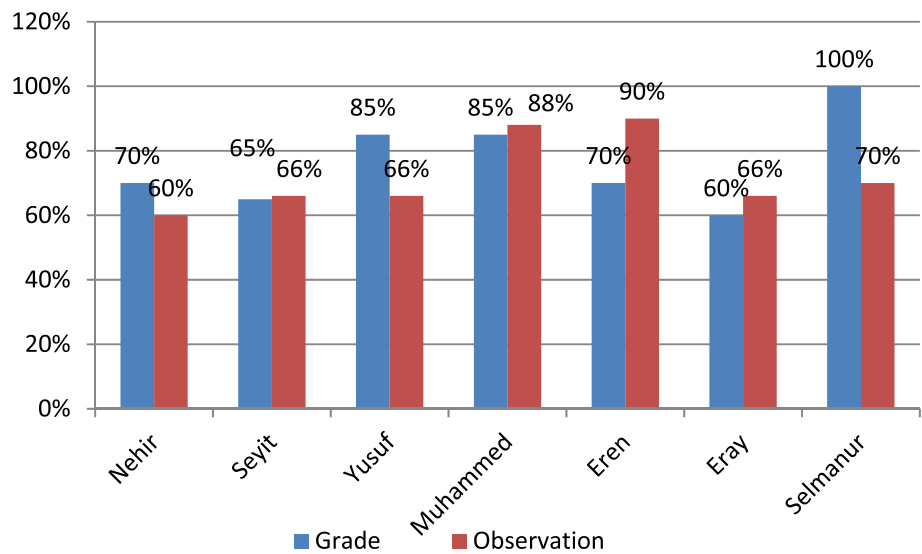
Fig. 8 Story grades

Table 4 Wilcoxon signed-rank test results of the pre-test and post-test total scores

Pre-test -Post-test	N	Mean rank	Sum of ranks	z	p	r
Negative ranks	0	.00	.00	2,527	.012	0.89
Positive ranks	8[b]	4.50	36.00			
Ties	0[c]					

[b]Post-test > Pre-test

4 Discussion and conclusions

In the context of this study, the utility of digital materials developed for students with mild intellectual disability at high school level and their effect on their academic success were analysed.

4.1 Students' learning proficiency

It has been observed that the post-test scores of the students increased significantly compared to the pre-test scores, and that the teaching materials had a positive effect upon their learning. Accordingly, the study determined the efficacy of the prepared materials in improving students' learning. Similar findings were found in the literature. Douglas et al. (2011) stated that text and illustrated graphic editors supported by electronic media help students with intellectual disability to understand the subject, and that such activities should be included in the school curriculum. Acungil [21] examined the effectiveness of the tablet computer curriculum offered with audio-visual technology in teaching students with mild and moderate intellectual disabilities, the ability to use tablet computers, and indicated all participants learned to use tablet computers with this audio-visual technology-supported program offered to them. Li et al. [14], Cullen [31], and Williams [32] have demonstrated that the curriculum supported by audio-visual technologies is effective in teaching vocational skills to individuals with intellectual disability. There are multiple studies in the literature which have argued for and proved the efficacy of technology in helping students with intellectual disability acquire academic skills Gökmen, [33]; Özgüç and Cavkaytar, [34]; Fitzgerald and Koury, [9]; Kellems et al, 2020; Sheriff and Boon, [35]; Öztürk, [36]; Özak and Avcıoglu, [37]. This study and its findings, therefore, contribute to the literature regarding the efficiency of technology in teaching students with intellectual disability.

4.2 The effect of using technology in Social Studies course on students in learning activities

When the students' opinions about the digital materials they used during the lessons and interacted with were reviewed, they stated that they liked doing such activities on computer and the fact that questions were optional and interactive brought fun and joy to learning in the class; furthermore, they wanted such digitalized applications to be applied in other lessons, such as Turkish, Mathematics, Music, and Art. The reason why students especially want to use such materials in Turkish lessons may be that they have difficulties in expressing themselves verbally

and in writing, as well as in understanding Turkish texts due to their disabilities, and those teachers do not have sufficient material related to this course. Similar findings can also be seen in the literature Acungil, [21]; Çankaya, [38]; Geçal and Eldenïz Çetïn [39]. This study's findings revealed that students showed a preference for receiving feedback regarding their answers (to interactive questions of the digitalized materials) while they were studying. In the literature, Smith and Okolo [40] argue that technology makes teaching more effective by providing consistent and immediate feedback, which supports the findings of this study.

Considering the findings of this study, some suggestions can be proposed for further research and application. Similar studies can be conducted for various students with different disabilities, and for those of different age groups. In other subjects for students with mild intellectual disabilities, teaching environments can be designed by following an approach similar to this study. If digital stories and questions related to them are both provided in a lesson, students' participation will be positively affected. In addition, there are several other factors to be considered in the presentation of course topics through gamification and stories along with curriculum-integrated system established on the web, which will enable students to continue their education and training activities in their homes, particularly when they cannot continue in the classroom environment due to situations such as COVID-19 pandemic.

The digital materials developed in the context of this study can be easily used at home or in any other environment by students' parents and/or any other family members of students with intellectual disability, similar to that of establishing a creative learning environment in the classroom. The interactivity feature used in the materials of this study positively affected the students' participation, learning and motivation, and increased the variety of media and materials for the social studies course. The preparation of digitally based material for the teaching of students with intellectual disabilities at high school level such as with interactive videos and animations will contribute to students' motivation and learning. This environment is not limited by either time or location. In order to prepare effective teaching environments in special education, special education and education technology specialists should come together and design collaborative studies for the special education curriculums by using gamification. The digital materials can be integrated into the widely used Android and iOS operating systems today and can be used on a website or Web 2.0. platforms (blogs, cloud computing environments, social networks, etc.) by creating repositories for learning material.

4.3 Limitations

In a single-subject design with a multiple baseline model that has probe conditions across participants' models, a general session is held after working with each student individually. However, in this study, due to crowded classrooms, limited time, and having only one instructor, lessons were delivered for the class collectively by the instructor through the smart board instead of individually for each student. At the end of each lecture, each student sat in front of a computer and answered interactive questions. Therefore, the materials are designed to be utilized both individually and in groups. Studies on the efficacy of materials in individual teaching should therefore be conducted in further studies.

Data availability The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request. Access to data can be provided if desired.

Declarations

Conflict of interest The authors declare that they have no competing interest.

References

1. Güngör, M., Bolat, A., Cengiz, H., Aslan, N.: Özürlülere yönelik teknolojik düzenlemeler (Technological regulations for disabled people). https://www.btk.gov.tr/uploads/pages/slug/ozurlulere-yonelik-teknolojik-duzenlemeler.pdf Accessed: 20 February 2020 (2011)
2. Tekinarslan, E.: Egitim ve teknolojisi: Teorik ve kavramsal temeller (Education and technology: theoretical and conceptual foundations). Abant İzzet Baysal Univ. J. Educ. Fac. **6**(1), 113–130 (2006)
3. Wehmeyer, M.L.: Universal design for learning, access to the general education curriculum and students with mild mental retardation. Exceptionality **14**(4), 225–235 (2006). https://doi.org/10.1207/s15327035ex1404_4
4. Jeffs, T., Behrmann, M., Bannan-Ritland, B.: Assistive technology and literacy learning: reflections of parents and children. J. Spec. Educ. Technol. **21**, 37–44 (2006). https://doi.org/10.1177/016264340602100104
5. Arpacık, Ö., Kurşun, E., Göktaş, Y.: Zihinsel engelli öğrencilere yönelik etkileşimli tahtalara uygun içerik geliştirme deneyimi: Bir durum çalışması (A Content Development Experience Suitable for Interactive Boards for Mentally Retarded Students: a Case Study). In: International Instructional Technologies &Teacher Education Symposium, Karadeniz Technical University, Trabzon (2013)
6. Boot, F.H., Dinsmore, J., Khasnabis, C., MacLachlan, M.: Intellectual disability and assistive technology: opening the GATE wider. Front. Public Health **5**, 1–4 (2017). https://doi.org/10.3389/fpubh.2017.00010

7. Kim, M., Cho Blair, K.S., Lim, K.: Using tablet assisted Social StoriesTM to improve classroom behavior for adolescents with intellectual disabilities. Res. Dev. Disabil. **35**, 2241–2251 (2014)

8. Mechling, L.C., Ayres, K.M., Foster, A.L., Bryant, K.J.: Evaluation of generalized performance across materials when using video technology by students with autism spectrum disorder and moderate intellectual disability. Focus Autism Other Dev. Disabil. **30**(4), 208–221 (2015). https://doi.org/10.1177/10883 57614528795

9. Özgüç, C.S., Cavkaytar, A.: Developing technology supported ınstructional activities in a class of middle school students with intellectual disability. Educ. Sci. **41**(188), 197–226 (2016). https://doi.org/10.15390/EB.2016.6691

10. Sola-Özgüç, C.: Developing technology supported ınstructional activities in a class of middle school students with ıntellectual disability. Dissertation, Anadolu University Institute of Educational Sciences (2015)

11. Yücesoy-Özkan, Ş., Öncül, N., Kaya, Ö.: The effects of computer-based instruction on teaching emergency telephone numbers to students with intellectual disability. Education and Training in Autism and Developmental Disabilities, 48(2):201–218 (2013). https://www.jstor.org/stable/23880640?seq=1

12. Xin, J.F., Sutman, F.X.: Using the smart board in teaching social stories to students with autism. Teach. Except. Child. **43**(3), 18–24 (2011). https://doi.org/10.1177/004005991104300402

13. Ramdoss, S., Lang, R., Fragale, C., Britt, C., O'Reilly, M., Sigafoos, J., Didden, R., Palmen, A., Lancioni, G.E.: Use of computer-based interventions to promote daily living skills in individuals with intellectual disabilities: a systematic review. J. Dev. Phys. Disabil. **24**, 197–215 (2012). https://doi.org/10.1007/s10882-011-9259-8

14. Li, T.-Y., Chen, M.-C., Yin, Y.-L., Li, S.-C.: The effectiveness of adapted web pages on the learning performance of students with severe mental retardation. Int. J. Rehabil. Res. **26**(3), 219–222 (2003). https://doi.org/10.1097/00004356-200309000-00009

15. Avcı, U.: Öğretim ortamları ve materyal tasarımı. In: Sarıtaş, M. (ed.) Öğretim teknolojileri ve materyal tasarımı içinde, pp. 37–54. Pegem Akademi, Ankara (2009)

16. Sümer, S., Eldeniz Çetin, M.: Comparison of the effectiveness and productivity of the use of digital stories and conventional listening in listening comprehension on individuals with intellectual disabilities. Education Sciences (NWSAES), 13(1),44–55 (2018), DOI: https://doi.org/10.12739/NWSA.2018.13.1.1C0679, https://dergipark.org.tr/tr/download/article-file/408622

17. Taşkıran, A. Dijital çağda yükseköğretim. Açıköğretim Uygulamaları ve Araştırmaları Dergisi, 3 (1) , 96–109 (2017). https://dergipark.org.tr/en/pub/auad/issue/34114/377387

18. Bates, A.W.: Teaching in a Digital Age: Guidelines for designing teaching and learning. Tony Bates Associates Ltd publishing (2016). https://opentextbc.ca/teachinginadigitalage/

19. Budak, E., Deveci-Topal, A., Geçer, A.: Lise düzeyinde zihinsel engelli öğrencilereyönelik öğretim teknolojileri kullanımındayaşanilan güçlüklerin belirlenmesi (Determining the difficulties in using educational technologies for mentally disabled students at high school level). In: Dönger A,Yıldız H (ed), Eğitim bilimlerinde akademik çalışmalar (Cilt 2). Ivpe print (2019)

20. Güleç-Aslan, Y., Özbey, F., Bilgiç, E., Çetinkaya, Ç., Sola Özgüç, C., Fidan, A., Cihan, H.: Özel eğitim öğretmenlerinin yeterlik algıları (Competence perceptions of special education teachers) (Project Number: 2012-06-12- 002). Sakarya: Sakarya University Scientific Research Project (2012)

21. Acungil, A.T.: Effectiveness of tablet computer instruction program (TACIP) presented via audio-visual technologies on teaching the use of tablet computer to students with intellectual disability. Dissertation. Eskisehir: Anadolu University, Institute of Educational Sciences (2014)

22. Martin, S.S.: Special education, technology, and teacher education (2006). http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.113.1310&rep=rep1&type=pdf Accessed: 10.02.2020

23. Tekin-İftar, E.: Çoklu yoklama modelleri (Multiple Probe Models). In: Tekinİftar, E. (ed.) Eğitim ve Davranış Bilimlerinde Tek Denekli Araştırmalar, pp. 217–255. Publications of the Turkish Psychological Association, Ankara (2012)

24. Tekin-İftar, E.: Tek denekli araştırmalar ve temel kavramlar (Single subject studies and basic concepts). In: Tekin-İftar, E. (ed.) Eğitim ve Davranış Bilimlerinde Tek Denekli Araştırmalar, pp. 15–34. Publications of the Turkish Psychological Association, Ankara (2012)

25. Sönmez, S., Kot, M., Sazak Pınar, E.: The review of comparative single subject research designs used in researches in Turkey. Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 350–371 (2017)

26. Yeni, S., Cağıltay, K., Karasu, N.: Usability investigation of an educational mobile application for individuals with intellectual disabilities. Univ. Access Inf. Soc. **19**, 619–632 (2020). https://doi.org/10.1007/s10209-019-00655-0

27. World Health Organization (1996) ICD guide for mental retardation. Geneva: https://www.who.int/mental_health/media/en/69.pdf.

28. LaJoie, J., Miles, D.K.: Treatment of attention-deficit disorder, cerebral palsy, and mental retardation in epilepsy. Epilepsy Behav. **3**, 42–48 (2002). https://doi.org/10.1016/s1525-5050(02)00506-1

29. Mayer, R.: Designing instruction for constructivist learning. In: Reigeluth, C. (ed.) Instructional-design theories and models: a new paradigm of instructional theory (II). Lawrence Erlbaum Associates, Mahwah, USA, NJ (1999)

30. Krippendorff, K.: Content analysis: an introduction to its methodology (2nd Edition). Sage Publications, California, CA (2004)

31. Cullen, J.M.: Effects of self-directed video prompting using ipads on the vocational task completion of young adults with ıntellectual and developmental disabilities. Doctoral dissertation, The Ohio State University (2013)

32. Williams, K.: The use of video prompting via an iPad® and a system of least to- most prompting to teach ındividuals with moderate ıntellectual disabilities the vocational task of rolling silverware. Doctoral dissertation, Liberty University, Lynchburg, VA (2013)

33. Gökmen, C.: The effectiveness of simultaneous prompting procedure on teaching the skill of watching instructional cd on the computer to students with intellectual disabilities. Published master thesis. Bolu: Abant Izzet Baysal University, Institute of Educational Sciences, Department of Education for the Mentally Retarded (2014)

34. Fitzgerald, G., Koury, K.: Research on computer-mediated instruction for students with high incidence disabilities. J. Educ. Comput. Res. **38**(2), 201–233 (2008). https://doi.org/10.2190/EC.38.2.e

35. Özak, H., Avcıoglu, H.: The effects of simultaneous prompting presented via computer on the reading skills of children with intellectual disability. Abant İzzet Baysal Univ. J. Educ. Fac. **12**, 33–50 (2007)

36. Öztürk, Z.H.: The effectiveness of touch math to teach number-object matching via simultaneous prompting on a tablet computer. Published master thesis, Abant İzzet Baysal University, Institute of Educational Sciences, Bolu (2016)

37. Sheriff, K.A., Boon, R.T.: Effects of computer-based graphic organizers to solve one-step word problems for middle school students with mild intellectual disability: a preliminary study. Res. Dev. Disabil. **35**, 1828–1837 (2014). https://doi.org/10.1016/j.ridd.2014.03.023

38. Çankaya, S.:Development and evaluation of skill teaching software for parents of individuals with intellectual disability to teach

self-care and domestic skills. Master thesis. Eskisehir: Anadolu University, Institute of Educational Sciences (2013)

39. Geçal, İ., Eldenïz Çetïn, M.: The effectiveness of addition without carry presented via tablet to children wıth mental disabilities. Educ. Sci. 13(1), 75–89 (2018)

40. Smith, S.J., Okolo, C.: Response to intervention and evidence-based practices: where does technology fit? Learn. Disabil. Q. **33**, 257–272 (2010). https://doi.org/10.1177/0731948710 03300404

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.