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The effect of algorithm teaching on the problem-solving skills of deaf-hard hearing students

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Abstract

Purpose – The purpose of this paper is to identify the effects of algorithm teaching on the problem-solving skills of deaf-hard hearing students.

Design/methodology/approach – In this research, a pre-test and post-test problem-solving scale was applied to the single group (16 deaf-hard hearing students at a secondary school level) that had received algorithm education. Pre-test and post-test results were compared in order to see whether there was a significant difference among students in terms of their problem-solving attitudes. Students' levels of performing the applications were examined through observation forms and their opinions about algorithm teaching were received.

Findings – As a result of the research, it was determined that implemented algorithm teaching had a significant effect on improving the problem-solving skills of the students.

Originality/value – Scratch training can be administered as either a compulsory or an optional course for hearing students as the Scratch programme offers the opportunity of teaching algorithmic reasoning with games, making the courses entertaining and giving students the chance to create their own designs which helps to improve their creative problem-solving skills and their motivation accordingly. Scratch teaching can be beneficial in developing students' problem-solving behaviours and creativity.

Keywords Programming, Secondary school, Algorithm teaching, Problem-solving skills, Scratch training, The deaf-hard hearing

Paper type Research paper

1. Introduction

In the world of ever-changing knowledge, the subject of the development of problem-solving skills and the use of programmes to aid the teaching of algorithms has caught the attention of many in the field. The teaching of programming is based upon algorithms. Karlı (2009) stated that algorithm is the way including procedures, decisions and performance of these respectively to solve a problem. According to the literature, training students in computer programming and design tools improve their digital literacy and motivation towards school and lessons (Akpınar and Altun, 2014). Moreover, students' problem-solving skills, analytical thinking, and learning habits such as designing major product-directed projects, learning by doing and learning by teaching to computer can be improved (Akpınar and Altun, 2014; Çakıroğlu *et al.*, 2011). In addition, programming improves the computational thinking (CT) skills of students. CT is taking an approach to solving problems, designing systems and understanding human behaviour that draws on concepts fundamental to computing (Wing, 2006). CT is being located at the focus of educational innovation, as a set of problem-solving skills that must be acquired by the new generations of students to thrive in a digital world full of objects driven by software (Román-González *et al.*, 2017).

In order to enable the beginners of programming education to be more competent with information technologies, various visual programming languages have been developed. Scratch is one of those languages and basically offers an attractive and entertaining

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environment for the students who are interested in learning programming. Users are able to design projects by dragging blocks of code without writing the code themselves, so this facilitates algorithm learning for new users (Scratch About, 2015). Owing to its simple, user-friendly interface, millions of people are creating Scratch projects at home, school, libraries or community centres and sharing their creations with Scratch users from all over the world in the online community. In a related study, students were asked to use the Scratch programming language and write response reports, which were examined following observations and interviews. As result of the study, it was understood that the programming environment had an effective and motivating influence on the students' comprehension of mathematical procedures (Calder, 2010). In another study, programming learned by using Scratch and Math test grades were found to be related and the curriculum leveraged and enriched students' mathematics content knowledge (Lewis and Shah, 2012). The students enjoyed the process and became more motivated as they created materials using their coding skills (Howland and Good, 2015).

Kalelioğlu and Gulbahar (2014) investigated the effect of Scratch programming on the problem-solving skills of primary school students in fifth grade. According to study's conclusions, the students found it easy to use the Scratch platform, enjoyed it and wanted to improve learning programming although there was no evidence that the Scratch platform significantly contributed to their problem-solving skills. On the other hand, Brown *et al.* (2008) conducted a study with students in grades 5 and 6; during each lesson with Scratch, students are taught to use a variety of problem-solving skills and strategies and determined that, after the training, the problem-solving skills of the students improved more than the control group.

Today, owing to technological tools, students have easier access to computer games, digital stories, simulations and animations. While students normally are users of the aforementioned tools, it is also possible for them to become producers by means of programmes such as Scratch.

Learning and refining problem-solving skills is critical for all students, but it makes an even greater difference for students with physical impairments such as hearing impairment. The type and degree of the hearing loss cause hearing-impaired individuals to encounter problems such as motor development issues in terms of balance and coordination disorders, cognitive delay due to the lack of auditory life, social problems caused by the delay in expressive language, and academic issues (Bayrakdar and Çuhadar, 2015). According to the theory of mind, development of hard hearing children in language acquisition is delayed in comparison to their peers due to their relatively more limited chances to learn cognitive structures at early ages (Russell *et al.*, 1998).

Ratner (1985) reported that visual-spatial-perceptual deficits in deaf children dramatically delay the linguistic and social development. Visual spatial skills of hearing impaired students are lower than hearing individuals and such skills are associated with different cognitive abilities and processes (Marschark *et al.*, 2015). The academic achievements of deaf-hard hearing students also fall behind their hearing peers (Marschark *et al.*, 2009; Tanrıdiler, 2013). Therefore, deaf and hard of hearing students, while they learn numerical skills relatively easily, have more difficulty in solving problem sentences because their verbal and written abilities do not improve adequately in comparison to their peers with normal hearing. According to Laurent (2014), hearing loss affects a child's language, social and cognitive development and the delay from one of these also affects the others. Deaf-hard hearing students in the studies conducted in many countries received low scores in evaluations such as problem solving, logical thinking and reasoning (Pagliaro and Kritzer, 2013). Also Luckner and McNeill (1994) and Laurent (2014) found out that the level of problem solving skills of hard of hearing and hearing-impaired students is lower than that of students with normal hearing.

The potential performance of the deaf and hard of hearing students can be enhanced to the highest level by including and implementing teaching methods that help to develop cognitive strategies in education programmes (Tüfekçioğlu, 2005). Improving their skills, cognitive strategies and learning algorithmic reasoning in order to increase their academic performance will help the deaf-hard hearing students to develop behaviours to solve the problems in future. The individual who understands algorithmic reasoning can suggest various ways of solving a problem, have a more systematic approach to situations, shorten the path to a solution, identify connections between situations more easily and think creatively.

As Giannakos and Jaccheri (2014) stated, particularly programming focussed, exciting, creative and collaborative environments facilitate learning process. Recent technologies do not only provide with more active physical engagement, but also enable new and collaborative interactions. Software- and hardware-intensive activities raise awareness of technology, intensify the experience, and invite students to explore boundaries and increase collaboration and the exchange of ideas and views (Giannakos and Jaccheri, 2014).

Studies with people who need special education in Turkey are rare (Karal *et al.*, 2016). In Turkey, computer programming skills and the adoption of these skills are becoming more significant with every passing day. The Ministry of National Education is also carrying out some studies about the topic and updating some courses in our education system. The results of the literature search revealed that there is no such work done that develops problem solving skills of deaf-hard hearing students in Turkey. Individuals who need special education should be provided developed learning environments that can provide equal opportunities, finding solutions to the problems they face throughout their lives and meet the training needs of them. From all reasons above, this research was deemed necessary to teach algorithmic reasoning with Scratch programming that involves less verbal structures and is implemented by the drag and drop method, in order to develop problem-solving skills of deaf-hard hearing students. The aim of this research was to identify the effects of algorithm teaching on the problem-solving skills of deaf and hard hearing students.

1.1 Research questions

RQ1. What is the effect of using the programme Scratch to teach algorithms to deaf-hard hearing students from the fifth, sixth, seventh, and eighth grades on their problem-solving skills?

1.1.1 Sub-questions

(1) Is there a meaningful difference between hearing-impaired students' scores on problem-solving skills before and after the application of the Scratch programme?

(2) What are the observations results of the students on the Scratch programme sub-skills?

(3) What are views of the students related to learning algorithm through Scratch and how is their perception about the course implementation?

2. Method

2.1 Research method

In this research, a mixed method that unified the research results through the triangulation approach, quantitative and qualitative data collection methods was used in order to see whether there was any difference between pre- and post-implementation scores of same group of the problem-solving skills scores of the deaf-hard hearing students using the applications based on the algorithmic reasoning. Thus, the quantitative and qualitative data were mixed in an effort to obtain more reliable results. Mixed research presents, analyses and allows us to bring together events in a framework by using various methods (Baki and Gökçek, 2012).

According to Creswell (2006), the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone. Mixed methodology expands the diversity of methods and techniques presented to the researcher and allows searching for answers to research questions (Karal *et al.*, 2016).

The findings gathered from the quantitative and qualitative measuring tools were compared and analyses were used to determine their consistency. In the research, the quantitative data were collected by using a one group pre-test & post-test experimental design and the qualitative data were collected through interview and observation techniques. Post-test was applied seven weeks after the pre-test was applied.

At the beginning of the research, one group was composed. The group was administered a 6-hour Scratch programming per week for six weeks during the research process.

2.2 Research participants

The participants in this study have been selected, by method of purposeful and easily accessible sampling, from Gazanfer Bilge Hearing Impaired Secondary School in Kocaeli, which is one of regional boarding secondary schools and has relatively more deaf-hard hearing students in number than other state schools and special education schools have, where deaf-hard hearing students can enrol in. All students in the school were included in the research because the number of students regularly attending these schools was low. According to Ministry of National Education Statistics, throughout Turkey, there were 2,065 deaf-hard hearing students at the secondary level and 45 schools in the 2014-2015 school year (Ministry of National Education Statistics, 2015). The group that took part in this research was composed of 16 students from the fifth, sixth, seventh, and eighth grades. Six of the students were female and ten of them were male. Three of the students had started school at the age of 10, 1 of them at 11 and 12 of them at 7. In addition, two of these students were diagnosed with a learning disability and one of them was reported to have behavioural problems by his/her teachers. Gender, age, grade, level of hearing loss, mathematical and reading skills of the students are given in Table I. The information in the school records was taken into account as there was no medical information about the students' hearing degree and added to the table. According to this table, the hearing loss levels of students are very high (except one) and eight of them use hearing aids. Students' reading abilities are generally weak and math achievement is moderate.

Student	Gender	Age	Grade	Using a hearing aid	Hearing loss grades of students Very high (91 dB HL) Medium (56-70 dB HL)
S1	Male	11	5	Yes	Very high
S2	Male	11	6	No	Very high
S3	Female	12	6	Yes	Very high
S4	Male	12	6	Yes	Medium
S5	Female	13	7	Yes	Very high
S6	Male	13	7	Yes	Very high
S7	Male	13	7	Yes	Very high
S8	Female	16	7	No	Very high
S9	Male	13	7	No	Very high
S10	Male	14	8	No	Very high
S11	Female	14	8	Yes	Very high
S12	Female	14	8	Yes	Very high
S13	Female	14	8	No	Very high
S14	Male	17	8	No	Very high
S15	Male	17	8	No	Very high
S16	Male	17	8	No	Very high

Table I. Demographic information of students related gender, age, grade, level of hearing loss, reading and mathematical skills

2.3 Data collection

As a tool for collecting data, a scale of problem-solving skills was administered to the group as a pre-test before the experimental procedure. The teaching of Scratch programming content was implemented as the experimental procedure. The deaf-hard hearing students were taught on Scratch by the first two authors of this paper. The teachers were from the same school as the students helped the researchers and students to communicate via sign language. Following the experimental procedure, the scale of problem-solving skills previously administered as a pre-test was performed as a post-test and observation forms were filled out by three observers (authors of this paper) during one hour of Scratch teaching implemented every week. In the end of the experimental procedure, the observers interviewed the students individually by asking open-ended questions so as to receive their opinions about the teaching process.

2.4 Data collection tools

To determine the problem-solving skills of the students, "The Scale of Problem-Solving Skills for The Deaf – Hard Hearing" and two forms were administered in the research; an observation form developed by the researchers to monitor the students' skills on Scratch and an open-ended questionnaire form to find out opinions of the students related to application process of Scratch programme were employed.

2.4.1 Scale of problem-solving for the deaf-hard hearing. The Scale of Problem-Solving Skills was developed by Sezgin (2011) to determine the problem-solving skills of secondary school students with no physical impairments. The prepared scale was administered to a group of 262 students enrolled in the 2010-2011 academic year in the fourth, fifth, sixth, seventh and eighth grades of a private primary and secondary school located in the province of Izmir. Expert opinion was received for the construct validity of the scale and a KR-20 reliability coefficient was calculated for the reliability of the scale. As a result of the statistical calculations performed on Excel and SPSS, the KR-20 internal consistency coefficient of the scale was found to be 0.76. Reliability coefficient, which meant consistency, was figured out by using the test-retest method as well. As a result of the calculations, the correlation coefficient was found to be 0.94.

In order to be able to use this scale in this research, permission was requested from the scale's author via e-mail. Then, the researchers, with the help of the teachers, visualized and simplified the expressions and options in the questions in the scale for the deaf-hard hearing students in accordance with their lives; thus, the scale of problem-solving for the deaf-hard hearing (SPSDH) was developed by the authors for this research (Author, in press). Three academicians (one from the field of special education, two from the field of computer and instructional technologies education) and six teachers from different fields, each with at least five years of experience and working in the deaf-hard hearing secondary school (three teachers of the deaf-hard hearing, two Turkish-language teachers, one maths teacher) were asked for their opinions about the items in the scale and the form. Constructed according to the opinions received, the scale was administered to 73 students (42 males, 31 females) studying in the fifth, sixth, seventh, and eighth grades of Duyum Hearing Impaired Secondary School in Bursa. During data collection from the students, the measurement instrument was given to them and they were instructed to read it. Despite the fact that most of the students read what was written, many were unable to comprehend the meaning and therefore their teachers had to explain the scale in sign language.

The SPSDH consisted of eight items regarding the planning of a holiday for a family of three, working out the problems they encountered and determining which questions they needed to answer in order to find a solution. To evaluate the responses, the right answer was scored with 1 and the wrong was with 0. The highest score that could be obtained from the scale was 8. The scale is given in the Appendix.

In the present research, context and construct validity were analysed within the scope of validity studies. Calculated for the results of SPSDH, Cronbach's α coefficient was found to be 0.70, moderately reliable.

For the reliability of the Scale of Problem Solving Skills in this case, KR-20 reliability coefficient was calculated. As can be seen from Table II, the KR-20 internal consistency coefficient was found as 0.704. According to Kline (2000), a reliability of 0.7 is a minimum for a good test. As shown in Table II, KR-20 internal consistency coefficient was 0.704 as "acceptable". This proved that the measurement tool explained the problem-solving skills with eight items by 70 per cent. The indices of items' difficulty and discrimination were looked into as well. The information related to the indices of items' difficulty and discrimination are presented in Table III.

The value of item difficulty index ranges between 0 and +1: the higher the value, the easier the item. If the index of item difficulty is 0.50, the question is accepted as moderate (Atılgan *et al.*, 2009).

The index of item discrimination ranges between −1 and +1. A negative index of item discrimination means that the individuals whose total test grades are high have obtained low scores from questions; in other words, the students who have succeeded on the whole test have answered the question less correctly and it discriminates the individuals in respect to the features of the items expected to be measured (Atılgan *et al.*, 2009).

Non-existence of the negative index of item discrimination on the items in the problem-solving scale proves that the existing items have measured what they are intended to. However, if the index of item discrimination is 0, that means there is no relationship between the item and test (Atılgan *et al.*, 2009). There were no items with a discrimination index of 0 in the measurement tool. The item with the lowest index of item discrimination was the second item with a value of 0.40.

2.4.2 Observation form. The content to be presented to the students on Scratch was first researched in the literature and then the observation form was created according to the established work plan. The designed observation form was submitted to the experts whose assistance had been asked regarding the scale of problem-solving skills. The content of the programme was split into weekly sections. There was an observation form for each week prepared for the skills within the context. The skills in the observation form were scored weekly (for 1 hour of training) for each student by a group of three researchers and when the process was over, the scorer reliability was calculated in the observers' forms. The subjects that would be scored in the observation form during the weekly Scratch teaching period (in total 6 hours of training) are seen in the example of observation form shown in Table IV. Observations were made for four different applications and points between 1 and 5 were given to them for every step and averages of these scores were taken. "S1", "S2" […] stand for the students.

Table II. The analysis result of problem-solving skills

Item number	8
KR-20	0.704

Table III. The indices of items difficulty and discrimination in the scale of problem-solving skills

Item no.	I1	I2	I3	I4	I5	I6	I7	I8
Index of Item difficulty (p)	0.30	0.25	0.58	0.63	0.35	0.45	0.55	0.58
Index of item discrimination (r)	0.60	0.40	0.85	0.75	0.70	0.50	0.50	0.75

Table IV.
Example of observation form

Date	Tasks	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
11 April 2016	Adding character	5	5	5	3	5	5	3	5	5	5	5	3	5	5	5	5
	Changing character	5	5	5	5	5	5	3	5	5	3	5	5	5	5	5	5
	Growing object	5	5	5	5	5	3	3	5	5	5	5	3	5	5	5	5
	Shrinking object	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
	Multiplying object	4	4	5	4	5	4	4	4	4	4	5	4	4	5	5	5
	Moving	5	5	5	5	5	5	4	5	4	5	5	3	5	5	5	4
	Rotating	5	4	5	3	3	4	4	5	4	3	3	4	5	5	4	4
	Moving right and left	4	5	5	5	5	3	4	5	5	3	4	5	5	4	4	5
	Adding object	5	5	5	4	4	4	3	5	4	4	4	5	5	5	4	5
	Setting loop	4	5	5	4	5	4	3	5	4	5	4	5	5	5	4	5
	Changing colour	4	3	3	4	5	3	2	5	5	3	3	3	5	4	5	5
11 April 2016	1. Application average	4.63	4.63	4.81	4.27	4.72	4.09	3.45	4.90	4.54	4.09	4.36	4.09	4.90	4.81	4.63	4.81
11 April 2016	1. Application average	5	5	5	4	5	4	3	5	5	4	4	4	5	5	5	5

2.4.3 Interview form. A form composed of open-ended questions to gather opinions of the students on Scratch was developed by the researchers after a review of the literature. Three experts' opinions were taken into consideration (one academician from the department of computer and instructional technologies education, one teacher of the deaf-hard hearing and one academician from the field of assessment and evaluation). The items included in the form are as follows:

(1) What are your positive and negative opinions about this study?

(2) In which phase did you have difficulty during the study?

(3) Could you learn new things through this study? What did you learn?

(4) Did you enjoy the study?
   - If yes, what made you enjoy it?/If no, why?

(5) Would you like to use this programme in all of your courses?
   - If yes, why?/If no, why?

(6) Would you want to participate in a study like this one again?
   - If yes, why?/If no, why?

With the above-mentioned interview questions, the goal was to determine the opinions of the students in regards to Scratch applications. The length of the interviews performed within the scope of the research ranged between 25 and 50 minutes. During the interviews, each student was given a number and the statements of the students were noted down in order to be analysed. The students were interviewed with the assistance of the teachers of the deaf-hard hearing via the sign language.

2.5 Experimental procedure

The scale of problem-solving was first administered as a pre-test to the deaf-hard hearing students. Then, the students received in total 36 hours of Scratch training in blocks of two hours on three separate days, for a total of 6 hours per week. During the experimental procedure of the training, the branch teachers also tried to be of help in the classes. But, as they did not know enough about sign language, they struggled to communicate with the students during the Scratch training. As the education given to the deaf-hard hearing students is not systematic, they find it difficult to focus on learning for long periods of study. The subjects taught within the context of the implemented education were as given below.

2.5.1 Weekly applied scratch programme training. In order to improve the algorithmic reasoning and problem-solving skills of the deaf-hard hearing students, the curriculum presented in Table V was carried out. Figures 1 and 2 show one example of the projects and codes performed by the Scratch programme.

2.6 The role of researchers

The researchers adapted the problem-solving skills scale, applied the experimental design and reported the research.

2.7 Data analysis

SPSS 16 was used in the analysis. A paired sample *t*-test was applied in the data analysis to find the difference between the pre-test and post-test results of the same group. The interviews carried out by the researchers were put in writing. The names of the students were not used during the interviews. The analysis of the data gathered from the interview forms was contextual. In the analysis of the observation form in this case, Fleiss' Kappa analysis was performed.

Week	Subject-purpose
1.	Adding backdrop and character, character styling, moving the character: The students are instructed to draw a picture of an aquarium and fish. Controlling motor development and hand coordination through drawing concrete concepts Creating animation with Scratch Changing the stage (background). Adding character (sprite). Giving a name to the character Performing stylistic functions on the character Deleting the character Imagery practice for creating animation Making the character (sprite) move. Making the character move right and left. Making the motion of the character continuous. Carrying on the motion of the character in accordance with the stage
2.	Multıplyıng the character, gıvıng colour effect: Learning the instructions of running the programme (clicking on the green flag) to control the algorithmic reasoning and imagery practice for creating animation and stopping the programme to detect an error in the programme or to add a command The application practice to be performed by the students Manipulating the characters and stage as animation. Adding speech bubbles by clicking on the character (object) and multiplying code objects Adding a character (sprite) that has more than one costume to the stage and learning the command of "switching the costume" on the characters. Learning the command of "wait 1 second" between the motion and switching to the characters' next costume
3.	Drawıng geometrıc shapes, calculatıng the area and cırcumference of the shapes wıth varıables: Drawing geometric figures, calculating the area and circumference of the figures by variables Imagery practice with Scratch Adding cat and butterfly sprites as characters to the stage. Changing the colour of the butterfly's wings as it is moving Imagery practice with Scratch. Growing the character (object). Performing the command with the keys on the keyboard and changing the character into its first size Imagery practice with Scratch Hiding the character (object) when clicked on it. Showing the object when pressing the desired key on the keyboard
4.	Desıgn of an ınteractıve story wıth scratch: Assigning a short story and making the students design it with Scratch so as to enable them to tell interactive stories Adding the command of speech after choosing the desired characters in the assigned story. Adding motion commands to the characters. Tracking time duration (seconds) based on the order of priority of the characters while designing the story Evaluation of the interactive stories designed by the students
5.	Mutual ask and answer game wıth the character, the concept of loop: Getting the students to multiply "by one" the character picked during stage practice (stamping). When the animation is started again, cleaning up the practice stage. Multiplying the picked character by as many as desired Asking question and answering it through keyboard. Learning the commands of "Ask and wait" and "Answer". Enabling the answers to be given as time (second) controlled. Asking basic math operations and learning if the answers are right or wrong by setting loops
6.	Drawıng of geometrıc shapes (trıangle, square, cırcle etc.), enablıng to paınt wıth colours, drawıng and changıng the stage: Learning to draw geometric shapes (triangle, square, circle etc.) with Scratch. Understanding the concept of variables to be able to calculate the circumference and area of the geometric shapes Enabling to paint with colours Drawing characters in whichever colour wanted. Learning the broadcast command "colour" when the drawn characters are clicked In a loop structure, the added character (such as pens, brushes) provide colour painting when it comes to colour news from "News release" command Having the students perform the labyrinth application Learning to draw the stage and change it. Making the added character move by means of buttons on the keyboard. Learning the calculation of scores with a variable

Table V.
Scratch curriculum

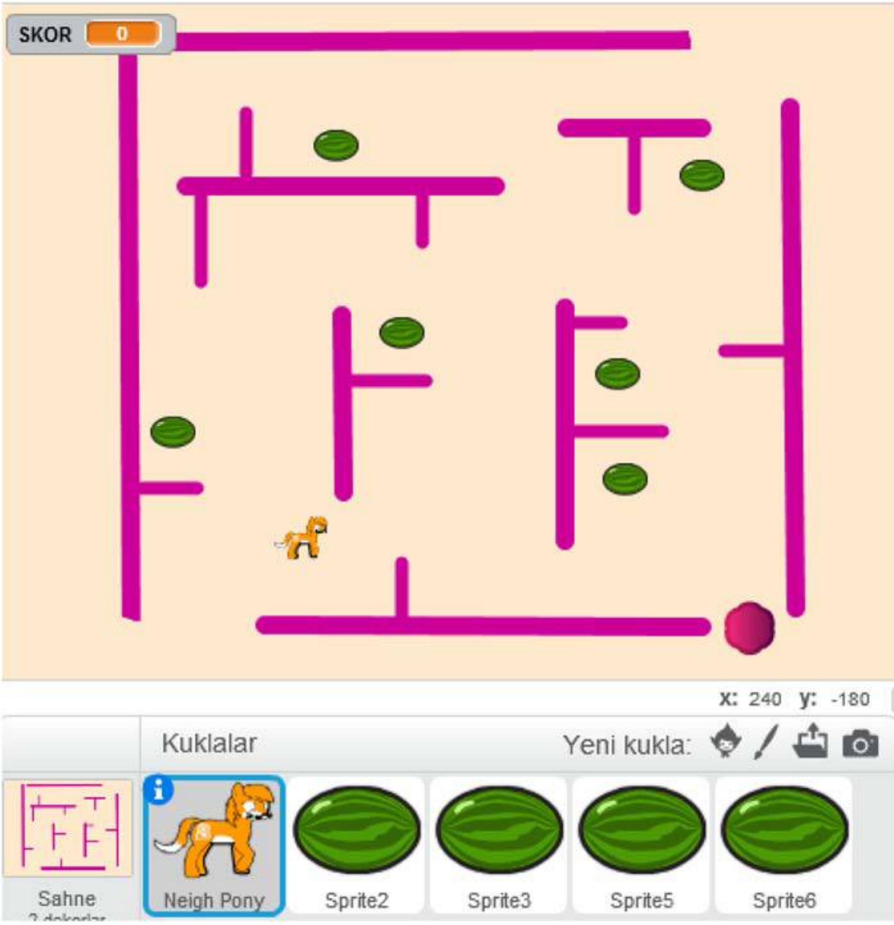

Figure 1.
Stage of watermelon eating game

3. Findings

3.1 Findings related to the scale of problem solving for the deaf-hard hearing

The SPSDH was applied as a pre-test and post-test in order to determine the effect of the Scratch programme on the students' problem-solving skills. A paired sample *t*-test was performed to find the difference between the pre-test and post-test results. The results are presented in Table VI.

When Table VI is examined, it is determined that after Scratch programme training, there was a significant difference in favour of the post-test regarding the students' problem solving-skills according to their pre-test and post-test repeated measure *t*-test results $t(15) = 2{,}73$, $p < 0.05$. Whilst the average score of the students before Scratch training was $= 4.19$, it increased to $= 5.5$ after the training. Cohen's *d* effect size was calculated and found as $d = 0.703$ and Effect Size(r) $=$ 0.332. $d \leqslant 0.2$ is considered a "small" effect size, $0.2 < d < 0.8$ represents "medium" effect size and $d \geqslant 0.8$ is accepted as "large" effect size (Sullivan and Feinn, 2012). In this study, effect size has been measured as $d = 0.70$ and accepted "medium". It can be concluded from this finding that algorithm teaching with Scratch had an important effect on improving the students' problem-solving skills.

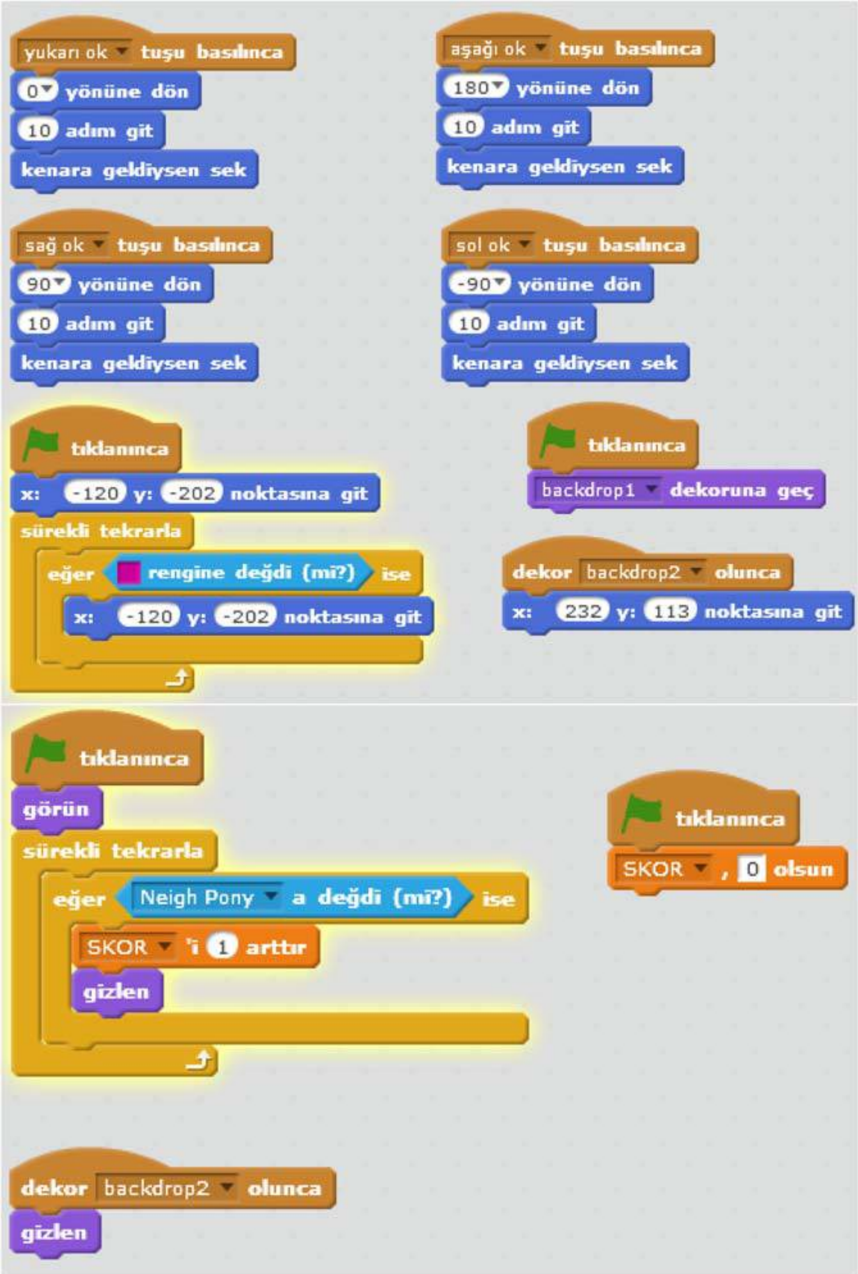

Figure 2.
Scratch codes of watermelon eating game

3.2 Observation results related to the students' Scratch applications

The students were assessed during the final hour of the training programme by three observers (the authors of the present research) and they were given scores ranging between 1 and 5. As there were more than two scorers, an intraclass correlation (ICC) can be a useful estimate of inter-rater reliability on quantitative data because it is highly flexible. Two-Way Random Consistency ICC Calculation in SPSS was measured as 0.884. Therefore, 88.4 per cent of the variance in the mean of these raters is "real". The mean scores given to the students for all of the applications by the observers are indicated in Table VII. When the general mean is examined, it is understood that the students received 3.73 out of 5 on average and this score can be count as a well grade.

3.3 Findings related to views and perceptions of the students about algorithm learning with Scratch

3.3.1 The positive and negative opinions of the students related to the implemented process. In total, 14 of the students had positive opinions about the Scratch applications they performed. The students with positive opinions reported that they liked the computer, creating stages, moving the characters in the application, colouring, hiding, and dramatization. They stated that the programme enabled them to think and study all together. However, three students had negative opinions. They said that they did not like it as they had some difficulties during the study and they could not attend their physical education lesson.

3.3.2 Opinions related to the difficulties encountered during the study. In total, 13 of the students found the study challenging. They stated that they had difficulty in writing, giving commands, doing math operations, colouring, moving the characters, changing colours, creating games, drawing geometric shapes, and constructing labyrinths. Four students declared that they did not find anything hard in the study.

3.3.3 The results related to whether the students learned any new information from the Scratch applications or not. All of the students reported to have learnt new things in the consequence of Scratch applications. They stated that they more easily learned to add a character, move it, change colours, create games, form stages, make the characters speak, understand the target teaching subject (for example, some math operations) and to do something on the computer by themselves.

3.3.4 The students' opinions related to enjoyable/unenjoyable aspects of the Scratch applications. All of the students expressed that they enjoyed themselves and had fun while studying the application. What they enjoyed in the study were colouring the characters, adding character, growing, shrinking, hiding, changing colour, moving the character, creating games on the computer, drawing geometric shapes, and colour practice with wizard. In short, they said that they liked being able to do something on computer and there was nothing they did not like.

Table VI. Pre-test and post-test results of the scale of problem solving for the deaf-hard hearing

	M	*N*	SD	*t*	*p*
Pre-test	4.19	16	1.42	2.73	0.015
Post-test	5.5	16	2.22		

Table VII. The average scores of the students from the observation

Student	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16
Mean of observation	3.44	2.92	4.75	4.06	4.00	3.19	2.89	4.36	3.89	2.86	3.78	3.61	4.17	3.44	4.22	4.11
General mean		3.73														

3.3.5 The students' opinions related to whether they would like to use the Scratch programme in all courses or not. All of the students stated that they would like to use that programme in courses. Seven of them wanted to use it in math courses, five of them preferred Turkish courses, five of them chose science and one of them wanted to use it in social studies courses.

3.3.6 The students' opinions related to whether they wanted to participate in Scratch training again or not. In total, 13 of the students reported that they would like to participate again in such a session, whilst three of them said they would not. The students that would want to participate expressed that they found these applications entertaining; however, the others found the study difficult and tiring.

4. Conclusion and discussion

In the present study, which aimed to research the effect on the problem-solving skills of deaf- hard hearing students in the fifth, sixth, seventh, and eighth grades when using the programme Scratch to teach them algorithms to, it has been determined that algorithm teaching performed with Scratch, which was applied as per pre-test and post-test results, had an important effect on improving the problem-solving skills of the students. According to Millner *et al.* (2013), programmes such as Scratch, StarLogo, and TNG contribute to the students' success by helping to build the students' self-efficacy, increase their repertoire for creative and personally meaningful expression and to compensate for limitations in other forms of expression. Furthermore, it has been concluded from the observation results that the students had a fair level of success. Also Giannakos and Jaccheri (2014) instructed the participants to design a game in a programming workshop they carried out by deaf-hard hearing K-12 students and concluded that it is helpful for the students. Goldman and Pellegrıno (1987) demonstrated that the use of computer education programmes for the children with impairments positively affects their academic achievements, lingual and mathematical skills, reading and writing literacies and advances their attention span and learning capability (adapted by Demirhan, 2008).

It has been found that the students had generally positive views about the process. Also, their statements revealed that they liked doing something together and the software helped them to think. However, many of the students reported to have had difficulty in writing, giving commands, doing math operations, colouring, moving the characters, changing colour, programming game, drawing geometric shapes, and constructing labyrinth. The reasons for this might be that their reading and comprehension skills have not been developed enough, a lack of analytical thinking abilities, attending the classes in groups and not having the opportunity of an adequate one-to-one education. As Li Hanjing (2014) stated, deaf or hard of hearing students' programming education is made difficult and negatively influenced by their fearful way of thinking developed towards the problems they have faced in the past, poor reading skills, and teaching methods. Li Hanjing gave 64 hours of Scratch education to deaf and hard of hearing undergraduate students as a part of a qualitative study she carried out and obtained positive results.

Because the ability of students participating in the study to express themselves is inadequate, general tendency is revealed by question titles. The students who participated in the present study stated that they enjoyed the Scratch application, acquired new information, more easily learned the target material and enjoyed doing something on the computer by themselves. According to Demirhan (2008), the students who make use of information technologies succeed more in their lessons than those who receive standard education; additionally they become more interested in the courses and the problem of distraction disappears as the learning process is more entertaining. The students of the present study also said that they would like to use the Scratch programme in the courses like math, Turkish, and science. As the Scratch programme is supported by multimedia factors, games and narrations, difficult abstract concepts are learned more easily and the concepts are associated to each other more strongly. So, the software of Scratch will have a significant influence on students' achievement and their level of motivation not only in programming courses but also in different courses (Çatlak *et al.*, 2015).

Scratch training can be administered as either a compulsory or an optional course for hearing students as the Scratch programme offers the opportunity of teaching algorithmic reasoning with games, making the courses entertaining and giving students the chance to create their own designs which helps to improve their creative problem-solving skills and their motivation accordingly. Scratch might also be used in the teaching of other courses because of its multimedia nature. Scratch teaching can be beneficial in developing students' problem-solving behaviours and creativity.

5. Limitations

Because the ability of students participating in the study to express themselves is inadequate, frequencies were not included in the findings of interview questions. In order to reveal general trends opinions were expressed with title of questions. The authors of the manuscript were the scorers in the observation form.

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(The Appendix follows overleaf.)

Appendix. Scale of problem solving for the deaf-hard hearing

Part I

Ali and his family will go for a holiday. Let's find the date on which the family can go together. Red coloured days are good for mother and father.

When will they be able to go for two weeks holiday together?

July

Mo	Tu	We	Th	Fr	Sa	Su
				1	**2**	**3**
4	5	6	7	8	**9**	**10**
11	12	13	14	15	**16**	**17**
18	19	20	21	22	**23**	**24**
25	26	27	28	29	**30**	**31**

August

Mo	Tu	We	Th	Fr	Sa	Su
1	2	3	4	5	**6**	**7**
8	9	10	11	12	**13**	**14**
15	16	17	18	19	**20**	**21**
22	23	24	25	26	**24**	**28**
29	**30**	31				

July

Mo	Tu	We	Th	Fr	Sa	Su
				1	**2**	**3**
4	5	6	7	8	**9**	**10**
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	**30**	**31**

August

Mo	Tu	We	Th	Fr	Sa	Su
1	2	3	4	5	**6**	**7**
8	9	10	11	12	**13**	**14**
15	16	17	18	19	**20**	**21**
22	23	24	25	26	**24**	**28**
29	**30**	31				

Part II- Part III

Where does the family want to go together?

Nature, history and sea

Nature and sea

Nature and sea

What is the problem of the family?

☐ How many people will go on holiday together

☐ Where and how will they have holiday

☐ Natural beauties and their historical significance

☐ When will they have a holiday.

Part IV

Table of Holiday Fares

Travel name	Fare
Star tour	2500
Rack tour	3000
Sun tour	2400

Which tour company did give the best price?

Part V

Return fares of the bus companies are given in the Table below:

Bus	Fare
efe tur	600 TL
ULUSOY	550 TL
METRO	500 TL

Which of the following is correct?

☐ Efe Tur's fare is cheaper than Ulusoy's.

☐ The cheapest bus is Metro.

☐ Ulusoy's fare is more expensive than Metro.

Part VI

Ali's family paid 2400 TL for the holiday. Fare 2400:3=800

Tour company made a discount of 300 tl as the family paid the fare in cash.

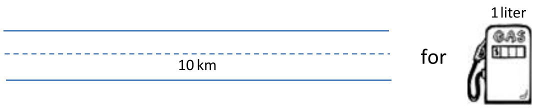
Which one is correct?

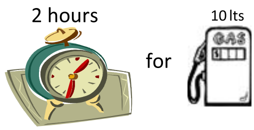
☐ 300:3= ☐ 300:2=

Part VII

Ali's family will go for holiday by car. They should fuel the car up. There is a way of 200 km.

How much should they fuel up? Which of the following sentences is correct?

☐ 

☐ 

How much fuel is needed?

☐ 10 liters ☐ 15 liters ☐ 20 liters

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