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Does Scratch Teach Only Programming?

Selen GALİÇ*, Cakir Schools, Turkey, ORCID ID: 0000-0002-3524-6428, selengalic@gmail.com
Bahadır YILDIZ, Hacettepe University, Faculty of Education, Turkey, ORCID ID: 0000-0003-4816-3071, bahadir@bahadiryildiz.net

Abstract: Scratch was designed by the Massachusetts Institute of Technology (MIT). This study aims to obtain mathematical concepts that students need while developing a Scratch project based on the Turkish national elementary mathematics curriculum. Within the scope of the research, six projects that are shared openly with users and site visitors on the Scratch site were selected. Dr. Scratch was used to the process of selecting quality Scratch projects under seven aspects over twenty-one points. In this study, Scratch projects were classified according to their Dr. Scratch scores in three different levels such as beginner, intermediate and upper level. For the current study, the selected projects are limited to the theme of the game. 119 Scratch projects were examined according to criteria and 9 games with different levels were selected. In the data analysis process each code blocks in every project were analyzed with regard to mathematics. Then, mathematical concepts were associated with related objectives in the curriculum. According to the findings, it was observed that 16 mathematical concepts in the elementary mathematics curriculum were used while developing Scratch projects at beginner and intermediate levels. Besides, it was found that there were mathematical concepts related to the secondary school curriculum. As a result of this study, students may have implicit learning during the process of developing a Scratch Project. For the future study, Turkish national curriculums may be investigated and rearranged as an holistic perspective.

Keywords: *Scratch, Coding, Implicit learning, Mathematics curriculum, Concept learning.*

1. INTRODUCTION

The term “concept” was used in mathematics education at first by Shlomo Vinner and Hershkowitz (1980). A concept is an abstract term by classifying common characteristics of events, facts, objects, and thoughts in the mind (Ülgen, 2004). According to another definition, a concept is an idea or principle related to abstract things (“concept”, n.d.). Unlike the definition of “concept”, concept image is relevant to the cognitive perception of the individual. (Karakuş, 2018). Tall and Vinner (1981) described concept image as the cognitive structure of the related concept that occurs in the individual’s mind when s/he encounters new stimuli or acquires new experiences throughout life. Gutiérrez and Jaime (1999) stated that students use the concept image in their minds while describing a concept.

Dickerson and Pitman (2012) claimed that improper or missing concept images cause misconceptions for students. A misconception is a form of a student’s conception that enables

*** Corresponding Author**
Cakir Schools, Turkey

producing a systematic pattern of errors (Smith et al., 1993). Behr et. al. (1992) argued that some misconceptions may be caused new concepts not being connected with the prior concepts strongly. According to the point of the constructivist view of learning, the learning process is related to an interaction between new and prior conception (Hewson & Hewson, 1984; Posner 1982). Besides, while students' concept learning process, teachers can cause misconceptions to students by term definitions, teaching methods, techniques or materials used (Zazkis & Leikin, 2008).

The learning process is the permanent/long-term behavioral changes of individuals with respect to their own experiences (İlhan, 2011). Reber (1993) classified the learning process into implicit and explicit learning. Implicit learning refers to the learning process and learning products without being conscious awareness (Gasparini, 2004). Explicit learning, on the other hand, refers to consciousness, and effortless learning (Ellis, 2005). Implicit knowledge is gained through implicit learning. Similarly, the knowledge learned through explicit learning is called explicit knowledge. Hence learning is related to the interaction of explicit and implicit knowledge (Sun et al., 2007). Implicit learning is defined as a learning process that occurs independently, learning consciously and also that occurs without having an exact idea of what s/he has achieved (Reber, 1993). Understanding the reasons of the computational steps during problem-solving by oneself can be considered as an example of implicit learning (Akbulut-Taş, 2010). Concept learning a passive learning process in which subjects are exposed to instances of the concept is a kind of implicit concept learning (Frick & Lee, 2008). Students are exposed to or have experienced this kind of learning process. Hence, some knowledge of the features of a concept may be in the implicit form (Frick & Lee, 2008). Students may have implicit learning about some mathematical concepts.

Scratch is an open-source coding programming environment that empowers students to develop animations, games, and interactive projects (Maloney et al., 2004). Scratch users tend to learn mathematical concepts while developing any Scratch projects (Resnick et al., 2009). The process of developing a Scratch project may be required using mathematical concepts. The research group of Scratch studies whose number has increased in recent years was mostly elementary school students both Turkish and English (Talan, 2019). It can be considered that elementary school students perform implicit learning as a passive concept learning process during developing the Scratch project. Their implicit learning can be related to mathematical concepts . For this reason, the aim of this study is to obtain the mathematical concepts students need to develop a Scratch project. This study is focused on the extent which mathematical concepts can be used in the process of developing a Scratch project, and provide a perspective of the distributions of the grade level with respect to the Turkish national elementary mathematics curriculum (Ministry of National Education [MONE], 2018a). At this point, Dr. Scratch used to reach a wide range and types of quality Scratch projects in student-designed games for mathematical concepts. The importance of this current is to discuss the effects of programming lessons learned from using Scratch into implicit learning with regards to mathematical concepts. Besides, it contributes to identifying the distributions and amounts of the games develops in Scratch and mathematical concepts with specific learning goals of the current Turkish national elementary mathematics curriculum from the perspective of implicit learning. Therefore, this current study has been answered the relationship between code structures in Scratch projects and the mathematical concepts to obtain implicit learning during programming in Scratch.

2. LITERATURE REVIEW

2.1. Scratch

Many countries around the world interest programming in both school curriculum or out-of-school learning activities (Sentance et al., 2017). Using block-based programming has been increased recently (Amanullah & Bell, 2019). The 5th and 6th-grade information technologies and software curriculum includes using block-based programming applications (Ministry of National Education [MoNE], 2018b). Scratch is one of the alternatives to use for this purpose.

Although Scratch was designed by the Massachusetts Institute of Technology (MIT) for the age group of 8 to 16 years in 2003, it is a simple programming language designed for all age groups (Scratch, n.d.). Users can create their projects such as interactive stories, games, and animations by using code blocks in Scratch (Saez-Lopez et al., 2016). Scratch allows both downloading on devices and web-based access (https://scratch.mit.edu/) to create any projects and share the projects with other users or site visitors on their websites.

Scratch supports students' creativity skills (Kobsipirat, 2015), and international communication and cooperation since it supports over forty languages support (Resnick et al., 2009). According to literature, Scratch has a positive effect on students' modeling (Calao et al., 2015), problem-solving (Shin & Park, 2014; Nam et al., 2010), reasoning (Lai & Yang, 2011) and geometric thinking (Kakavas & Zacharos, 2019) skills and the understanding mathematical concepts such as variables (Okuducu, 2020) prime numbers (Çubukluöz, 2019), and integers (Mercan, 2019). Since the emergence of computers, programming was suggested to emphasize mathematics education for the learning of mathematical ideas (Papert, 1980). Scratch motivates students to learn mathematical concepts, and it develops students' mathematical thinking skills (Calder, 2010; Taylor et al., 2010). Calder (2010) claimed that the Scratch is valuable for learning mathematical concepts. Saez-Lopez et al. (2016) stated that Scratch can be used in teaching logic and mathematics. Lewis and Shah (2012) argued that the programming curriculum includes mathematics content knowledge. Students need to acquire mathematical skills in problem-solving during coding (Aytekin et al., 2018). For instance, a 13-year-old student creating a scoreboard for the game he designed in Scratch should know how to use variables in mathematics (Resnick et al., 2009). According to Iskrenovic-Momcilovic (2020), Scratch makes mathematics learning easy, effective, and interesting. Joini et al. (2015) claimed that Scratch can be used basic mathematical principles during teaching and learning. It can be considered that students may need to learn mathematical concepts or make sense of the structure concerning their knowledge by imitating the codes in Scratch. Pinto (2013) claimed that Scratch contributes mathematical learning more intuitively. Students may learn some mathematical concepts during Scratch programming unconsciously. It can be related to implicit learning. Utilizing the Scratch projects, the purpose of this study is to obtain the implicit learning of mathematical concepts such as the following way in encoding (constructing the code blocks), representations of the blocks (representing the code blocks algebraically), decomposition (constructing equations), planning (constructing a sequence of code blocks) in Scratch (Daher et al., 2020). For this purpose, qualitative and the widely range of Scratch projects should be chosen. Dr. Scratch used to reach a widely range and types of quality Scratch projects in this study.

2.2. Dr. Scratch

Dr. Scratch, is a free and accessible web application, aims to assess the quality of Scratch projects and provide easy and meaningful feedback to offer both learners and educators (Moreno-León & Robles, 2015). The URL of the Scratch projects or upload it as the file is required to provide the assessment. Dr. Scratch analyses the code blocks of the Scratch projects to give a score on various aspects of its quality (Chang et al., 2017). These aspects are given with their definitions in Table 1 (Dr. Scratch, n.d.). Each of these aspects is scored on a scale of zero and three points, and the score is overall added in total.

Table 1. *Scoring Aspects and Its Definition in Dr. Scratch*

Scoring Aspects	Definition
Flow control	The control of the behavior of the characters.
Data representation	Set of characters'' knowledge
Abstraction	The ability of decomposition and subtraction of the problems.
User interactivity	Interactivity between user and project
Synchronization	To organize the code blocks with respect to meaningful order.
Parallelism	The possibility of occurring simultaneously.
Logic	To carry through between situation and behavior

3. METHODOLOGY

3.1. Research Design

This current study is designed as a document analysis form of qualitative research in which documents are interpreted by the researchers to make a voice and meaning around the related topic (Bowen, 2009).

3.2. Data Collection and Analysis

This study aims to explore mathematical concepts with respect to implicit learning in student-designed games with Scratch, to provide insights on how students approach and use mathematical concepts in game design for the Turkish national elementary mathematics curriculum. To provide the range and types of Scratch projects, the following inclusion criteria are given in below in this study.

- Scratch projects have to be open access for all users and site visitors (To access the codes).

- The scores of Dr. Scratch have differed from each other (To ensure the computational thinking metrics of projects).
- The Scratch projects have different types of games (To ensure the codes used are not the same for all projects).

According to given criteria below, 119 Scratch projects were evaluated. All data are collected from the Scratch website online. Since Scratch is an open-source website, users can share their Scratch projects with other uses and site visitors. Therefore, using their Scratch projects does not constitute a problem. 110 Scratch projects have excluded this study for the following reasons:

- The Scratch Project include my block code blocks (user-made code blocks),
- The Scratch projects do not work clearly.
- The Scratch projects have dead codes that never are executed in the programming.
- There are duplicated Scratch projects.
- The number of Scratch projects is the same at each classification level.

Hence nine Scratch projects were selected to be appropriate for this study. In this study, Scratch projects are classified according to their Dr. Scratch scores as follows:

- Beginner level from zero to seven points,
- Intermediate level from seven points to 14 points,
- Upper level from 14 points to 21points.

Scratch projects selected, their URL address to access them, and its Dr. Scratch scores are given in Table 2.

As seen in Table 2, there were three Scratch projects for each level. Although the Scratch projects that include the “MyBlock” code block are excluded from this study, all Scratch projects get upper level includes MyBlock code blocks. Therefore, the upper level is out of the scope of this study. The codes in the rest of the Scratch projects selected are analyzed related to the mathematics objectives in the Turkish national elementary mathematics curriculum individually to obtain the possible implicit learning for users.

The code blocks in selected projects were transferred to the table in order to analyze with regards to mathematics objectives from the Turkish national elementary mathematics curriculum through the implicit learning during programming in Scratch. In the line of this purpose, each code block in Scratch projects is analyzed in accordance with the reasons of the code block use related to mathematics objectives to obtain mathematical concepts consciously or implicitly. Findings were represented by using the frequency and percentage distributions of the mathematical concepts .

Table 2. *Dr. Scratch Score of Selected Scratch Projects and URLs*

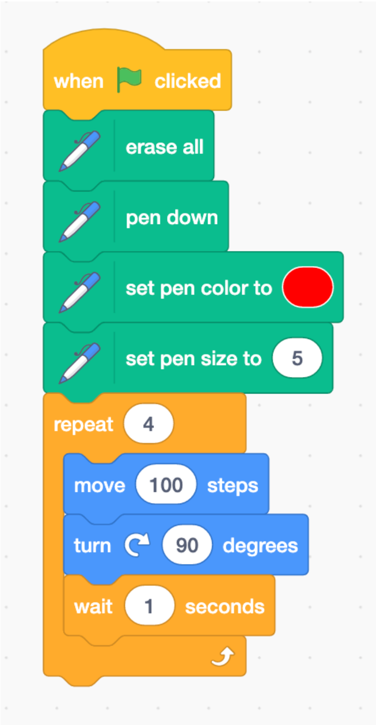
Name	Selected Projects	Flow Control	Data Representation	Abstraction	User Interactivity	Synchronization	Parallelism	Logic	Total Score	Level
		Dr. Scratch Score								
B1	https://scratch.mit.edu/projects/467154457/	2	1	0	1	1	0	0	5	Beginner
B2	https://scratch.mit.edu/projects/2529604/	2	1	0	2	0	0	0	5	
B3	https://scratch.mit.edu/projects/382759097/	1	2	1	2	0	0	0	6	
I1	https://scratch.mit.edu/projects/472432773/	2	2	0	2	0	0	2	8	Intermediate
I2	https://scratch.mit.edu/projects/474987481/	2	2	1	2	1	2	1	11	
I3	https://scratch.mit.edu/projects/473286423/	3	1	1	2	3	1	3	14	
U1	https://scratch.mit.edu/projects/468547907/	2	3	3	2	3	3	3	19	Upper
U2	https://scratch.mit.edu/projects/469292411/	3	2	3	2	3	3	3	19	
U3	https://scratch.mit.edu/projects/471978397/	3	3	3	2	3	3	3	20	

4. FINDINGS

In this section, analysis of each Scratch project within the scope of this study is given firstly. The related mathematical concepts based on the Turkish national elementary mathematics curriculum are defined with their definitions and explanations. Finally, the distributions of mathematical concepts related to the grade level is represented by using frequency and percentage.

4.1. Scratch Projects Analysis

Table 3. *Explanation of the B1*

Code Blocks	Objectives	Definition of Objectives
	M.5.2.1.2	Students are able to determine the position of a point according to another given point by using direction and unit.
	M.5.1.1.3	Students are able to find any term in a number or shape pattern using a given rule.
	M.5.2.1.4	Students are able to draw an angle (acute, right, or obtuse) concerning using 90 degrees.
	M.5.2.2.3	Students are able to draw and identify the properties of rectangle, parallelogram, rhombus, and trapezoid.
	M.8.2.2.2	Students are able to define the coordinate systems and identify coordinate correspondences.
	12.4.1.1*	Students are able to verify experimentally the image of rotations, reflections, and translations in plane analytic geometry.

**Excluded objective*

The code blocks created by the user in this Scratch project are given in Table 3. The necessary mathematics contents related to the Turkish national elementary mathematics curriculum while coding are as follows:

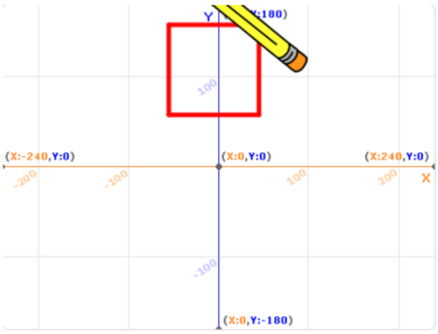
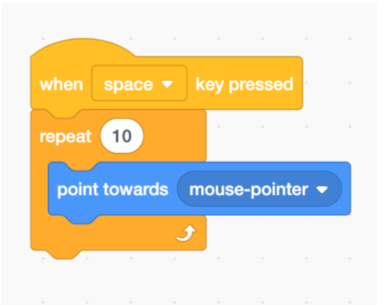


Figure 1. *The Screenshot of B1*

- In this project, the "pencil" block from extensions was used. Drawing an edge of the square was drawn by using the "move 100 steps" block four times. In primary school, students define physical measurements such as overarm and steps. Hence using steps may cause misinterpretation. However, since the scope of this study was at the elementary school level, this finding was excluded from the study.

- A rotation according to the exterior angle of the square was required at the corner of the square. Students learn the concept of angle in primary school. Students are able to draw an angle (acute, right, or obtuse) with respect to using 90 degrees in the 5th grade. The rotations were made according to the external angle while coding. However, the exterior angle was not learned in 5th grade. Besides, although the students know the concept of the angle, rotations in plane analytic geometry were not included in the elementary mathematics curriculum. The related objectives in the secondary mathematics curriculum were given in Table 2. It can be said that the students may have implicit learning for the rotations and plane analytic geometry intuitively. However, it was not included because it was out of the scope of this study.
- "Repeat four times" block was associated with the pattern. Students are expected to repeat the pattern four times according to the given rule, respectively.

Table 4. *Explanation of B3*

Code Blocks	Objectives	Definition of Objectives
	M.5.2.1.2	Students are able to determine the position of a point according to another given point by using direction and unit.
	M.8.2.2.2	Students are able to define the coordinate systems and identify coordinate correspondences.
	M.12.4.1.1*	Students are able to verify experimentally the image of rotations, reflections, and translations in plane analytic geometry.

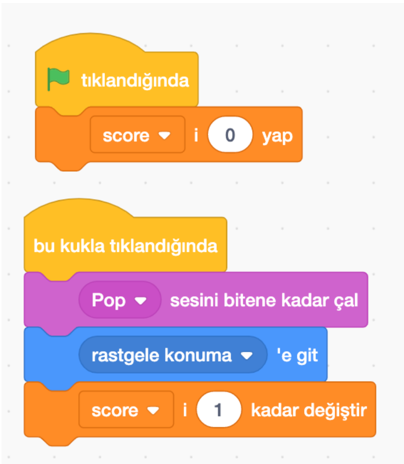
**Excluded objective*

The code blocks created by the user in this Scratch project are given in Table 4. The necessary mathematics contents related to the Turkish national elementary mathematics curriculum while coding are as follows:

Figure 2. *The Screenshot of the B2*

- The direction of rotating the sprite at its location depends on the direction of the user's mouse in this project. In the elementary mathematics curriculum, students are able to determine the position of a point according to another given point in the 5th grade. Merely students are only able to do it by using dotted paper etc.
- In the Scratch stage, students can express the direction of the sprite with respect to the user's mouse. But the related objective with rotation is not included in the elementary mathematics curriculum. A related objective was given in Table 3. Therefore, rotation can be considered as implicit learning for elementary school students. However, it was not included because it was out of the scope of this study.

Table 5. *Explanation of B3*

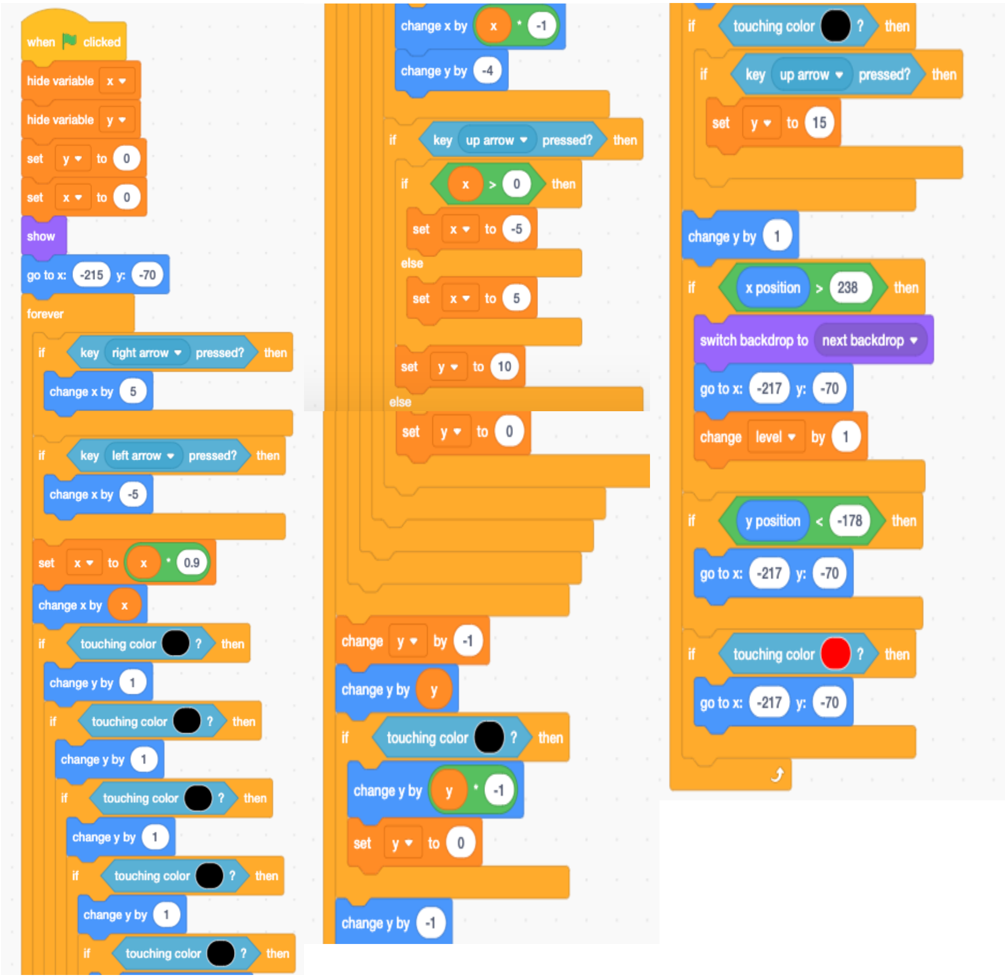
Code Blocks	Objectives	Definition of Objectives
	M.5.2.1.2	Students are able to determine the position of a point according to another given point by using direction and unit.
	M.6.2.1.1	Students are able to evaluate expressions in which letters stand for numbers when given a real-world situation and vice versa.
	M.6.2.1.2	Students are able to solve an expression with respect to the given value.
	M.8.2.2.2	Students are able to define the coordinate systems and identify coordinate correspondences.

The code blocks created by the user in this Scratch project are given in Table 5. The necessary mathematics contents related to the Turkish national elementary mathematics curriculum while coding are as follows:

Figure 3. *The Screenshot of B3*

- The term "position" was used for determining any random location. Students learn the term of position in 5th grade for the first time in the elementary mathematics curriculum. Scratch stage consists of a coordinate system. The random position on Scratch is expressed between -240 and +240 on the x-axis and between -180 and +180 on the y-axis in the coordinate system. While looking at the curriculum, students are able to identify the coordinate system in 8th grade for the first time. Hence it can be said that students may have implicit learning about the concept of the coordinate system before learning in the mathematics lesson.
- In this Scratch project, students get one point for any puncturing balloon. Adding a new point for the total score represents an additional operation. In addition, this project includes an algebraic expression whose constant term is one to create the scoring. Students are able to identify the related terms of algebraic expression in 6th grade for the first time in mathematics lessons. In this project, students can determine algebraic expressions intuitively. This may cause implicit learning for algebraic expression, variable, constant term, and coefficient terms.

Table 6. *Explanation of I1*



Code Blocks	Objectives	Definition of Objectives
	M.5.2.1.2	Students are able to determine the position of a point according to another given point by using direction and unit.
	M.5.1.1.3	Students are able to find any term in a number or shape pattern using a given rule.
	M.8.2.2.2	Students are able to define the coordinate systems and identify coordinate correspondences.
	M.6.1.4.1	Students are able to identify the term of integer and show them in the number line.
	M.6.2.1.1	Students are able to evaluate expressions in which letters stand for numbers when given a real-world situation and vice versa.
	M.6.1.6.4	Students are able to make a multiplication operation by using given decimals.
	M.6.1.6.6	Students are able to make division operations by using a given decimal with 10, 100, and 1000.
	M.7.1.1.3	Students are able to make multiplication and division operations by using integers.
	M.8.2.3.1	Students are able to write the inequality to represent a constraint or condition in a real-world or mathematical problem.

*** Corresponding Author**
Cakir Schools, Turkey

The code blocks created by the user in this Scratch project are given in Table 6. The necessary mathematics contents related to the Turkish national elementary mathematics curriculum while coding are as follows:

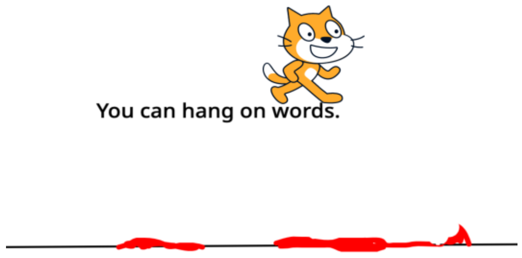
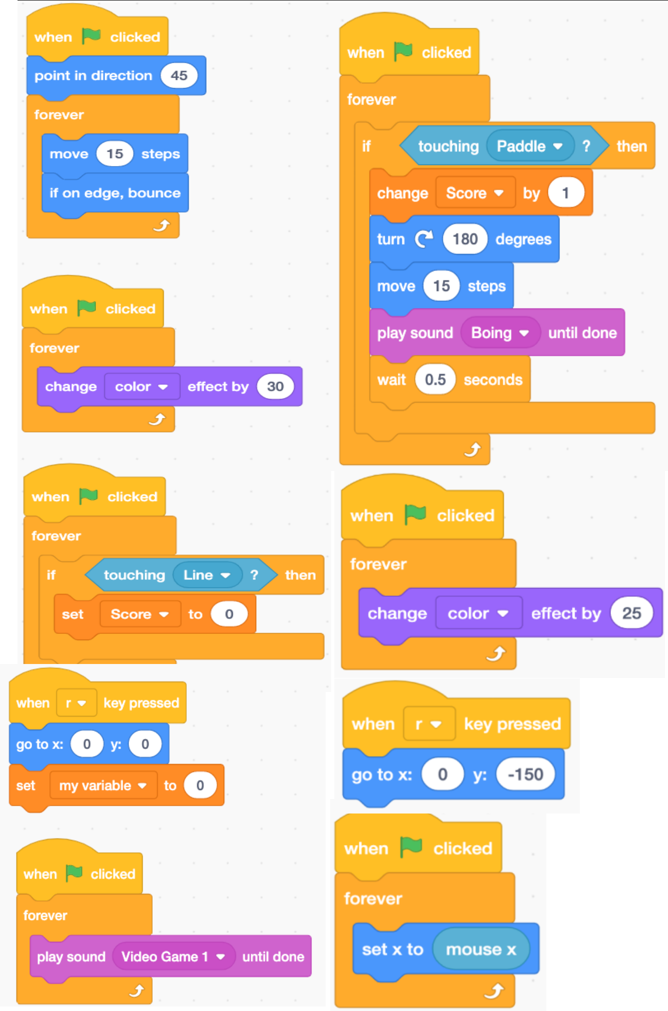


Figure 4. *The screenshot of I1*

- In this project, students make multiplication operations by using decimals to identify the x-axis of the objects. In the Turkish national elementary mathematics curriculum, students learn the term of position in 5th grade and they make multiplication and division operations by using decimals in 6th grade for the first time. It can be considered that making operations by using decimals may cause implicit learning for students.
- In this project, a variable can be defined to present the location of the object. It is multiplied by the given decimal. The objective about the operations by using decimals is in 6th grade. It may cause implicit learning for algebraic expressions.
- The expression “x position > 238” is defined as inequality. An object takes a value between -240 and +240 for the x-axis in the scratch stage. The project is designed to work if the position of the object is greater than 238, switch the background, and go to the given place. Students can learn inequality in 8th grade for the first time. The related objective is given in Table 6. Therefore, it may cause implicit learning about both algebraic expression and inequality.
- The concept of “position” is used to express the location in the coordinate system. Students may have implicit learning about determining position in the coordinate system to identify any random location in the Scratch stage intuitively.
- "Forever" code blocks were associated with the pattern. Students are expected to repeat the pattern forever according to the given rule, respectively.
- Location can be determined by using integers in the coordinate system. Students are familiar with the national number system in 5th grade. In other words, students use zero and positive integers until 6th grade. They are able to identify the term of integer in 6th grade. Therefore, students may have implicit learning about negative integers.
- Scratch stage consists of a coordinate system. The random position on Scratch is expressed between -240 and +240 on the x-axis and between -80 and +180 on the y-axis in the coordinate system. The "go to x:-217 y: 70" code block expresses the location on the coordinate plane. Therefore, students can visualize these concepts in their minds by using implicit learning to determine the coordinate system intuitively.

Table 7. *Explanation of I2*

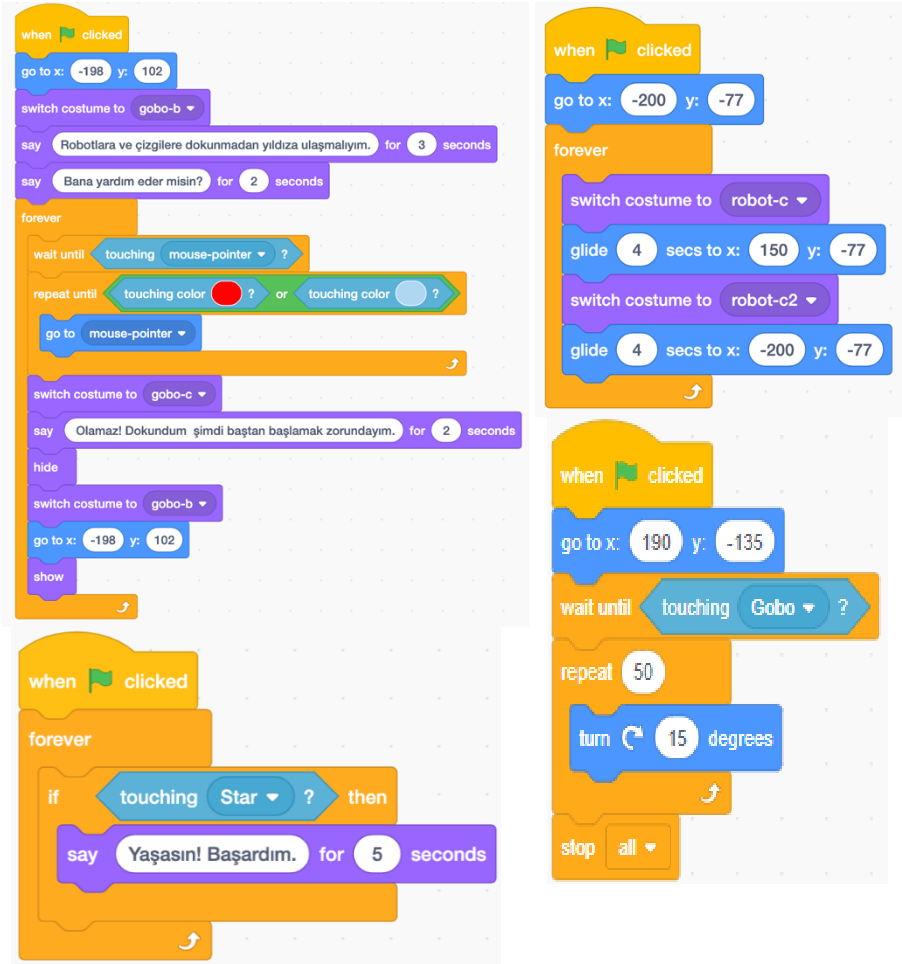
Code Blocks	Objectives	Definition of Objectives
	M.5.2.1.4	Students are able to draw an angle (acute, right, or obtuse) with respect to using 90 degrees.
	M.8.3.2.1	Students are able to draw any image of objects (dot, line segment, or other shapes) after translation on dotted paper, squared paper, or coordinate system.
	M.8.3.2.2	Students are able to draw any image of objects (dot, line segment, or other shapes) after reflection on dotted paper, squared paper, or coordinate system.
	M.5.1.1.3	Students are able to find any term in a number or shape pattern using a given rule.
	M.8.2.2.2	Students are able to define the coordinate systems and identify coordinate correspondences.
	M.5.1.1.3	Students are able to find any term in a number or shape pattern using a given rule.
	M.5.1.5.2	Students are able to determine any fraction into decimals when the denominator is given 10, 100, or 1000.
	M.6.2.1.2	Students are able to evaluate expressions in which letters stand for numbers when given a real-world situation and vice versa.
	M.8.2.2.3	Students are able to identify linear equations in two variables corresponding to the table and equations.
	M.5.1.1.3	Students are able to find any term in a number or shape pattern using a given rule.
	M.6.1.4.1	Students are able to identify the term of integer and show them in the number line.
	M.8.2.2.2	Students are able to define the coordinate systems and identify coordinate correspondences
	M.8.2.2.3	Students are able to identify linear equations in two variables corresponding to the table and equations.
	M.5.1.1.3	Students are able to find any term in a number or shape pattern using a given rule.

The code blocks created by the user in this Scratch project are given in Table 7. The necessary mathematics contents related to the Turkish national elementary mathematics curriculum while coding are as follows:

Figure 5. *The screenshot of the I2*

- In this project, it is expected to reflect the ball at the same angle after hitting the bar with the angle it hits. Related objectives are given in the 8th grade according to the elementary mathematics curriculum. Students are able to identify the reflection on the coordinate system. Therefore, it can be considered that students may have implicit learning about the concept of reflection while thinking about the process of the ball intuitively.
- The ball score in the corner of the stage is updated according to the ball moves. Updating score as ball moves is about dependent and independent variables. Students are able to identify linear equations in two variables corresponding to the table and equations in the 8th grade elementary mathematics curriculum. Hence the concept of variables can be considered as implicit learning for students.
- Location can be determined by using integers in the coordinate system. Students are familiar with the national number system in 5th grade. In other words, students know zero and positive integers until 6th grade. They are able to identify the term of integer in 6th grade. Therefore, students may have implicit learning about negative integers.
- In this project, the waiting time for the ball is determined as 0.5. Students are able to identify decimals in the 5th grade. Therefore, it can be said that students may have implicit learning about decimals intuitively.
- Scratch stage consists of a coordinate system. The random position on Scratch is expressed between -240 and +240 on the x-axis and between -80 and +180 on the y-axis in the coordinate system. The "go to x: 0 y: 0" block expresses the location on the coordinate plane. Therefore, students can visualize these concepts in their minds by using implicit learning to determine the coordinate system intuitively.
- "Forever" code block was associated with the pattern. Students are expected to repeat the pattern forever according to the given rule, respectively.

Table 8. *Explanation of I3*



Code Blocks	Objectives	Definition of Objectives
	M.8.2.2.2	Students are able to define the coordinate systems and identify coordinate correspondences.
	M.6.1.4.1 M.5.1.1.3	Students are able to identify the term of integer and show them in the number line.
	M.9.1.1.2.*	Students are able to find any term in a number or shape pattern using a given rule.
	M.12.4.1.1*	Students are able to define the properties of "and, or" in compound propositions and show their properties by using the De Morgan rule in the truth table.
	M.8.2.2.2	Students are able to verify experimentally the image of rotations, reflections, and translations in plane analytic geometry.
	M.6.1.4.1 M.5.2.1.2	Students are able to define the coordinate systems and identify coordinate correspondences.
	M.5.1.1.3	Students are able to identify the term of integer and show them in the number line.
	M.8.2.2.2	Students are able to draw an angle (acute, right, or obtuse) with respect to using 90 degrees.
	M.6.1.4.1 M.5.1.1.3	Students are able to find any term in a number or shape pattern using a given rule.
		Students are able to define the coordinate systems and identify coordinate correspondences.
		Students are able to identify the term of integer and show them in the number line.
		Students are able to find any term in a number or shape pattern using a given rule.

**Excluded objective*

The code blocks created by the user in this Scratch project are given in Table 8. The necessary mathematics contents related to the Turkish national mathematics curriculum while coding are as follows:

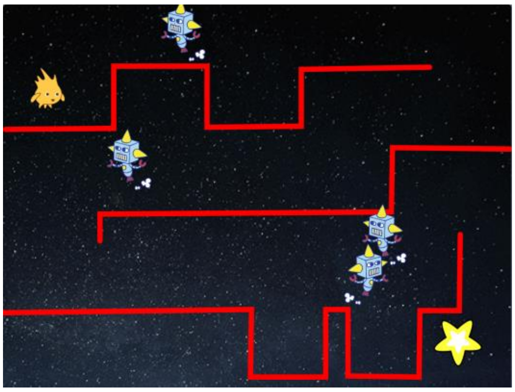


Figure 6. *The Screenshot of the I3*

- Scratch stage is defined as a coordinate system. Any position on Scratch is expressed between -240 and +240 on the x-axis and between -80 and +180 on the y-axis in the coordinate system. The "go to x: -198 y: 102" block expresses the location on the coordinate plane. Therefore, students can visualize these concepts in their minds by using implicit learning to determine the coordinate system intuitively.
- Location can be determined by using integers in the coordinate system. Students are familiar with the national number system in 5th grade. In other words, students use zero and positive integers until 6th grade. They are able to identify the term of integer in 6th grade. Therefore, students may have implicit learning about negative integers.
- "Repeat 50 times" code block was associated with the pattern. Students are expected to repeat the pattern forever according to the given rule, respectively.
- To code blocks for repeating until when touching the red or light blue colour, students use propositions. It is defined as a compound proposition in mathematics lessons that are not included in the elementary mathematics curriculum. The related objectives in the Turkish national secondary mathematics curriculum were given in Table 7. It can be said that the students may have implicit learning for the compound proposition intuitively. However, it was not included because it was out of the scope of this study.
- In the Scratch stage, students can express the direction of the object with respect to the user's mouse. But the related objective (which was given in Table 3) with rotation is not included in the elementary mathematics curriculum. Therefore, rotation can be considered as implicit learning for elementary school students. However, it was not included because it was out of the scope of this study.

4.2. The Distribution of Mathematical Concepts in Scratch Projects

The mathematical concepts obtained from the analysis of Scratch projects with respect to a game level are given in Table 9.

Table 9. *The Distributions of Frequency and Percentage of Scratch Projects*

Mathematical Concepts	Beginner		Intermediate	
	f	%	*f*	%
Pattern	1	7	3	12
Location	3	21	1	4
Geometric Shape	1	7	0	0
Angle	1	7	2	8
Decimal	0	0	2	8
Integer	0	0	3	12
Algebraic equation	1	7	1	4
Variable	1	7	1	4
Constant term	0	0	1	4
Inequality	0	0	1	4
Translation	0	0	1	4
Reflection	0	0	1	4
Linear equation	0	0	1	4
(In)dependent variable	0	0	1	4
Coordinate system	3	21	3	12
Coordinate corresponding	3	21	3	12
Total	**14**	**100**	**25**	**100**

As seen in Table 9, it can be said that the concepts of the coordinate system and coordinate corresponding were used in all projects at both levels. It can be the reason that the Scratch stage is identified by using a coordinate system. According to Table 9, all projects at a beginner level use location term. It is seen that this term from the 5th grade curriculum is frequently used by the students by developing a Scratch project. Although students are able to determine the position of a point according to another given point by using direction and unit in 5th grade, they can use the coordinate system from 8th grade objectives to define the location in Scratch stage. Repeat code block was used in all intermediate-level projects. It was associated with the pattern. Hence students need a term of pattern to develop a Scratch project at the intermediate level. Also, students may need to understand the term of integers.

Scratch projects examined in this study were associated with the elementary mathematics curriculum according to level. The frequency of the distribution is given in Table 10.

Table 10. *The Number of Objectives Related Grade According to Level*

Scratch Project Level	Grade Level				Total
	5	6	7	8	
Beginner	4	0	0	2	6
Intermediate	4	5	1	6	16
Total	8	5	1	8	22

As seen in Table 10, it can be said that beginner-level Scratch projects were not associated with any 6th or 7th grade objectives. However, two objectives from 8th grade were examined at beginner-level Scratch projects. It can be expected because the Scratch stage is defined by a coordinate system. It is seen that the projects at the intermediate level are a majority in the 8th grade. It is followed by the 6th and 5th grade objectives respectively.

5. RESULTS AND DISCUSSION

This study aims to obtain implicit learning about students' mathematical concepts while developing a Scratch project. Within the scope of the research, six projects that are shared openly with users and site visitors on the Scratch site are used. Dr. Scratch is used to evaluate the Scratch projects (Moreno-León & Robles, 2015) under seven aspects over twenty-one points. In this study, Scratch projects were classified according to their Dr. Scratch scores in three different levels such as beginner, intermediate, and upper level. The Scratch projects are limited as the game theme in Scratch. 119 Scratch projects were examined according to inclusion criteria and nine games with different levels were selected. Three Scratch projects were identified at each level. Those in the upper level are excluded since they do not meet the inclusion criteria. In the data analysis process, each code block in every project is analyzed concerning the mathematical concepts. Then, mathematical concepts were associated with related objectives in the curriculum.

According to findings, 16 mathematical concepts in the Turkish national elementary mathematics curriculum were related to developing Scratch projects at beginner and intermediate levels. Besides, it was observed that some code blocks are related to the Turkish national secondary school mathematics curriculum. Although related objectives were given in findings, they are excluded because of out of the scope of this study.

Kaplan and Sarıışık (2019) investigated the difficulties while designing Scratch as a teaching story. Prospective elementary mathematics teachers were asked to design a Scratch project related to a mathematics objective. According to this study, participants defined that using Scratch was not appropriate for each mathematics objective in the Turkish national elementary mathematics curriculum. They also claimed that there were some issues about moving in the coordinate system. According to the finding of this study, students used the coordinate system while developing Scratch projects at all levels. The objectives of the coordinate system are present in the 8th grade Turkish national elementary mathematics curriculum. For this reason, it can be considered that students may have implicit learning about coordinate systems. Hence, this study is consistent with Kaplan and Sarıışık's (2019).

According to Table 9, 14 mathematical concepts at the beginner level and 25 mathematical concepts at the intermediate level are related to develop Scratch projects. As seen in Table 10, Scratch projects at the intermediate level were related to the 6th and 8th grade Turkish national elementary mathematics curriculum. When it is considered that students use Scratch in 5th and 6th grade and also the related objectives are in 6th and 8th grade they need, they may expose implicit learning in accordance with that they do not have conceptual learning.

According to the literature, it is observed that using Scratch in mathematics lessons has a positive effect on the context of variables (Okuducu, 2020), prime numbers (Çubukluöz, 2019), and integers (Mercan, 2019). Hence, it can be said that these concepts are needed by students while developing Scratch projects in the information technologies and software class before the mathematics lesson. For this reason, developing Scratch projects may cause implicit learning intuitively about mathematical concepts .

Students learn the term of position in 5th grade, addition and subtraction operations with decimals in 5th grade, and multiplication and division operations with decimals in 6th grade for the first time according to the Turkish national elementary mathematics curriculum. Students have misconceptions about multiplication operations with decimals (Aykaç, 2008; Başgün & Ersoy, 2000). It is observed that decimals are required in Scratch projects at the intermediate level. It can be considered that it may cause misconceptions because of having implicit learning about decimals.

It is observed that integers are used in all projects at the intermediate level. Students have difficulties with negative integers (Altıparmak & Özdoğan, 2010; Hativa & Cohen, 1995; Kilhamn, 2011). Students cannot understand the minus (-) sign (Erdem, et al., 2015). Besides, students have difficulties making operations with integers (Işıksal-Bostan, 2009; Janvier, 1983). Hence it can be said that a student may have implicit learning while developing Scratch projects if s/he can need to use the term of integers without conceptual learning. It may cause misconceptions. It is also possible to say that it may not. According to Mercan (2019), using Scratch has a positive effect on teaching integers. This is an important thing to consider when using Scratch in the learning process.

According to the findings, it was seen that the students used the concept of a variable at both beginner and intermediate levels. Therefore, information and software technology lessons and mathematics lessons are considered simultaneously since they depend on each other to overcome possible misconceptions.

6. RECOMMENDATIONS

In future studies, studies about implicit learning can be considered by using students' cognition maps. This current study was limited to the projects included in the research. By doing similar studies, other mathematical concepts in Scratch projects can be examined. Besides, upper-level projects were not included in this study. They can also be examined in future studies. This study enlightens the relationship between the programming in Scratch and mathematics concept. Previous studies have indicated that Scratch has a positive effect on mathematics learning. The concept learning during the programming on Scratch will be held on clearer. The process, as opposed to the product, will be investigated. Students' individual differences may be enlightened. According to the findings, students may have implicit learning in accordance with mathematical concepts. Hence, the order of the objectives can be discussed in the Turkish national elementary mathematics curriculum. The objectives from whole other disciplines may be arranged as a holistic perspective.

7. ABOUT THE AUTHORS

Dr. Bahadır Yıldız holds a BA degree in mathematics education, MA and PhD degree in computer education and instructional technology. He is an assistant professor at the Department of Mathematics Education, Hacettepe University. He is the founder of the www.matematik.us website. His research interests include ICT, algorithm and coding, misconceptions, interdisciplinarity, games, and artificial intelligence in education.

Selen Galiç holds a BA and MA degree in mathematics education. She is a mathematics teacher and IB MYP Coordinator in Çakır Schools and a doctorate student at Hacettepe University. Her research interests include games, technology, and artificial intelligence in education.

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