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# The impact of blocky programming on probabilistic thinking of seventh-grade students

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*The main purpose of current research is to use Scratch in math lessons to improve the probabilistic thinking of seventh-grade students. In this regard, 100 students in the academic year of 2020-2021 were selected from Rafsanjan city in Kerman province (south-east of Iran) and assigned to the two experimental and control groups. In the experimental group, the content of mathematics textbooks related to probability was taught using Scratch. In the control group, the same concept was taught by the same teacher without using Scratch. The experimental group of students participated in a 4-week online course about Scratch and they learned about basic programming. Analysis of the post-test shows that the performance of the experimental group students in probabilistic thinking significantly was higher than the control group students. The experimental group students enjoy using Scratch in the process of learning concepts related to probability.*

*Keywords: Scratch, blocky programming, probabilistic thinking, computational thinking, school curriculum.*

## Introduction

In today's world, having statistical and probabilistic thinking to analyze various issues in the real world is one of the necessities of every citizen. Because they have to have the critical skills needed for interpreting the huge amount of data produced within the media and everyday life. The ever-increasing growth of new technologies has made large-scale data (big data) to be produced and made available to everyone. Therefore, teaching statistics and probability in a way that enables students to better and more efficiently face their real-world problems in the future. This necessity is well stated in the document of principles and standards of the National Council of Mathematics Teachers (2000) that announced the teaching of statistics and probability at all educational levels. It should be noted that statistics and probability have twice been the main focus of the yearbooks of the National Council of Teachers of Mathematics, which shows the importance of this topic. The first one was the 43<sup>rd</sup> yearbook of the National Council of Teachers of Mathematics in 1981, which was published on the teaching of statistics and probability (Shulte, 1981). The second one was the 68<sup>th</sup> National Council of Teachers of Mathematics yearbook in 2006, entitled Thinking and Reasoning with Data and Change (Burrill & Elliott, 2006).

New technologies have affected human life in different dimensions. Since access to new technologies increased, the idea of using these technologies in various fields, including in the

teaching-learning process of statistics and probability, was raised. There are many examples of it in the research literature (e.g. Martignon & Krauss, 2009; Chaput et al., 2011; Eichler & Vogel 2014; Nilsson, 2014; Nunes et al., 2014). With the ever-increasing advancements of new technologies, the capacity of this technology has increased in ways to help improve the teaching-learning process of statistics and probability like other disciplines. As a result, methods that introduce a new path for using new technologies to improve educational performance; are still among the innovative ideas in the field of statistics and probability education. One of these innovative ideas is the use of blocky programming languages like Scratch to simulate and model real-world phenomena in the field of statistics and probability education. Programming is identified inside of computational thinking (CT) which is identified by Ziefler and Garfield (2018) as one of the necessary skills for 21<sup>st</sup> century for everyone.

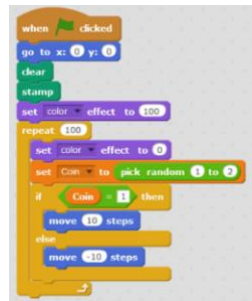
Scratch is one of the visual programming languages in which users do not need to write code, but the codes of this programming language are exposed to the user in the form of different shapes, and the user starts coding by putting these shapes together. Scratch was invented and produced in the Media Lab of Massachusetts Institute of Technology (MIT) and introduced to the world for free. The main goal of developing programming languages such as Scratch is to design a programming language that is easy to work with. The designers of the Scratch programming language were inspired by the LOGO software to achieve their goal. The Scratch environment has various facilities for producing stories, games, and animations, and users can share their creations online. Currently, this programming language is used in different countries for the teaching-learning process of course materials to students (for more information, refer to the Scratch website).

In recent years many educational systems around the world start to integrate some sort of computational thinking (e.g. programming and coding) in their school curriculum. In Iran's educational system, it can be identified the vein and root of computational thinking in both the school curriculum and after school program. The current study is an empirical research paper proposal that addresses the impact of computer-based tools in the learning and teaching of probability. The specific, main research question that guide this study was to investigate the impact of using blocky programming (Scratch) in improving the probabilistic thinking of seventh-grade students.

## **Literature Review**

In the following, there are more explanations about block programming languages and how to simulate and model phenomena by providing concrete examples. In the Scratch programming environment, children can write a program and test it, without getting involved in the complexities of traditional programming languages. Three columns can be seen in the Scratch programming language environment. In the middle column, there are command blocks that the user can easily create a new program by dragging and dropping these blocks in the right column. The result of the application test can be seen by the cat animation in the left column. To test the program, the user can also use the button with the green flag icon located at the top of the left column.

Figure 1 shows programming in Scratch, which simulates the phenomenon of random coin tossing 100 times. By running this program, the scratch software cat starts walking left and right. By using this simple block programming and cat animation, complex concepts such as binomial distribution can be modelled and easily taught to children at lower elementary school levels. This modelling will bring a pleasant experience for students because the whole simulation and modelling work is done by themselves and the result of their work is displayed very quickly by the cat animation.



**Figure 1: A program written in Scratch for simulating random coin toss**

Various studies have shown that blocky programs such as Scratch can be easily reproduced by elementary school students (for example, Gadanidis, Hoges, Minetti, & White, 2016). As a result, complex concepts of statistics and probability can be taught to elementary school students as well. In this way, through learning more meaningful and deeper concepts of statistics and probability from the very beginning, students get to know the real applications of statistics and probability concepts through concrete experiences in the real world.

In the research conducted by Paparistodemou, Meletiou-Mavrotheris, and Vasou (2017), they asked 26 students aged eight to 13 to create their own game based on what they learned during four two-hour workshops on scratch programming. The research question was how students display and develop their reasoning about probability by designing a game in a computer environment. The findings of Paparistodemo et al. (2017) study show that the idea of chance played an important role in students' designed games. The law of large numbers is used for describing the result of repeating an experiment many times. Quinn (2011) refers to various projects on the Scratch website which are suitable to get a better understanding of the law of large numbers. For example, in tossing a coin several times and calculating the probability for "heads" or "tails", if we have more trials, then we will be closer to 0.5.

## **Method**

The current study used a quasi-experimental (two-group post-test) quantitative method. Participants of this study were 100 seventh-grade students from two lower secondary schools in the city of Rafsanjan in Kerman province (south-east of Iran) were selected for participation in this study. Fifty students were allocated to the experimental group and fifty students were assigned to the control group. Data collection occurred in the 2020-2021 school year. At that time the pandemic covid-19 virus exists all over the world and schools in many countries provide lessons in a virtual mood for students. In Iran also like in other parts of the world, students participated in a virtual

class. They use their special platform namely SHAD which is designed at the national level for supporting the teaching and learning process of Iranian students. All of the students announced that they didn't have any sort of prior knowledge or experience in programming and coding. Almost all of them have the same level in their education progress (according to their scores in math and science).

All fifty students in the experimental group participated in three 45-minute online sessions which became familiar with Scratch blocky programming and its capability for designing different programs and animation. After that, they participate in one session about using Scratch blocky programming for the probabilistic phenomenon (about generating random numbers). All of the class videos are recorded and uploaded to [www.apparat.com](http://www.apparat.com) which is a platform for producing and sharing videos in Iran. So, students have access to the content of the class through [www.apparat.com](http://www.apparat.com) and the student educational network (SHAD). After each training session, the students programmed their creative ideas in their projects and sent them to the researchers. The researchers saved their projects and analysed them and send feedback to students. The final project of students in the experimental group was based on the probability content of the grade seventh Iranian mathematics textbook on page 121 which related to the law of large numbers (Figure 2).

<b>Probability and Experience</b>	
Activity	<ul style="list-style-type: none"> <li>Mohsen wants to throw a coin and check which side is showing when it lands. Does the coin come with “heads” or “tails”? He tosses the coin and it comes tail. If he throw the coin again, what would be happened? “heads” or “tails”? He tosses the coin three more times and at all times he gets tails. If he throw the coin one more time, what would be happened? “heads” or “tails”?</li> <li>You can pick a coin and try to do this experience. You can throw the coin 10 times and note the results. Make a table based on your results.</li> <li>Compare your table with other classmates' tables. Are they the same?</li> <li>Write the ratio of the number of “heads” to the total number of tests as a fraction based on your table.</li> <li>Compare your fraction with other classmates' fractions. Are they the same?</li> </ul>
Work at Class I	<ul style="list-style-type: none"> <li>Put one red bead and two blue beads in a bag. Draw a bead at random from the bag and note its color. Put the bead back in the bag. Do this test 9 times and <i>make a table</i>.</li> <li>Compare your table with your friends? Is everyone's table the same? In what fraction of trials did the red bead seal come out of the bag? In what fraction of trials did the blue bead seal come out of the bag?</li> <li>Calculate the sum of these two fractions.</li> <li>Compare the answers with your friends. What differences and similarities do you see?</li> </ul>
Work at Class II	<ul style="list-style-type: none"> <li>Toss a dice for 30 times and record it down in diagram.</li> <li>Compare your answer with your friends' answers.</li> <li>Was each number of dice observed exactly 5 times in the 30 tests of throwing dice?</li> </ul> <div style="text-align: right;"> </div>

**Figure 2: Activity and “Work at Class” page 121 of seventh- grade Iranian mathematics textbook**

During these activities, students could have several experiences with the law of large numbers, but there is a limitation to deep understanding. Because they couldn't examine several numbers before throwing the dice. It is boring for them. In this situation, technology and blocky programming (Scratch) could help students. In this study, after 4 sessions of instruction about Scratch, students were invited to build a simulation or practical model for calculating the probability of a phenomenon through programming. They developed creative and interesting simulations (pictures of these projects will be reported in the results section). Finally, for comparing the probabilistic thinking of students in the experimental and control group, a post-test with six questions (each question has one point) related to probability content was designed and both experimental and control group students' response to these test. Figure 3 show an example of the question that ask students in post-test. Each student obtains a number between 0 to 6 in this test based on their correct responses to this test.

We throw a dice. Determine whether the following sentence is true or false.

- In 60 throws of the dice, the number 3 always comes exactly 10 times.

**Figure 3: An example of the question in the test related to probability content**

These questions after designing sent to group of 5 teachers who had teaching experience in grade 7 mathematics to modified it a validate for using in post-test. Also, a short questionnaire was designed in Google form platform for investigation of the level of satisfaction of students when they use Scratch in learning probability concepts.

## Results

During the creating scratch program students were able to throw a dice or toss a coin several times and see what is happening immediately. So, limitations in the number of throws of dice and tossing the coins that exist in the traditional teaching method will be removed by using new programming tools. For example, two projects designed by students using Scratch come in figure 4. On the left side of figure 4, students design a program that imports a number as we desire for throwing dice and the program will determine how many times each number of dice would have appeared. On the right side of figure 4, students designed a program that gets a number as we desire to toss a coin and the program will determine how many times each of the "heads" or "tails" will be appeared.



**Figure 4: Two projects designed by experimental group of students as example**

Table 1 shows the descriptive analysis of the post-test for experimental and control groups of students. As we can see in this table, the average score of students in the experimental group was reported as 4.18, and the average score of students in the control group was addressed by 2.54.

**Table 1: Descriptive statistics of post-test for experimental and control groups students**

Variable	Group	Number	Mean	Standard Deviation	First Quartile	Second Quartile,	Third Quartile
Probabilistic Thinking	Experimental	50	4.18	1.30	3	4	5
	Control	50	2.54	1.47	1	2	3.25

For the investigation of statistically significant differences between the performance of students in experimental and control groups, we use T-test. hypotheses that were tested in the current study are as below.

- The null hypothesis: there are no significant differences between the performance of two experimental and control groups of students in the probability post-test.
- The opposite hypothesis: there are significant differences between the performance of two experimental and control groups of students in the probability post-test.

The results of the T-test shown in table 2 stated that the score of the experimental group is significantly higher than the score of the students in the control group. According to the p-value of the test of equality of variances, which is more than 0.05, then the null hypothesis of equality of variances is accepted, and according to the p-value of the test of equality of means, which is less than 0.05, the null hypothesis of equality of means is rejected. So the difference between the averages of the two experimental and control groups was confirmed.

**Table 2: The output of T-test for experimental and control group students in post-test**

Variable	Levene's Test for Equality of Variance		T-test for Equality of Means		
	F	Sig.	T	df	Sig.
Probabilistic Thinking	5.9	0.27	5.9	48	0.000

Finally, in a short questionnaire, researchers ask students to respond to one question which revealed students' opinions about using blocky programming in the process of teaching and learning probability. Students in the experimental group were asked to answer the below question with a Likert spectrum from 1 (means completely disagree) to 4 (means completely agree). Results of the descriptive analysis of experimental group students are shown in table 3.

- Making probability projects in blocky programming (such as tossing a coin, throwing a dice, etc.), help me to understand the subject of probability in a better way.

**Table 3: Descriptive analysis of experimental group students in a short questionnaire**

Variable	Number	Percent	
Learning Probability with Blocky Programing like Scratch	completely disagree	0	0
	Disagree	3	6
	Agree	21	42
	completely agree	26	52
Sum	50	100	

## Discussion and Conclusion

In this research for responding the main research about the investigation of the impact of using blocky programming (such as Scratch) in improving the probabilistic thinking of seventh-grade students, we design a semi-experimental research design and find that using blocky programming (such as Scratch) can increase students' ability in probabilistic thinking. The results of the descriptive and inferential analysis shown in Tables 1 and 2 show that the average score of students in the experimental group (4.18) was higher than the average score of students in the control group (2.54) and this difference is statistically significant. Through this research, a new approach was introduced that could enhance the process of teaching and learning probability. In this new approach, students could write a program for tossing a coin or throwing a dice several times. With this tangible experiment, students can make their meaning for the law of large numbers.

Furthermore, the results of the analysis of the short questionnaire show that almost all of the students who participated in the experimental group were satisfied with their experiences during this study. Upon table 3, about 94 percent of students in the experimental group agreed or completely agree with using blocky programming (such as Scratch) in teaching and learning probabilistic thinking. In addition, students' feedback in the Google form questionnaire reveals their satisfaction with using blocky programming in teaching and learning probabilistic thinking.

The new insight that comes up from the current study is that with new technology tools (in this case blocky programming), it is possible to do something that was not possible before (e.g. throwing the dice 100 times and showing the results immediately). These types of experiments enhance both the computational thinking and the probabilistic thinking of students and increase students' interest and motivation to create new ideas using blocky programing, most importantly they do it autonomously which is one of the final goals of the education system.

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