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Original Article

Teaching cell division topic using computational thinking skills and determining its' impact on creative thinking skills and student perspectives [*]

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Abstract

The aim of this research is to determine the impact of cell division teaching designed with computational thinking applications on the creative thinking skills and opinions of 7th-grade middle school students. The teaching design used in the research was created by taking inspiration from a study that provides application steps in the literature and was revised by the researcher. The research, which examines creative thinking skills in both quantitative and qualitative dimensions, was conducted based on the mixed methods design. The study group of the research consists of 39 students attending the 7th grade in two different classrooms of a state school located in the Kadıköy district of Istanbul province during the fall semester of the 2020-2021 academic year. Since the study was conducted during the pandemic period, it was carried out online. Throughout the implementing period, the teaching design integrated with computational thinking skills was done with the 21 students in the experimental group, while in the control group, consisting of 18 students, lessons were conducted according to the existing constructivist approach. Torrance Creative Thinking Test was used as the data collection tool in the quantitative dimension of the research, and a Creative Thinking Question and Semi-structured Interview were used in the qualitative dimension. The data obtained from the Torrance Creative Thinking Test were analyzed using the SPSS program, and it was determined that the implemented teaching design provided significantly enhanced creative thinking skills. Descriptive analysis was conducted on the data obtained from the creative thinking question in terms of flexibility, fluency, and lateral thinking, and it was observed that there was an improvement in students' creative thinking sub-skills and lateral thinking skills parallel to the quantitative findings. The data obtained from the semi-structured interview were analyzed using the MAXQDA program, and it was concluded that students found the teaching integrated with computational thinking skills more enjoyable and were able to easily integrate these skills into other subjects and daily life.

Keywords

Computational thinking skills
Creativity
Algorithm design
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Introduction

Computational thinking has become a key competency in today's information-rich world, enabling individuals to tackle complex problems using strategies inspired by computer science. Throughout history, scientists have demonstrated forms of computational thinking as they systematically analyzed data, formulated hypotheses, and designed models to understand complex phenomena. Charles Darwin, for instance, employed such thinking in developing his theory of evolution; he meticulously collected data, identified patterns across species, and ultimately conceptualized the 'tree of life' to represent the branching relationships among organisms (Koruk, 2021). This historical example illustrates that computational thinking is not merely a contemporary skill, but one deeply embedded in scientific inquiry. Di Sessa (2001) exemplified Galileo's creation of the heliocentric view of the universe by dividing his ideas into sub-steps such as speed, time, and distance, which can be considered as instances of computational thinking skills. The utilization of computational thinking skills by scientists during significant historical discoveries highlights the importance of integrating computational thinking skill applications in science education. Furthermore, with the recognition of computational thinking skill (CTS) as one of the essential skills individuals should possess in the 21st century, the studies focusing on how to teach this skill and integrate it into the existing curriculum have gained significance (Voogt and Roblin, 2012).

Computational thinking can be defined as "a set of skills that assist in solving complex problems or designing large and complex systems" (Wing, 2006, p. 33). Based on this definition, it can be said that computational thinking processes involve the use of versatile sub-skills and the formulation of solution paths for problem-solving (Kert, 2017). The fundamental aim of teaching CTS is not to make individuals think mechanically like machines but to enhance their intellectual skills, enabling them to transfer this high-level skill to various areas of their lives and establish multidimensional thinking processes (Wing, 2010). Furthermore, Wing's (2006) assertion that biologists can benefit greatly from this thinking skill underscores the integration of computational thinking in the teaching of cell division, which is one of the points of support in this research. In this context, Peel et al. (2019) designed and implemented the teaching of the concept of natural selection using computational thinking skills, and as a result, they found that students were able to learn the concept of natural selection more profoundly, and misconceptions regarding the topic disappeared. This study by Peel et al. (2019) represents one of the significant works supporting Wing's claim.

Weintrop et al. (2016) discussed four different application paths for integrating computational thinking skills with science and mathematics disciplines. These paths include data applications, modeling and simulation applications, problem-solving applications based on computational thinking skills, and thinking practices related to systems. In this study, the teaching design was created by adding a data application step to the modelling and simulation-based lesson plan proposed by Peel and Freidrichsen in 2018.

There are both differences and similarities in the identification of the sub-skills, i.e., components, of computational thinking. The computational thinking sub-skills used in this study are abstraction, algorithmic thinking, iteration, branching, and variables. According to Wing (2010), the key skill of computational thinking is abstraction. Wing (2010) defined abstraction as the skill of identifying patterns in a problem, making generalizations from examples, and formulating data. Computing At School (CAS) described abstraction as the process of reducing unnecessary details to make a work more understandable (2015, p. 7). An example given for this process is the London Underground map: "London is a complex city. The London Underground map is a refined abstraction that allows travelers to navigate underground without unnecessary information such as distance and exact geographical location" (CAS, 2015, p. 7).

Wing (2006) claimed that within 50 years, computational thinking would become one of the essential skills that everyone should possess, similar to basic skills such as counting and reading. The computational thinking activities conducted from preschool onward, the announcement of the creation of a subsection within the Programme for International Student Assessment (PISA) 2021 Mathematics section that includes questions involving computational thinking skills (The Organization for Economic Cooperation and Development [OECD], 2018), and the widespread integration efforts of computational thinking across various domains further reinforce Wing's claim. While studies focusing on computational thinking are increasing, they tend to primarily focus on coding, robotics, programming, STEM, and computer games (Akkaya, 2018; Altın, 2021; Bolat, 2020; Ceylan, 2020; Oluk et al., 2018; Şimşek, 2018). In this study, computational thinking skills are utilized in the context of scientific process explanations, and cell division teaching was designed with CTS applications. Thus, this research is expected to contribute to the literature by addressing an underrepresented area. Furthermore, the study proposes practical steps and a draft instructional design that allows science teachers to integrate computational thinking with topics and learning outcomes of their choice, indicating the practical relevance of the study in the field of education.

Creativity is a process that encompasses characteristics such as flexibility, the ability to see from different perspectives, sensitivity, awareness, and engagement with the environment and people, fluency, the ability to think and act flexibly, quickly, and independently, originality, and ability to arrive at different and diverse outcomes (Bilge & Erdoğan, 2011). De Bono (2003) defined creativity as a system that generates and structures knowledge in various ways. De Bono emphasized the importance of lateral thinking as an essential aspect of creative thinking. To De Bono, lateral thinking is the conscious and deliberate inclination to consider events from different perspectives and is closely connected to creativity (De Bono, 1986). On his website, which provides information about lateral thinking, De Bono described lateral thinking as a thinking style that recognizes the nature of one's own thoughts and explores a wide range of possibilities to discover the original. He emphasized the significance of lateral thinking over vertical thinking with the statement: "Digging the same hole deeper does not create a different hole (De Bono, n.d.).

Creative thinking skills, which are accepted as one of the 21st-century thinking skills, are sometimes expressed as part of computational thinking in some studies (Partnership for 21st Century Skills [P21], 2009). For example, Brennan and Resnick (2012) identified creativity as one of the six sub-skills of computational thinking. Additionally, Sternberg and Lubart (1993) mentioned that creative individuals enjoy formulating problems and deriving different rules, which can be directly related to the key computational thinking skill of abstraction. This study aims to determine the impact of computational thinking skill applications on creative thinking skills and test this inference.

Based on these considerations, this study aims to investigate the impact of teaching cell division using computational thinking skill applications on the creative thinking skills of 7th-grade middle school students, as well as evaluate the students' perspectives during this process. The research problem is formulated as follows: "What is the effect of teaching cell division using computational thinking skill applications on the creative thinking skills of middle school students?" The following research questions were addressed:

1. Does teaching cell division using computational thinking skill applications have an impact on students' creative thinking skills?
   a. Do the creative thinking skills of students in the experimental group, where teaching cell division is conducted using computational thinking skill applications, differ from those of the control group, where teaching is carried out according to the existing curriculum, in terms of groups (experimental-control) and measurements (pre-test-post-test)?
   b. What is the effect of teaching cell division using computational thinking skill applications on the creative thinking skills of students in the experimental group?
2. What are the perspectives of students in the experimental group regarding the teaching of cell division using computational thinking skill applications?

Method

Model of the Research

This research was designed in accordance with the triangulation design (combination) of the mixed method. The design of the research was designated as the combination (triangulation) design owing to collecting qualitative and quantitative data simultaneously and independently of each other, combining the data to comment, and attaching equal importance to both two types of data (Creswell & Creswell 2017). In the quantitative part of the study, the pretest-posttest quasi-experimental design with a control group was used. At this point, the independent variable of the research is teaching science which is integrated computational thinking skills. The lesson design planned for the development of computational thinking skills includes applications of abstraction, algorithms, programming and development, data collection and analysis, as well as modeling and simulation. These applications were implemented through designing Scratch blocks, algorithm design and branching, creating graphs, and conducting Lightbot activities. The dependent variable is creative thinking. At the same time, the creative thinking skill of the students was evaluated qualitatively with the creative thinking question and pre- and post-application. At the end of the application, an interview was done to pinpoint the experimental group students' views towards the application.

Study Group

This study was executed with 7-grade students in a government secondary school in the sub-province of Kadıköy throughout the 2020-2021 academic year. The available classes were randomly chosen as the control and the experimental group. Even though the population of the classes was equal to 30 students for each, the population of the experimental group decreased to 21, and the control group to 18 because of students' absence. The experimental group includes 10 girls (%48) and 11 boys (%58); the control group has 11 girls (%61) and 7 boys (%39). "The 'Creative Thinking Question' and 'Structured Interview Questions' were applied to 8 voluntary students from the experimental group, who were identified as having high, medium, and low levels of school achievement and attendance, using the maximum variation sampling method." The 8 students from different levels of success, who were asked about the creative thinking question, were chosen in view of their grade point average and the suggestion of the subject teachers. It is a great advantage that the maximum variance sample method provides describing the study problem from a greater perspective depending on different conditions (Büyüköztürk et al., 2008). Voluntary participation forms were received from the students and their parents for all of the qualitative and quantitative scales.

Data Collecting Tools and The Process of Data Collection

To evaluate creative thinking in this study, the **"Torrance Test of Creative Thinking: Verbal Form A"** and a **"Creative Thinking Question"** were administered as pre-tests to eight students from the experimental group. Following the pre-tests, the topic of **cell division** was taught to the experimental group using **computational thinking activities**, whereas the same topic was taught to the control group using **activities from the standard textbook**. This intervention continued for **18 class sessions**. At the end of the instructional period, the **"Torrance Test of Creative Thinking: Verbal Form B"** and the **"Creative Thinking Question"** were administered again to the same eight students in the experimental group as post-tests. Meanwhile, **"Semi-Structured Interview Questions"** were used to gather the students' opinions on the computational thinking-based instruction. The researcher ensured that all eight students completed the interviews individually and in written form. Details regarding the quantitative and qualitative data collection tools used in the study are provided below.

Torrance Creative Thinking Test

In the literature, various ideas, and methods for evaluating creative thinking skills are suggested and there are even some researchers who say that creative thinking skills should not be evaluated (Kaygın & Çetinkaya, 2015). These different ideas caused to emerge different methods and views towards evaluating creative thinking skills. In this study, to evaluate the creative thinking skills of the groups quantitatively 'Torrance Creative Thinking Test', which is mostly accepted, and was developed by E. Paul Torrance and published by the USA in 1966 (Kaygın & Çetinkaya, 2015). This test composes of four forms, Verbal Form A, Verbal Form B, Modal Form A, and Modal Form B. Verbal Forms A and B are parallel to each other and include 7 activities, which are asking a question, estimating the reasons, estimating the results, developing a product, usual usages, and 'given that'. These 7 activities are evaluated in three dimensions; fluency, flexibility, and authenticity (Avcu, 2014; Gölcük, 2017).

Adaptation of the Torrance Creative Thinking Test into Turkish and validity and reliability studies were conducted by Aslan (2001). The test was applied to 922 people ranging from kindergarten students to adults and Cronbach Alfa internal consistency coefficient value was found 0.50 at the lowest and 0.71 at most. To determine the internal validity of the seven sub-activities of the Verbal Creative Thinking Test, total items, excluding items, and item distinctiveness analysis were committed. At the end of the analysis, a significant difference in the level of $p<0.01$ was obtained in all verbal creative tests at all ages. To determine external validity, a series of analyses of criterion validity was also done. These analyses showed that the whole of the test is both valid and reliable for all ages (Aslan, 2001). Before the test was used in this study, necessary permission was received. In the study, the reliability analysis of the scale was done, and the value of Cronbach Alpha was determined as 0,882, 0,799, and 0,751 in the order of fluency, flexibility, and authenticity. The total layer Cronbach Alpha value was found as 0,935. This situation shows that this test is reliable also for this study.

The Creative Thinking Question

To determine the development of the student's creative thinking skills qualitatively, the creative thinking question 'If you want to use your pencil in a different way, how would you do it? (You can write all the ideas coming to your mind. It is expected you write something new and different) was prepared. While preparing the question, the validity of the question was evaluated with the help of expert opinion. To see the reliability of the creative thinking question, a pilot scheme was applied to 4 students with the expert opinion again. The data of the pilot scheme was evaluated in the context of fluency, flexibility, and lateral thinking by committing descriptive analysis. It was obtained that students could read, understand, and answer the question and the given time (20 min.) was enough. Fluency and flexibility were used as subdimension in the Torrance Creative Thinking Test. For this reason, the context of fluency, flexibility, and lateral thinking to evaluate the creative thinking question. Lateral thinking, a problem-solving approach introduced by Edward de Bono, encourages individuals to think outside traditional linear patterns and explore alternative solutions by challenging established assumptions and employing creative, non-sequential thinking processes (De Bono, 1970). Even if authenticity resembles lateral thinking, they are not the same. Authenticity is the answers are statistically scarce and in Torrance Creative Thinking Test if an opinion is scarcely thought, it increases the point of authenticity (Kim, 2006). This authentic idea might be vertical or lateral thinking. Lateral thinking is naturally thinking out of the box and springs to rarely mind that's why the possibility of being authentic is high. However, an idea that is produced by thinking vertically is accepted as authentic if it was thought by few people. In these circumstances, a relationship can be built between lateral thinking and authenticity, but they don't meet each other. Lateral thinking is expressed as the core of creative thinking by Edvard de Bono (De Bono, 1970).

Semi-structured Interview Form

To find the students' opinions towards teaching science integrated with CTS, the semi-structured interview form was applied to the experimental group of students. The semi-structured interview form comprises 6 open-ended questions that were prepared by the researchers and were finalized by receiving one's opinion of who the expert in the field is. The expert made suggestions like taking out the questions meaning the same, decreasing the number of the questions, and adding the 'Can you explain your answer?' expression to the questions to supply students to express themselves better. When these suggestions are considered, the number of questions in the interview form, which was formed with 25 questions at first, was decreased to 6 questions which are not boring and provide students to express themselves, and these 6 questions were applied in the custody of the expert.

The Applied Lesson Design

Before the application, the necessary permissions were received from The Provincial Directorate for National Education which the school is inhered in, and an ethics committee from a university. After receiving the permissions, the essential training was completed to comment on the Torrance Creative Thinking Test. After the permissions and the training, quantitative data was collected from the control group students 2 weeks before and 2 weeks after the application. Students were given 35 minutes to answer the Torrance Creative Thinking Verbal Form. Creative Thinking Question, one of the qualitative tools, was applied by a researcher to 8 students by giving 20 minutes 7 days before and 7 days after the application. The other qualitative data collection tool, the Structured Interview Form, was applied by a researcher to 8 students giving 30 minutes on the day of ending the application to find the students' opinions towards the application.

The lesson designs were applied online in both groups during the distance education because of the pandemic. The lesson design which was applied to the experimental group was structured with CTS applications and activities in the context of the 'Cell and Divisions' unit of 'Living Things and Life' subject. In the lesson design, the steps of lesson planning that were structured by CTS and consisted of the algorithm, abstraction, reiteration, and branching steps suggested by Peel and Friedrichsen (2018), and data practices were added to these steps. According to the literature, data practices underlie the computational thinking skill practices (Weintrop et al., 2016). Moreover, the lesson design, formed by adding the step of data practices, happens to involve the whole of abstraction, algorithm, programming, and developing, data collection and analyzing, modeling, and simulation practices that were used for the standards of computational thinking skill of Computer Sciences and Digital Literacy by MIT (K-12 Computer Science Framework Steering Committee, 2016). The lesson design, which was planned as two lessons at a time for 9 days in total, includes the applications of story exposition, designing the scratch block, designing and branching algorithms, and creating graphics. The teaching design is comprised of 5 steps: respectively structuring the concepts about the subject, exploring computational thinking skills with the light bot game, developing algorithms of cell division, creating scratch block design with these algorithms, and data practices. In the first step of the practice, the students perceive and structure the concept of the subject. In the second step, the students are provided with learning the concepts of CTS, algorithm, abstraction, reiteration, and branching with the Lightbot game.

Table 1. Computational Thinking Skill Components and Samples

Computational Thinking Skill Components	Definition	Sample
Algorithm	A series of steps or a description to solve a problem.	A recipe that tells how to cook a meal.
Abstraction	Simplifying the information and choosing the necessary parts.	When someone asks you what you did yesterday, you talk about the film you watched on Netflix, not you woke up, ate, or took a shower.
Reiteration	Repeating a series of steps until a condition is met.	Chew the food while eating your meal and swallow it. Repeat this action till you finish your meal.
Branching	Selecting a way in the conditions of 'if'.	Crossing the road at the traffic lights: cross the road if it is green, stop if it is red.
Variances	The variable value that is used to make programs worldwide.	The algorithm of our morning routine is getting up, taking a shower, getting dressed, and having breakfast. Here, clothes are variances, and it changes according to what we wear every day.

(Peel & Friedrichsen, 2018)

The students provide to create cell division algorithms by exploring the concepts; of the algorithm, abstraction, reiteration, branching, and variance over the Lightbot and with the help of the teacher and using these concepts, of which explanations are in Table 1. While the students are playing Lightbot and evaluating each other's algorithms, the teacher makes the students find out abstraction and reiteration and note them down with the arguments that the teacher starts. Later on, the students continue playing the game and make comments on each other's algorithms. Examples related to the concepts of abstraction and repetition in Lightbot are provided below in Figure 1.

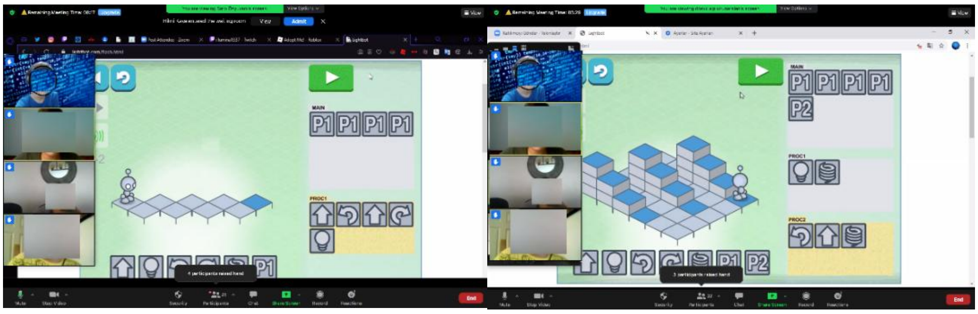

Figure 1. The Abstraction on Lightbot Game (P1 and P2 on the right) and Reiteration (P1 repetition on the left)

During the process of the teaching design, the lesson frame, which is applicable to every subject, of the teaching design, in which data practices were added, was formed, and this frame was shown in Table 2.

Table 2. The Lesson Frame Prepared by Using Computational Thinking Skill Applications

Day	Learning Activity	Objectives
1	Checking their prior knowledge, Implicating the concepts of the subject and teaching them.	The objectives of the subject area are acquired (subject area acquisition).
2	Prologuizing computational thinking with Lightbot game.	The students explore the concept of basic computational thinking skills, algorithm, abstraction, reiteration, and branching with the ways of problem-solving they use in a programming game (acquisition of computational thinking skills).
3	Application of computational thinking skill: Developing algorithms	The students develop the algorithm showing the process regarding the text or the video (acquisition of both subject area and computational thinking skills).
4	Application of computational thinking skill: Programming the algorithms with Scratch	The students design a program on Scratch to simulate the algorithm they developed (acquisition of both subject area and computational thinking skills).
5	Application of computational thinking skill: Data practices	The students collect data about the number of cells and chromosomes during and after division concerning the problem given. Then, they transform the data into tables and graphics to visualize data (acquisition of both subject area and computational thinking skills).

By adding the content of the Cell Division unit into the frame of the lesson shown in Table 2, this frame was structured going with the objectives of the program for both mitotic and meiosis division. This frame was applied for 18 lesson hours for 9 days in total. Since the 2nd step that the Lightbot game was used was headed in the mitotic division, this step was not given a place in the meiosis division lesson design. In the circumstances, 10 lesson hours for 5 days of mitotic division and, 8 lesson hours for 4 days of meiosis division were designed. The committed teaching design was given in detail in Table 3.

Table 3. Cell Division Teaching Design Prepared by Using CTS Applications

Day	Teaching Design of the Experimental Group
1	Introduction to mitotic division, providing students to explore the concepts about the importance of mitotic division from a text and a visual.
2	Introduction to computational thinking with Lightbot game, the student levels up some in the game. Then, the teacher gives the samples and definitions which are stated in Table 1. By creating a discussion platform with the students, they are supplied with exploring the concepts of algorithms, abstraction, and reiteration in the game. The teacher gives the samples. The students continue playing, they create different algorithms and comment on each other's algorithms. While the game is going on, the teacher starts a debate about the concepts of computational thinking skills from time to time. The students are asked to give samples from their daily life. (Introduction to the algorithm, abstraction, reiteration, and branching concepts)
3	The students are divided into groups. The teacher reminds the students of the variable concepts, algorithm, abstraction, and branching done in the previous lesson, with the brainstorming technique. Later, every group is delivered a text telling the mitotic division procedure and the students create their own algorithms by using the computational thinking skill concepts, which they have learned, and show these concepts in their algorithms. In the remaining time, they comment on each other's algorithms.
4	The mitotic division algorithms that they created before are programmed with Scratch, like continuing the group work, and simulation is formed.
5	In the step of data practices of the mitotic division, the teacher provides the students use the skills of reading graphs, obtaining the formula inside the data (abstraction), and graphs reading with the activities and questions the teacher prepared beforehand. In this part, it is important to make homogeneous groups.
6	Introduction to the meiosis division, the importance of the meiosis division, and providing exploration of the relevant concepts.
7	The students are divided into groups. The teacher reminds the concept of the computational thinking skill, which the students explored with the Lightbot game, with the questions and answers technique. Later, the teacher plays the video talking about the meiosis division and shared the link to the video. The groups create their own meiosis division algorithms by using the concepts of the computational thinking skill, which they have learned for 40 minutes. In the remaining time, they comment on each other's algorithms. (The used video: https://www.youtube.com/watch?v=mF3HnE5eOUw&t=70s)
8	The meiosis division algorithms that they created before are programmed with Scratch, like continuing the group work, and simulation is formed.
9	In the step of data practices of the meiosis division, the teacher provides the students use the skills of reading graphs, obtaining the formula inside the data (abstraction), and graphs reading with the activities and questions the teacher prepared beforehand. In this part, it is important to make homogeneous groups.

In the control group, as in the experimental group, student-centered teaching was done for 18 lesson hours based on the objectives of the 2018 Ministry of National Education Science studies program. With the control group, brainstorming, group work, Web 2.0 tools (Learning apps), modeling practices, and solving skill-based questions were used and qualified teaching was planned to apply. In Table 4, the applications maintained for 18 lesson hours during 9 days with the experimental and the control group were given comparatively.

Table 4. The Applications Done with the Experimental and Control Group

Day	The Experimental Group Applications	The Control Group Applications
1	Introduction to the mitotic division, providing the exploration of the importance of the mitotic division and its concepts over a text and visual.	Introduction to the mitotic division, providing the exploration of the importance of the mitotic division and its concepts over a text and visual.
2	Introduction to computational thinking with Lightbot game (introduction to algorithms, abstraction, branching, reiteration, and variance concepts.)	To provide ordering the phases given tangled in the order of happening by using a certain logic in group work.
3	With reference to the text, the students create mitotic division algorithms by using the concepts they learned with the Lightbot game.	Forming the mitotic division phases over the Learning apps.
4	Programming the obtained mitotic division algorithms with Scratch.	The mitotic division deepening activities
5	The mitotic division practices (data collection, creating tables and graphs)	The course book evaluation work
6	Introduction to the meiosis division, providing the exploration of the importance of concepts about the mitotic division.	Introduction to the meiosis division, the importance of the meiosis division, providing the exploration of the related concepts
7	With reference to the video, the students create meiosis division algorithms by using the concepts they learned with the Lightbot game.	Providing an explanation of only the phases of which photos are given in the group work.
8	Programming the obtained meiosis division algorithms with Scratch.	The meiosis division deepening activities, modeling of the meiosis division by using waste materials from home.
9	The meiosis division practices (data collection, creating tables and graphs)	Solving skill-based problems of the Cell Division Unit

As stated in Table 4, with the applications done with the experimental group, students are provided to explore the computational thinking skills, algorithm, abstraction, reiteration, branching, and repetition sub-dimensions. Later, they are provided to reach the objectives of the cell division unit by using these sub-dimensions. With the applications done with the control group, acquiring only the objectives of the cell division unit was done by using the constructivist approach.

Data Analysis

Torrance Creative Thinking Test Analysis

The analysis of the Creative Thinking Test was conducted quantitatively with the help of the SPSS program. To determine the tests to be used in the program, the condition of normal distribution of data was first analyzed. Since the greatness of the group is less than 50, Shapiro-Wilk test results were given a place in Table 5.

Table 5. The Results of Normality Analysis of Torrance Creative Thinking Test Data of the Groups

Group	Test	Shapiro Wilk (p)
Experimental Group	Torrance Total Points Pretest	0,006
	Torrance Total Points Posttest	0,238
Control Group	Torrance Total Points Pre-test	0,515
	Torrance Total Points Posttest	0,467
Experimental Group	Torrance Total Points Pre-test	0,019
	Torrance Fluency Posttest	0,031
Control Group	Torrance Total Points Pre-test	0,311
	Torrance Fluency Posttest	0,323
Experimental Group	Torrance Total Points Pre-test	0,006
	Torrance Flexibility Posttest	0,224
Control Group	Torrance Total Points Pre-test	0,374
	Torrance Flexibility Posttest	0,513
Experimental Group	Torrance Total Points Pre-test	0,003
	Torrance Authenticity Posttest	0,111
Control Group	Torrance Total Points Pre-test	0,336
	Torrance Authenticity Posttest	0,242

As seen in Table 5, it was confirmed that the p values of flexibility and authenticity sub-dimensions in the experimental group creative thinking posttest and p values in every dimension of the control group pretest and posttest are greater than 0.05 and so the test data range normally. However, the experimental group's Torrance creative thinking skills pretest total point, fluency, flexibility, and authenticity sub-dimensions data does not show normal distribution. Considering this data, it was specified whether there is a significant difference between the points of the pretest of the experimental and the control group or not by committing 'The Mann Whitney U Test for Independent Groups'. It was specified if there is a significant difference between the fluency sub- dimension test points of the control group and the experimental group by committing again 'Mann Whitney U Test for Independent Groups'. Considering there is a significant difference between pretest points in the authenticity sub-dimension of the control and experimental group and do not range normally, it was specified if there is a significant difference between posttests of them by applying the 'ANCOVA Test'. It was determined if there is a significant difference between the points of other sub-dimensions in the control and experimental group posttests by applying the 't-Test for Independent Groups'. It was again specified if there is a significant difference in every dimension between the points of the pretest and posttest in the control group by using 'The Wilcoxon Signed Rank Test for the Dependent Group'. Considering the data in every sub-dimension of the control group showing normal distribution, the comparison of the points of the pretest and posttest was done by using 'the t -Test for Relevant Groups'.

Creative Thinking Question

The creative thinking question (If you wanted to use your pencil in a different way, how would you do it?) was analyzed by an expert lecturer excluding the researchers in the context of fluency, flexibility, and lateral thinking. Fluency represents the number of ideas produced by the student and is a sub-dimension used in the evaluation of the Torrance Creative Thinking Test. Every idea produced by the students was evaluated as 1 point and the total number of the ideas was accepted as fluency score. Flexibility represents how many different categories/fields the students produce ideas from and is again one of the dimensions used in the evaluation of the Torrance Creative Thinking Test. The ideas produced by the students were categorized and the number of the different categories was accepted as flexibility. Lateral thinking is a tendency of taking a different approach to events voluntarily and is closely related to creativity (De Bono, 1986). Here, the ideas of not tagging the pencil as just a lead pencil but using different kinds of pencils or using lots of pencils instead of one and using the inner side and outer side of the pencil separately are defined as lateral thinking ideas, and each of these ideas was evaluated as 1 point. Students' points of fluency, flexibility, and lateral thinking were compiled by making tables and analyzed integratively. Before and after the application, students' answers to the creative thinking questions were evaluated and compared in the determined categories. And their progress in creative thinking skills was obtained and explained qualitatively.

Semi-structured Interview Question

The content analysis of the form containing 6 open-ended questions was done by using the MAXQDA program. The Word files including the students' answers to the interview form one by one were uploaded to the program and first, the codes about which the researchers come to an agreement, then the themes were determined. After that, the shapes showing the codes and themes in the creative coding part were organized and presented in the findings.

In Table 6, each measurement tool with the research questions, the research method, and the analysis method of the data were matched and summarized.

Table 6. Research Question and The Period of Data Analysis

Research Question	Study Group	The Measurement Tool	The Research Method	The Analysis Method
Research Question 1: a) Does it differentiate the creative thinking skills of the experimental group which was taught cell division subjects integrated with computational thinking skills and the control group which was taught in the existing teaching program according to the groups (control and experimental) and evaluations (pretest and posttest)?	The Experimental and Control Group	Torrance Creative Thinking Scale	Quantitative Research	t-Test for Independent Groups t-Test for Independent Groups Mann Whitney U, Wilcoxon Signed Ranks Test, ANCOVA Test
"What is the effect of integrating cell division instruction with computational thinking skills on the creative thinking abilities of students in the experimental group?"	8 students chosen from the experimental group	Creative Thinking Question	Qualitative Research	Descriptive Analysis
Research Question 3: What are the experimental group students' views towards the lesson design done by integrating the cell division subject into the computational thinking skills?	8 students chosen from the experimental group	Semi-structured Interview Form	Qualitative Research	Content Analysis

In Table 6 the research question and research method were displayed separately but explained by correlation in the 'Result and Discussion' part. The findings of 1st and 2nd research questions which requires evaluating creative thinking skill qualitatively and quantitatively were interpreted in the same context. Besides, the Findings of the Semi-structured Interview Form in the Result and Discussion part were explained with its relationship with the other research questions. Grover et al. (2015) stated the necessity of using more than one data collection method while evaluating complex upper-level skills. In the study done by taking this suggestion into consideration, the 'Creative Thinking Question', which was analyzed with a qualitative method and creative thinking test, was used to evaluate the progress of creative thinking skills.

Internal and External Validity of the Research and Ethics

First, the necessary permissions were received from Marmara University Ethical Committee to commit the research and with this permission, to apply the data collection tools to secondary school 7th-grade students, the necessary permissions were obtained by the İstanbul Provincial Directorate of National Education. This study was based on voluntary and highlighted by the researcher frequently. The Participation Form based on both students' and parents' declarations was prepared and delivered to the students who took part in the research and their families. Within the form, the aim of the research was clearly stated. The students' faces were not included at all in the research. The analysis of reliability and validity of all the data collection tools used in the research were given below the data collection tools heading of the method part.

Results

In this part, the results of the analysis done for pretest points of the groups were given in Table 7 with the aim of determining whether the pre-application creative thinking skills of the experimental group and control group vary between the groups or not. Later, the obtained findings in accordance with the research questions were displayed.

Table 7. Fluency, Flexibility, Authenticity and TYDT Pretest Points of the Experimental and Control Groups Mann Whitney U Results for Independent Groups

Type and Dimension of the Test	Group	N	Mean Rank	Rank Sum	U	p
Verbal A Form	Experimental group	21	18,48	388,00	157,000	0,366
Fluency	Control group	18	21,78	392,00		
Verbal A Form	Experimental group	21	17,93	376,50	145,500	0,219
Flexibility	Control group	18	22,42	403,50		
Verbal A Form	Experimental group	21	16,60	348,50	117,500	0,043
Authenticity	Control group	18	23,97	431,50		
Verbal A Form	Experimental group	21	17,45	366,50	135,500	0,131
Medium Creativity	Control group	18	22,97	413,50		

With reference to the data of the TYDT pretest in Table 7, it is seen that there is not a significant difference between mean creativity points and points of fluency and flexibility sub-dimensions of the experimental and control group students ($p_{\text{fluency, flexibility, creativity}}$>0,05), besides, between the points of authenticity sub-dimension points, a significant difference is seen for the good of the control group ($p_{\text{authenticity}}$<0,05).

The findings of the research question 'Do the creative thinking skills differ according to the measurements (pretest and posttest) and the groups (experimental and control), which the experimental group is taught cell division subject with a lesson design integrated with computational thinking skills and the control group is taught with the existing teaching program?' were presented in four tables for the tests are different from each other. For the comparison of the experimental and control groups, the findings of the general result of TYDT and flexibility sub-dimension were shown in Table 8, the fluency sub-dimension was in Table 9, and the authenticity sub-dimension was in Table 10. For the comparison of the evaluation within the groups, the experimental group comparison was given in Table 11, the control group comparison was in Table 12.

Table 8. t-Test results for the independent groups about the Experimental and Control Group Students' TYDT Verbal Form B Posttest Flexibility Sub-dimension and Their Mean Points

Type and Dimension of the Test	Group	N	$\bar{x}$	S	sd	t	p
Verbal B Form Total Point	Experiment	21	21,92	11,52	37	2,90	0,00
	Control	18	13,33	5,25			
Verbal B Form Flexibility	Experiment	21	17,90	8,44	37	2,25	0,03
	Control	18	12,88	4,57			

While the experimental group TYDT mean creativity point is $\bar{x}$=21.92, the control group's is $\bar{x}$=13.33. The mean point of flexibility is $\bar{x}$=17.90 for the experimental group and $\bar{x}$=12.88 for the control group. In Table 8, concerning TYDT post-test data, it is seen there is a significant difference for the good of the experimental group between the experimental and control group students in the mean creativity points ($p<0.05$) and flexibility sub-dimension points ($p<0,05$).

Table 9. The Mann Whitney U results for the independent groups about the Experimental and Control Group Students' TYDT Verbal Form B Posttest Fluency Sub-Dimension Points.

Group	N	Mean Rank	Rank Sum	U	p
Experiment	21	22,55	473,50	135,50	0,13
Control	18	17,03	306,50		

In Table 9, with the reference to TYDT posttest fluency data, it is seen there is not a significant difference between the experimental and control group students' fluency sub-dimension points (u=135,500, $p>0,05$).

Table 10. The Ancova Results of Authenticity Sub-dimension Posttest Points Arranged According to the Experimental and Control Group Students' TYDT Verbal Form B Pretest Points

Source of the Variance	Sum of Squares	sd	Mean Squares	F	Significance Level (p)
Pretest	2300,901	1	2300,901	34,725	,000
Group	2300,901	1	2300,901	34,725	,000
Fault	2451,665	37	66,261		
Total	4752,565	18			

The experimental group authenticity posttest mean of the total point is $\bar{x}$=17.61, and the control group authenticity posttest mean point is $\bar{x}$=6.27. In Table 10, with the reference to TYDT posttest authenticity data, it is seen there is a significant difference for the good of the experimental group between the experimental group and control group's fluency sub-dimension point of creative thinking ($F= 34.725$; $p<.05$).

Table 11. The Results of Dependent Groups Wilcoxon Signed Rank Test related to the Experimental and Control Group Students fluency, flexibility, authenticity and TYDT Pretest- Posttest Points

Sub-dimension		N	Mean Rank	Rank Sum	z	p
Fluency	Positive order	20	11,50	230,00		
	Negative order	1	1	1.00	3,981	,000
	Equal	0				
Flexibility	Positive order	19	11.87	225.50		
	Negative order	2	2.75	5.50	3.830	,000
	Equal	0				
Authenticity	Positive order	21	.00	.00		
	Negative order	0	11.00	231.00	4,015	,000
	Equal	0				
Medium	Positive order	20	11.50	230.00		
Creativity	Negative order	1	1.00	1.00	3,980	,000
	Equal	0				

With reference to the TYDT data in Table 11, between the pretest and posttest points of the experimental, in every sub-dimension (fluency, flexibility, authenticity) and its mean creativity points, it is stated there is a significant difference for the good of the posttest ($p_{all}<0.05$). According to the data obtained from the test, in the experimental group fluency sub-dimension, 20 students increased their pretest points, and only one student decreased them. There is a significant difference between fluency posttest and pretest points for the good of the posttest (z=3,981, p<,05). In the flexibility sub-dimension, 19 students increased their pretest points, and 2 students decreased them, and there is a significant difference between the experimental group flexibility pretest and posttest points for the good of the posttest (z=3,830, p<,05). In the authenticity sub-dimension, 21 students increased their pretest points and there are no students who decreased them. There is a significant difference between the experimental group authenticity pretest and posttest points for the good of the posttest (z=4.015, p<0.05). When the mean creativity points are considered, 20 students increased their pretest and 1 student decreased them, and there is a significant difference between the experimental group mean creativity pretest and posttest points for the good of the posttest (z=3.980, p<0.05).

Table 12. t-Test Results for Related Groups Related to The Control Group Students' Fluency, Flexibility, Authenticity and TYDT Pretest -Posttest Points

Sub-dimension	Measurement	N	$\bar{x}$	S	sd	t	p
Fluency	Pretest	18	16,05	6,91	17	2,426	0,027
	Posttest	18	20,83	9,01			
Flexibility	Pretest	18	11,38	4,57	17	1,374	0,187
	Posttest	18	12,88	3,98			
Authenticity	Pretest	18	8,77	5,53	17	1,917	0,316
	Posttest	18	6,27	3,87			
Medium Creativity	Pretest	18	12,07	4,98	17	1,033	0,316
	Posttest	18	13,33	5,25			

Considering TYDT data in Table 12, it is stated there is a significant difference between fluency pretest and posttest points of the control group for the good of the posttest (p<0.05), and there is not a significant difference between pretest and post-test points of flexibility, authenticity and mean creativity (p>0.05). The mean of the fluency post-test ($\bar{x}$=20,83) in the control group is found higher than the mean of the pretest ($\bar{x}$=6,91) and according to the result of the committed t-test, the significant difference was found for the good of the posttest (t=2.42; p=0.027). The mean of the flexibility posttest of the control group ($\bar{x}$=12,88) is greater than the mean of the pretest point ($\bar{x}$=11,38); however, the difference is not significant according to the result of the committed t-test (t=1,37; p=0,187). The mean of the authenticity posttest in the control group ($\bar{x}$=6,27) is less than the mean of the pretest ($\bar{x}$=8,77); however, the difference is not significant according to the result of the committed t-test ama (t=1,91; p=0,316). The mean of the average creativity posttest points of the control group ($\bar{x}$=13,33) is greater than the mean of the pretest ($\bar{x}$=12,07); however, the difference is not significant again according to the result of the committed t-test (t=1,03; p=0,316).

The answers that were given to the research question ''What is the effect of the lesson design created by being integrated the computational thinking skills with the cell division subject on the experimental group students' creative thinking skills?'' and "If you wanted to use a pencil in a different way, how would you do it?'' (Table 13) and the analysis of it in terms of creative thinking (Table 14) was given in the following.

Table 13. The Students' Answers to the Question Before and After the Application

Student	The Answers Before the Application	The Answers After the Application
S1	• Making an item searching for fingerprints by mixing some graphite with some iron filling	• As a dart by sharping the penpoint • Transforming the graphite into graphene and using it in nanotechnology • An electrolyze experiment with pencils • As a chair by using many pencils
S2	• Sculpture study • A monument made with ink	• As a statue • Producing new colors with the color of the pencil • As a computer mouse
S3	• A lantern	• Being able to write both on a piece of paper and a computer • As a camera • As a visual image opener
S4	• Lamp	• Christmas tree ornaments • As a pencil box by breaking some pencils and then joining them with the help of silicon
S5	• A cable	• I would use it as a smart pen like a smartwatch • As a sheet of paper
S6	• A hairclip • A ruler	• As a hairclip • As a measurement tool
S7	• Shape of a rose	• As a pencil including lots of different colors • As a box that can be opened from both sides
S8	• A pencil that has its point inside	• As a pencil that has one side of a pen and the other side of a pencil • As a pencil that has one side of a pen and the other side of a pen eraser

In Table 13, it is seen that the students cannot produce many ideas, and lateral thinking skill is used little before the application. It is seen that the students can produce more ideas comparing the period before the application and lateral thinking skill is again used more than the period before the application.

To create a clear image, the answers given before and after the application were handled in the context of fluency, flexibility, and lateral thinking one by one, and Table 14 was formed.

Table 14. The Analysis of the Students' Answers in the Context of Fluency, Flexibility, and Lateral Thinking Dimensions of Creative Thinking, Before and After the Application

	Before the Application			After the Application		
Student	**How many ideas did she produce? (Fluency)**	**How many different dimensions did she think of? (Flexibility)**	**Using the inner and outer sides of a pencil for different purposes, dividing a pencil, or using more than one pencil (Lateral Thinking)**	**How many ideas did she produce? (Fluency)**	**How many different dimensions did she think of? (Flexibility)**	**Using the inner and outer sides of a pencil for different purposes, dividing a pencil, or using more than one pencil (Lateral Thinking)**
S1	1	1	+	4	4	+2
S2	2	1	+	3	3	+
S3	1	1	-	3	2	-
S4	1	1	-	2	2	+
S5	1	1	-	2	2	-
S6	2	2	-	2	2	-
S7	1	1	-	2	2	-
S8	1	1	-	2	1	-

It was seen that 6 students out of 8 produced 1 idea, and only 2 of them could produce 2 different ideas before the application. It was found that 1 student out of 8 could produce 2 different ideas in the flexibility category and the other 7 students could produce only 1 idea in the flexibility category. Besides, only 2 students used expressions including lateral thinking once for each. After the application, it was seen 1 of the 8 students produced 4 ideas, 2 of them produced 3 ideas each, and the left 5 students produced 2 ideas each. It was decided that one of the students produced ideas in 4 different flexibility categories, one produced idea in 3 different flexibility categories, 5 of them produced in 2 different flexibility categories, and 1 of them produced in 1 flexibility category. Besides that, 1 student used expressions including lateral thinking skills twice, and 3 students in total used an expression including lateral thinking skills.

The findings regarding the interview question asked in the research ''What are the experimental group students' ideas about the lesson design created by being integrated the computational thinking skills with the cell division subject?'' are as the following.

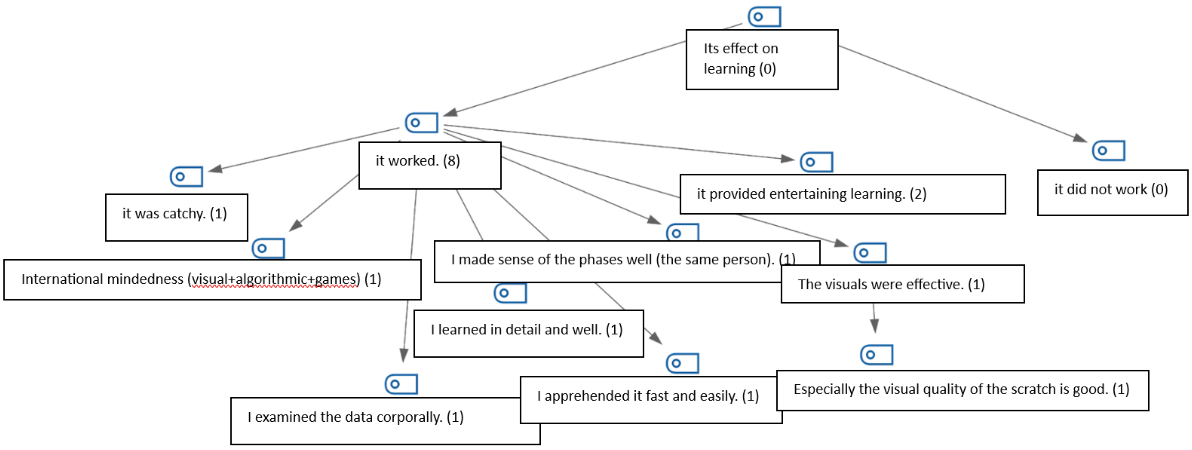

Figure 2. It shows the Views Towards the Lesson Design Created by Being Integrated with CTS According to the Number of the Coded Parts

All 8 students who were interviewed stated that the lesson design contributed to their learning of the subject. The students explained this positive effect in the context of making learning persistent, providing international mindedness, providing examining the data corporally, making learning the subject in detail and well, making sense of the phases of division better, happening learning fast and easily, providing entertaining learning, and the effect of the visuals.

"Would you like the whole science lessons to be taught over the applications focused on computational thinking skills? Whatever your answer is, can you explain your reason?'' The students' answers towards implementing science lessons with computational thinking skills and their views about the reason for the answers are as the following.

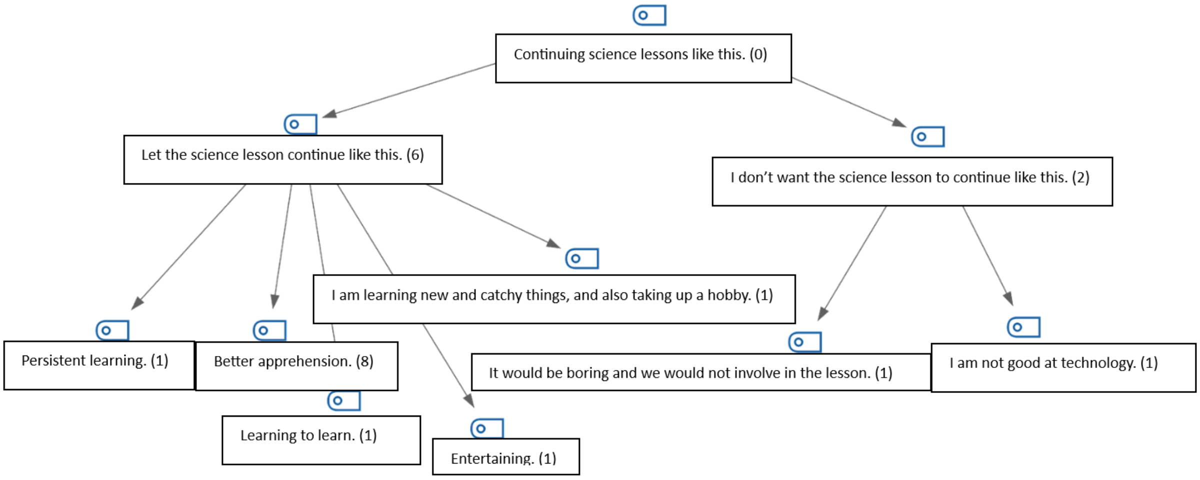

Figure 3. It shows the views towards using CTS design in science lessons continuously according to the number of coded parts.

6 students of 8, who were interviewed, stated that they would like the science lessons to be implemented over the applications focusing on computational thinking skills, but 2 of them wouldn't. the 6 students, who would like the science lessons to be done with these applications all the time, stated their reasons as the topics become catchier and apprehension gets easy, providing learning how to obtain data, becoming the lessons more enjoyable, learning interesting new concepts, providing taking up new hobbies. The students, who would not like the lesson to be implemented with these applications, explained their reasons as they are not good at technology, and thinking of using the same application continuously can make it boring.

"What is your favorite feature of the lessons focused on computational thinking skills? Why? The students' views towards their favorite feature of the lesson focused on computational thinking skills and what are their reasons as follows.

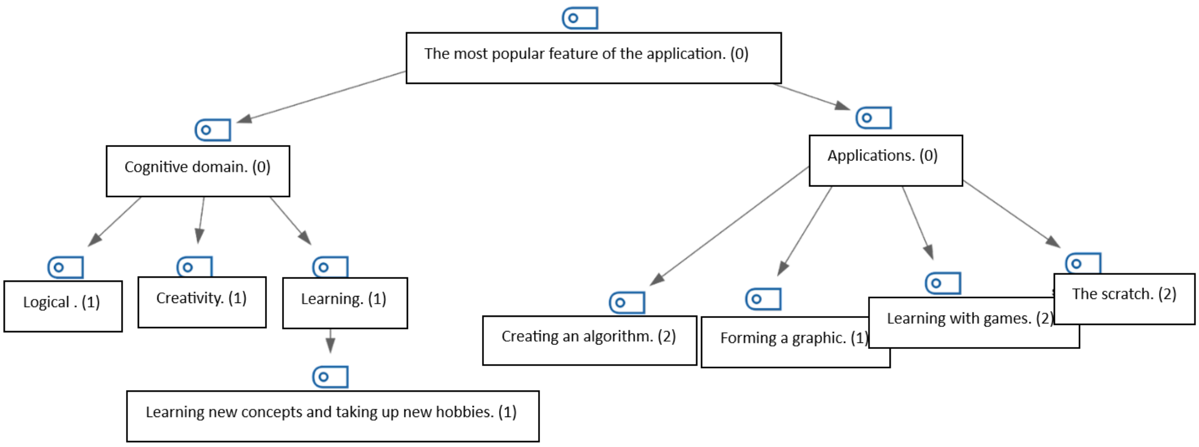

Figure 4. It shows the views towards the popular features in CTS design according to the number of coded parts.

The students stated their favorite features of the lesson design focusing on computational thinking as; having a more enjoyable lesson for two students, creating algorithms makes learning easier for two students, involving the usage of Scratch for two students, involving creativity, and forming graphics for one student, providing obtaining new hobbies and concepts for one student. When the students' comments are classified, the most highlighted features are the applications that take place in the lesson design and the cognitive effect of the lesson design. Hence, it can be deduced that the students could absorb the applications in the lesson design and acquire the facts and concepts of science lessons by using these applications.

"Would you think that you will be able to use a program like Scratch to learn Science lessons?" The students' answers to the question if they think of using a program like Scratch to learn Science lessons or not beforehand are presented in Table 15.

Table 15. Expecting the Use of the Scratch in Science Lessons in Advance

Views	The number of individuals (Frequent)
I expected.	6
I didn't expect it.	2

6 students out of 8 who are interviewed stated they expected the usage of the Scratch program in science lessons, and 2 of them didn't expect it. One of the students who expected the usage of the Scratch program in science lesson learning stated the lesson happened more useful and more enjoyable. This shows us that the students had already used the scratch program before the application.

"Before and after this application, did any changes happen in your thoughts about scratch block-based coding program? If you answer yes, can you explain the reason?" The students' point of view about these changes in their thoughts towards the Scratch program and what the change is, are as follow.

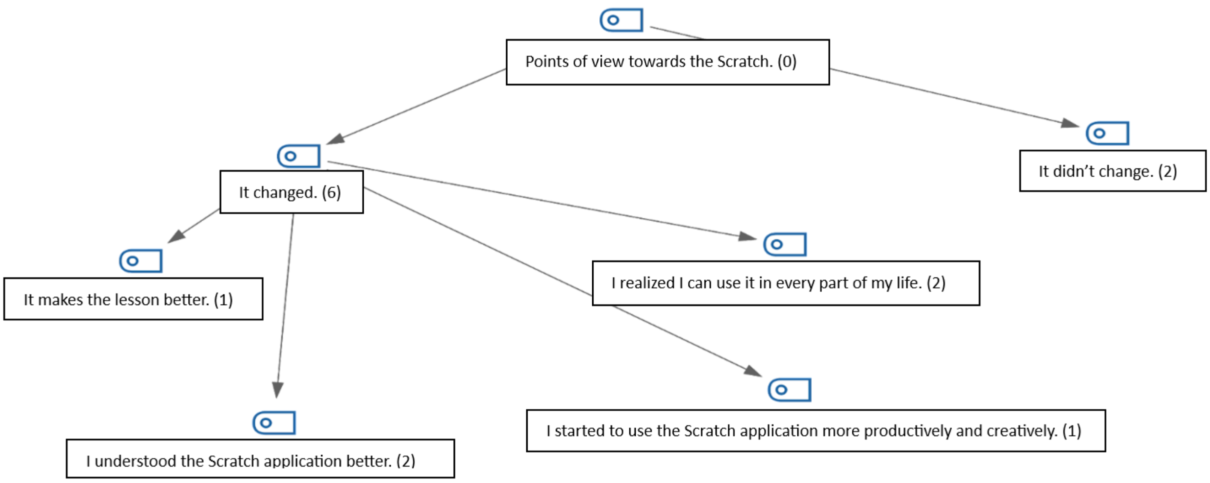

Figure 5. It shows the changing point of view towards the Scratch program according to the number of coded parts.

6 students of the 8 who were interviewed stated their point of view towards the Scratch program has changed. One of the students remarked this change made the lesson better, 2 of them understood the application better by force of the lesson, 2 students learned that they benefit from the application in many parts of their life, and 1 student stated using the program provides them to be creative and productive. The 2 students, who said it did not change, stated they had been using the application intensely and actively before.

"Have you ever thought, recalled, or associated the algorithmic designs that we did in the lesson design based on computational thinking in the other subject or daily life events? If you did, can you explain these events and lesson subjects?'' In Table 16, students' answers if they transferred the algorithmic designs, which were used during subject teaching based on computational thinking skills, to the other lessons or daily life or not, and if they did it, which lessons or events they transferred to were given.

Table 16. Transferring The Algorithmic Designs Used in the Application to the Other Lessons and Daily Life

Views	The Number of People
I started to use algorithmic designs in my daily life and other lessons.	3
I use algorithmic designs in my daily life.	1
I use algorithmic designs for science lesson revision.	1
I did not use algorithmic designs in my daily life and other lessons.	3

3 students of 8, who were interviewed, stated that they use the algorithmic designs both in their daily lives and the other lessons, 1 of them uses them in their daily lives, and 1 of them uses them while revising science lesson subjects. 3 of the students said that they could not associate the algorithmic designs with their daily lives and the other lesson subjects. One of the students who stated that they use them in their daily lives told that she creates an algorithm for the things to do after the lessons. One other student told she discovered that every action has its own algorithm. One student expressed the use of algorithms in daily life '*I tried to create an algorithm of the way to reach home by stairs.'* One of the students who stated that she uses the algorithmic designs with other lessons told '*I used them in finite verbs subject of Turkish lesson, with present perfect-past simple tenses and subjects which take have or has in English lesson.* The other one stated her usage in the drawing lesson as writing *'' the phases of drawing''* in the interview form. One student only stated that she started to use algorithmic designs in the other lessons.

Results, Discussion, and Recommendations

- Does teaching cell division using computational thinking skill applications have an impact on students' creative thinking skills?

Results and Discussion related to the research question:

Based on the data from the Torrance Creative Thinking Test, it was determined that teaching designed with computational thinking skills positively influenced students' creative thinking skills. Significant increases were observed in the flexibility and particularly originality sub-dimensions of creative thinking in the experimental group, indicating that these improvements could not be achieved through the existing constructivist approach. The International Society for Technology in Education (ISTE) and the Computer Science Teachers Association (CSTA) have stated that computational thinking may not encompass creative thinking skills but can contribute to their development (Seehorn et al., 2011). Similarly, this study found that computational thinking skills applications enhance creative thinking skills. Acar (2022) also concluded in their study that computational thinking-based science activities enhance students' scientific creativity.

No significant difference was observed in the fluency sub-dimension of creative thinking between the experimental and control groups. It was determined that fluency, which refers to generating a large number of ideas rapidly, can be developed through both the existing constructivist system and teaching designed with computational thinking skills. However, it should be noted that the development of fluency alone is not sufficient for the enhancement of creative thinking skills. In this context, De Bono (1986) emphasized the importance of lateral thinking, which involves exploring the different instead of the existing, for creative thinking. Lateral thinking is closely associated with the originality and flexibility sub-dimensions of creative thinking.

The data obtained from the creative thinking question were analyzed in terms of flexibility, fluency, and lateral thinking. It was found that teaching designed with computational thinking skills improved students' flexibility in terms of generating thoughts from different categories. Additionally, there are other data obtained regarding that students also showed improvement in fluency. These quantitative findings align with the qualitative data. Lateral thinking, which focuses on discovering new and different ideas instead of existing ones, was evaluated in terms of responses that transcend boundaries, such as the use of the inside and outside of a pen, breaking the pen, and using multiple pens. Prior to the implementation, it was determined that students had weak lateral thinking skills and could hardly generate ideas. After the implementation, although more responses were produced in terms of lateral thinking, it was found that many students still struggled to generate ideas. This indicates the need for more studies that focus on lateral thinking.

Both qualitative and quantitative findings indicate that teaching based on computational thinking skills enhances creative thinking skills. Ogegbo and Ramnarain (2022) analyzed all studies that utilized computational thinking skills in science education and found that such teaching methods attracted students' interest and led to engagement in creative activities. This finding aligns with the results of this research. The literature also emphasizes the key role of creative thinking in Scratch applications, which are known for their focus on analysis (Romero et al., 2017). In this study, a modeling activity was conducted using Scratch, and significant improvement in algorithm writing, Scratch design, and graphic creation skills was observed by the researcher during the topic transition from mitosis to meiosis.

- What are the perspectives of students in the experimental group regarding the teaching of cell division using computational thinking skill applications?

Results and Discussion related to the research question:

Based on the Semi-structured Interview data, all students stated that teaching designed with computational thinking skills facilitated a better understanding of the topic. They mentioned that they learned cell division thoroughly, comprehended the stages of division more easily, and enjoyed faster learning. İskender (2007) found in his study on teaching mitosis and meiosis using animations that students perceived the lessons as enjoyable, interesting, and more understandable. Similarly, the utilization of Scratch animations in this study may have contributed to similar results.

A majority of the interviewed students expressed a desire for all science lessons to be conducted in the same enjoyable manner, as they believed that this teaching style facilitated better learning. A small number of students preferred the traditional teaching method, and these students were characterized by low-class participation and inadequate academic performance. They attributed their disinterest to their poor relationship with technology. A significant number of students mentioned that they transferred the algorithm design skills they learned through the application to other subjects and daily life. Those who transferred the skills mentioned using them to determine verb tenses and suffixes in their English lessons, such as distinguishing between "have" and "has." Students who applied the skills in their daily lives mentioned creating algorithm designs to navigate their way home from stairs. The ability of students to transfer knowledge demonstrates the successful conceptualization of computational thinking skills through the implemented teaching (Doruk & Umay, 2011).

The current research has two main limitations. The first limitation is that the research was conducted in a public middle school located in the Kadıköy district. Therefore, it is unknown whether the results would be valid in schools with students from different socio-cultural backgrounds. The second limitation concerns the implementation process of the study, which was carried out online. It remains uncertain whether similar effects would be observed if the implementation were conducted in a face-to-face educational setting.

International exams like PISA, which assess higher-order thinking skills, often reveal that our students do not perform as expected and usually excel only in knowledge-based questions. By enhancing students' thinking skills, we can enable them to achieve more meaningful results in such exams and in their lives. Based on the results obtained from the research and the observations made by the researcher during the implementation, the following recommendations are provided for future researchers:

1. Teaching complex topic contexts, particularly those that are difficult to comprehend, using teaching methods designed with computational thinking skills can enhance topic clarity.
2. The most challenging part for students in the implemented teaching design was the data applications step, particularly activities involving graph reading and data visualization. It would be beneficial to ensure students' readiness in graph reading and data visualization prior to data applications.
3. The implemented teaching design incorporates computational thinking skills, and CTS are high-level skills. While this motivates academically strong students who are proficient in thinking skills, it can cause disengagement in academically weak students. To address this, level classes can be implemented initially to support students who are struggling.
4. There is a lack of studies that evaluate creative thinking in terms of its product context in science education, and further research in this area is recommended.
5. Students were found to have insufficient lateral thinking skills. Rapid implementation of lateral thinking-based activities in education can bring about differentiation.
6. Creativity and computational thinking encompass numerous sub-skills involving complex thinking systems, and their development requires a significant amount of time. Selecting elective courses or domains that allow for longer periods of such applications can be beneficial.

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