Integrating Computational Thinking into Mathematics Education: Its Effects on Achievement, Motivation, And Learning Strategies

Onur Top*, Taner Arabacıoğlu**

Makale Geliş Tarihi:03/11/2023 *Makale Kabul Tarihi:27/02/2024*

DOI: 10.35675/befdergi.1385749

Abstract

This study aimed to explore the impact of mathematics instruction supplemented with CT activities on mathematics achievement, motivation, and learning techniques. A quasi-experimental research design involving a pretest-posttest control group was used for the present study. Research was carried out in a Turkish middle school with sixth-grade pupils in a mathematics class. The courses were provided via CT tasks to the experimental group. CT tasks were performed using a scratch-block-based coding tool. The results showed that the experimental group had much higher mathematical performance than the control group. Furthermore, substantial differences were discovered in favor of the experimental group in the motivation scale sub-dimension of learning control belief and the learning methods scale sub-dimension of time and study environment. The results of this research show that mathematics instruction supplemented with CT activities is effective in enhancing students' mathematical achievement. This helps students to organize their study time and environment effectively. This also reinforces the belief that learning objectives provide successful outcomes. Thus, computer laboratories should be considered essential alternatives for mathematical instruction.

Keywords: *Computational thinking, scratch, mathematics education, motivation, learning strategies.*

Bilgi İşlemsel Düşünmenin Matematik Eğitimine Entegre Edilmesi: Başarı, Motivasyon ve Öğrenme Stratejileri Üzerindeki Etkileri

Öz

Bu çalışmanın amacı, BİD etkinlikleri ile desteklenmiş matematik öğretiminin matematik başarısı, motivasyon ve öğrenme stratejileri üzerindeki etkisini araştırmaktır. Bu çalışma için öntest-sontest kontrol gruplu yarı deneysel bir araştırma deseni kullanılmıştır. Araştırmanın çalışma grubunu ortaokul altıncı sınıf öğrencileri oluşturmaktadır. Dersler deney grubuna BİD

* Aydın Adnan Menderes Üniversitesi, Sosyal Bilimler Enstitüsü, Aydın, Türkiye, tp.onur@gmail.com Orcid: 0000-0002-5337-5987

** Aydın Adnan Menderes Üniversitesi, Eğitim Fakültesi, BÖTE, Aydın, Türkiye, tarabacioglu@adu.edu.tr Orcid:0000-0003-1116-1777

Kaynak Gösterme: Top, O., & Arabacıoğlu, T. (2024). Integrating computational thinking into mathematics education: Its effects on achievement, motivation, and learning strategies. *Bayburt Eğitim Fakültesi Dergisi, 19*(42), 2034-2066.

görevleri aracılığıyla verilmiştir. BİD görevleri, blok tabanlı bir kodlama aracı kullanılarak gerçekleştirilmiştir. Sonuçlar, deney grubunun kontrol grubuna göre çok daha yüksek matematik başarısına sahip olduğunu göstermektedir. Ayrıca, motivasyon ölçeğinin öğrenme kontrolü inancı alt boyutunda ve öğrenme stratejileri ölçeğinin zaman ve çalışma ortamı alt boyutunda deney grubu lehine önemli farklılıklar bulunmuştur. Bu araştırmanın sonuçları, BİD etkinlikleri ile desteklenen matematik öğretiminin öğrencilerin matematik başarılarını artırmada etkili olduğunu göstermektedir. Ayrıca, öğrencilerin çalışma zamanlarını ve ortamlarını etkili bir şekilde düzenlemelerine yardımcı olmaktadır. Aynı zamanda öğrenme hedeflerinin başarılı sonuçlar sağladığı inancını da pekiştirmektedir. Bu nedenle, bilgisayar laboratuvarları matematik öğretimi için önemli alternatif olarak düşünülmelidir.

Anahtar Kelimeler: *Bilgi işlemsel düşünme, scratch, matematik eğitimi, motivasyon, öğrenme stratejileri.*

Introduction

In our current age, computer science is ubiquitous. Robotics, automation, and software are used in the work or daily lives of all individuals. As such, the effective use of information technology, which provides great convenience, is an important skill in all age groups. With this skill, tasks can be accomplished in a short time or effectively, and alternative methods can be developed quickly to solve the problems encountered.

Individuals believe that many solutions to modern problems can be solved using mathematics, and while this association is not completely wrong, the mathematics discipline cannot do this in isolation. Different disciplines must be employed to solve digital age problems. Computer science is definitely crucial in creating tools that enable and accelerate problem-solving, and in certain cases, even identify problems. Therefore, students should gain problem-solving skills that are appropriate for the changing world and developing technology (Aslan, 2007; Çetin & Mirasyedioğlu, 2019). Although its conceptual foundations are old, computational thinking (CT) skills are an important option among 21st-century problem-solving skills (Üzümcü & Bay, 2018).

Data collection, data processing (analysis), and complex mathematical calculations, which are essential elements of problem-solving, sometimes present difficulties. With the support of a programming language, an automation device can rapidly process an extensive amount of data, do complicated calculations, and show the results. In this context, to utilize computer science to solve problems, it is necessary to write a solution in a detailed and step-by-step manner. The goal of CT is to design a problem-solving process that can quickly and efficiently transform solutions into information technologies.

As therefore, it may be claimed that students require a learning technique that teaches them how to learn rather than transferring knowledge, fulfills the needs of the twenty-first century, and prioritizes high-level thinking skills all at once. Top (2020) stated that educators should no longer transfer knowledge to students as a source of information but should teach them how to access knowledge. CT is a high-level thinking skill (Üzümcü, 2019), and a teaching-learning environment designed with CT can enable learning at the levels of analysis, evaluation and creation, which are the high-level learning stages in the revised Bloom's Taxonomy.

Mathematics is considered difficult (Husnah et al., 2021) and lessons become progressively more complex. Thus, it may be difficult to maintain students' interest in the lesson. At this stage, it is thought that CT will positively affect students' motivation due to its advantages, such as providing them with a new teaching environment, being suitable for teamwork, and seeking solutions to real-life problems. The purpose of this study aims to come up with and use a new way to learn math that brings together math and computer science in the context of CT. In this sense, this study aims to examine the effect of mathematical instruction supplemented with CT-based mathematics learning activities on students' mathematics achievement, motivation, and learning strategies.

Computational Thinking

Cognitive ability is a fundamental trait that sets humans apart from other living beings. Cognitive processes are inherent to the functioning of our mind. The process begins at the moment of birth and is cultivated either directly or indirectly in the subsequent years (Güneş, 2012). Thinking skills refer to the cognitive abilities that enable individuals to utilise their knowledge in order to comprehend the structure of the universe and effectively resolve problems (Çubukçu, 2011). Various thinking skills have been examined in the literature, including analytical thinking (Akkuş-Çakır & Senemoğlu, 2016), critical thinking (Tok & Sevinç, 2010), reflective thinking (Kızılkaya & Aşkar, 2009) or creative thinking (Yaman & Yalçın, 2005). Given the significant role that technology advancements play in our lives, it is unavoidable that they will bring about alterations in individuals' cognitive processes. However, the technologies used for particular age groups, and the tools developed for using these technologies differ according to age relevance and how people problem-solve. In other words, it can be argued that the factor that determines the limits of technological development is the way individuals solve the problems they face. Therefore, individuals' educational and training needs should be shaped to address modern problems. The skills that individuals are expected to possess to solve today's problems are referred to as 21st-century skills. CT is a the twenty-first century skill that is getting more and more attention in education research and instructional design around the world (Nordby et al., 2022). Wing (2011) explained CT as a thinking process concerned with formulating problems and their solutions in such a way that they can be realized using an information processing tool. Yadav et al. (2014) analyzed the cognitive process involved in abstracting problems and developing solutions that can be automated. Accordingly, the realization of the problem-solving process per information processing tools is of significance. To achieve this, a mental process should be implemented in which abstraction skills are prioritized. At this point, it should be noted that the problems encountered might differ in terms of difficulty level, data collection, data processing, and measurement tools used (Yadav et al., 2014).

Although CT has a long history, it is considered a new skill area in the literature. In 1962, the American computer scientist Alan Perlis suggested that every student should learn the logic of computers and computer programs as part of their liberal education (Guzdial, 2008). This initiative laid the conceptual foundation of CT. In 1966, a group including Seymour Papert developed a programming language called LOGO (Solomon et al., 2020). LOGO is an educational setting where children engage in the exploration of mathematical concepts and develop their own projects (Solomon et al., 2020). Although Papert (1980) was the first researcher to use the concept of CT, its popularity was due to Wing's (2006) research.

Components of Computational Thinking

Wing (2008) defined CT as analytical thinking. However, this thinking system includes the features of different thinking structures. It integrates mathematical thinking for problem solving, engineering thinking for creating and evaluating complex systems, and scientific thinking for computability and intelligence. In addition, Wing (2008) stated that the most important components of CT are abstraction and automation. Although the abstraction component is considered a common construct in the literature, the other components differ. Barr and Stephenson (2011) listed the basic concepts of CT as problem algorithms and procedures, abstraction, decomposition, automation, parallelization, and simulations. Angeli et al. (2016) limit it to five components: decomposition, abstraction, algorithms, debugging, and generalization, whereas Shute et al. (2017) state six components: algorithm, abstraction, decomposition, debugging, iteration, and generalization. Atmatzidou and Demetriadis (2016) listed abstraction, algorithms, generalization, modularity and decomposition. Tosik-Gün and Güyer (2019) identified 18 components in their systematic literature review. Çetin and Toluk Uçar (2020) found that problem-solving, algorithmic thinking, evaluation, abstraction, pattern recognition, decomposition and generalization are components of CT commonly accepted in the literature. In this respect, it is not possible to design a course that includes all the components, and it would be appropriate to focus on components commonly accepted in the literature. In this study, abstraction, decomposition, algorithmic thinking, automation, and generalization were considered the basic components of CT.

Abstraction

Abstraction is the key differentiating element that sets CT differ from other skills (Grover & Pea, 2013). Abstraction, according to Rabiee and Tjoa (2017), is the process of elucidating actual concepts and data that affect the outcomes of solving a complex problem. The two most crucial components of abstraction, according to Mirolo et al. (2021), are "extracting similarities" and "ignoring non-essential features." Similarly, explaining a problem by removing superfluous content and generating patterns is a fundamental abstraction skill (Kert, 2020). Abstraction, according to Shute, Sun, and Asbell-Clarke (2017), has been separated into three subcategories. Collecting data and analysis, pattern recognition, and modeling are descriptions of these categories. Abstraction, according to Kramer (2007), is an essential step in the development of models, designs, and applications for specified goals. In brief, abstraction is ignored, or aspects that are useless in attaining the purpose are removed if necessary. Eliminating unnecessary details when solving a problem or in any real-life circumstance is equally vital in terms of efficiency. In regards to efficiency, it is especially crucial in CT-oriented automation activities to find the shortest path that results in repetitive actions in the form of a loop. Every superfluous automation activity is a waste of time and resources.

The concept of abstraction used in CT differs from that used in other disciplines (Wing, 2008). Hoppe and Wernburg (2019) describe the source of this difference as "the essence of CT lies in the creation of logical artifacts that externalize and reify human ideas in a form that can be interpreted and run on computers.” Mirolo et al. (2021) stated that this difference occurs when modeling real-life computational problems.

Problem Decomposition

Problem decomposition refers to the act of dividing a problem into smaller, more manageable components or sub problems (Barr & Stephenson, 2011). This is an essential stage in the process of problem solving, which entails recognizing the elements of a problem, determining their interconnections, and organizing them into a well-organized strategy. As stated by Grover and Pea (2018), issue decomposition is a crucial technique that allows individuals to tackle intricate challenges, gain competence in particular fields, and generate new knowledge. Decomposition refers to the process of breaking down an algorithm or programme, or dividing a real-life problem into smaller components (Curzon et al., 2019).

Problem decomposition offers the advantage of enabling the development of code that is modular and can be reused. By decomposing a problem into smaller sub-problems, each element can be individually constructed and evaluated, facilitating the identification and solution of errors (Kelleher & Pausch, 2005). Problem decomposition is a crucial aspect in the process of designing and implementing algorithms. Algorithms are systematic procedures used to solve problems. Problem decomposition is the process of breaking down a problem into smaller steps or subproblems that can be addressed using a specific algorithm. This methodology allows for the development of effective and adaptable algorithms that can be employed to address extensive and intricate problems (Cormen et al., 2009).

Algorithmic Thinking

An algorithm is a systematic approach to addressing problems, which involves a certain number of well-defined and sequential stages that may be executed within a specific timeframe (Kanaki & Kalogiannakis, 2022). Algorithmic thinking refers to the capacity to identify issues and create and execute algorithms to solve them (Barr & Stephenson, 2011). The process is decomposing a problem into a sequence of smaller steps or sub problems and creating an algorithm to address each step. This methodology enables the development of effective and adaptable solutions to sophisticated problems and is a fundamental competency for programmers and computer scientists. An important issue in algorithm building, and hence, algorithmic thinking, is to try to get the most efficient algorithm for the task (Curzon et al., 2019). According to Wing (2006), algorithmic thinking is a fundamental skill that enables individuals to solve problems in any domain and not just computer science. Algorithmic thinking is closely related to CT and these two concepts are often used interchangeably (Denning, 2009). CT is a broader concept that encompasses algorithmic thinking as well as other skills such as data representation, modeling and simulation, and debugging (Wing, 2008).

Automation

Automation refers to the configuration of the developed algorithms on computers and the technological capabilities to be effectively applicable to other problems. (Cansu & Cansu, 2019). In other words, automation can be seen as a way of improving efficiency and accuracy as well as reducing the need for repetitive or tedious tasks. Automation involves the use of algorithms and computer programs to perform repetitive or labor-intensive tasks, such as data entry, sorting, and analysis.

A key benefit of automation is that it can save time and increase efficiency, allowing organizations to process data and perform other tasks much faster than they would be able to perform manually (Brynjolfsson & McAfee, 2014). Automation can also reduce the likelihood of errors, because computers are generally more accurate and reliable than humans in repetitive tasks (Davenport & Kirby, 2015).

Generalization

The process of generalization emphasizes the phase of recognizing how various components of a solution can be reused and then applied to the solution of issues that are quite similar (Voon et all, 2022). Curzon et al. (2019) stated that generalization involves solving a problem and creating a more general version that can be applied to a broader set of problems. CT thinking was primarily applied to these algorithms. However, generalization skills apply not only to programming but also to problem-solving more generally.

To summarize, generalization is a fundamental principle in computer science that entails recognizing patterns and similarities in data or methods, then utilizing them to make predictions or address problems in new situations. Generalization can save time and effort in problem-solving but also has limitations when it comes to over-generalization or applying a solution that is not appropriate for a specific context.

The Study

As a result of the systematic literature review and a meta-analysis of CT studies, it is apparent that there are common findings regarding CT. Taslibeyaz, Kursun, and Karaman (2020) reviewed the systematic literature in which they aimed to evaluate the development process of CT skills and included 29 experimental studies conducted between 2011-2018 in Web of Science and Eric databases. The most frequently emphasized concept in the definition of CT is "analyzing and solving a problem." In addition, the concepts associated with CT in experimental research include problem-solving skills, lifelong learning skills, programming skills, and development. STEM applications are in second place, where research is predominantly conducted in the context of programming. Similarly, Israel-Fishelson and Hershkovits (2022) state that research should focus on STEM-related disciplines. According to Kakavas and Ugolini (2019), the majority of the 53 CT studies conducted at the primary school level (K6) used a programming (plugged or unplugged) framework to develop students' CT skills and focused on STEM disciplines. The reason why computer science and STEM fields are so popular can be explained by the results of Helsa et al. (2023) meta-analysis study. The researchers disclosed that interventions utilizing computer technology had a substantial positive impact on pupils' CT skills. Although the literature is predominantly focused on CT in the computer sciences and STEM fields, according to Ye, Lai, and Wong (2022), there are also studies investigating CT skills in the humanities. In addition, the research results showed that the use of CT skills in other disciplines generally had a positive and significant effect. Lei et al., (2022) state that there is a positive relationship between CT and academic achievement.

However, some issues are still under debate, as are the common findings. Israel-Fishelson and Hershkovits (2022) state that research has mostly been conducted in the United States and developed European countries, whereas Lei et al., (2022) comment on the impact of Eastern and Western cultures on CT skills. The results of their moderator analyses indicated that the relationship between CT and academic achievement is stronger among students from Eastern cultures. In addition, elementary school students are reported to be the age group in which this relationship is strongest, and it has been reported that the relationship between academic achievement and CT decreases as grade level increases. In contrast, however, Ye, Lai, and Wong (2022) state that grade level has no effect. As stated by Helsa et al. (2023), education level, geographical region, size of group of the intervention, learning instrument and topic characteristics had no effect on the development of CT skills.

Lv, Zhong, and Liu (2023) summarized the results of the integration of mathematics and CT through a systematic analysis of 22 experimental articles in SSCI. They concluded that there is a need for research on the integration of mathematics and CT at middle and high school levels. Geometry, number domain, and CT components, such as abstraction, problem decomposition, algorithm design, pattern recognition, and debugging, are frequently used in mathematics and CT integration studies. Ye, Lai, and Wong (2022) state that geometrized programming and student-centered methods of instruction make CT and mathematics instruction more effective. Furthermore, CT-based mathematics instruction requires interactive and cyclical processes that involve mathematical and computational reasoning. It utilizes mathematics to create CT artifacts, anticipate and interpret CT outputs, and generate new mathematical knowledge concurrently with CT development. Refvik and Bjerke (2022) believed that it is possible and sometimes useful to incorporate CT into the solution of mathematical problems. However, they emphasize that more research is needed to determine whether the inclusion of CT and programming tools improves students' problem-solving skills in mathematics.

The correlation between CT and problem-solving skills, the common usage of coding software for developing CT skills, and the frequent investigation of STEM fields have been influential factors in the current research. The literature also highlights the importance in developing a design that is specific to the middle school mathematics lesson. In line with the necessity stated in the literature, this study focuses on the integration of CT into mathematics courses. The following research questions were addressed per the aims of this study:

RQ1: How do CT activities affect mathematics achievement?

RQ2: What is the effect of CT activities on student motivation?

RQ3: How do CT activities affect learning strategies?

Method

Research Design

We determined the effect of mathematics instruction supported by CT activities for a 6th-grade middle school class on “Multipliers and Multiples” on mathematics achievement, motivation, and learning strategies. This study used a quasi-experimental design with a pretest-posttest control group. In the experimental group, the lessons were conducted using CT activities, whereas in the control group, the lessons were based on textbook activities.

According to Christensen, Johnson, and Turner (2015), a quasi-experimental design is a research design in which the experimental process is applied, but not all exogenous variables are controlled. Gliner, Morgan, and Leech (2016) categorized quasi-experimental research into three groups: weak, moderately strong, and strong, based on two main factors. This section discusses the researcher's role in assigning the independent variable and ensuring equivalence of participant characteristics between groups. When the independent variable is assigned to groups without bias, the researcher can assume control over it. However, in quasi-experimental designs, unbiased assignment of participants to groups is not always possible. Therefore, the fact that participants did not choose their group or that no specific purpose was pursued during the formation of the branches is equivalent to unbiased assignment. In the research design proposed by Gliner, Morgan, and Leech (2016), two factors were considered: the assignment of students to groups was done without bias, and the CT, which was examined in the experimental process, was assigned to the groups in an unbiased manner.

Participants

This research was carried out in a Turkish middle school with sixth-grade pupils in a mathematics class. The research process involved the utilization of block-based coding software. The instruction of coding software is included within the domain of the Information Technologies and Software course. Secondary school level provides instruction in Information Technologies and Software lessons for students in the 5th and 6th grades. Hence, this factor was appropriately considered when selecting the research sample. The experiment lasted for four weeks in the fall semester of the 2021–2022 academic year and focused on the learning areas of multipliers and multiples being taught in the mathematics class. The study comprised a total of 39 students, 19 in the experimental group and 20 in the control group.

Data Collection Tools

The study employed three data collection instruments. The Mathematics Achievement Test developed by Başün (2016) was used to measure students' mathematics achievement. The Motivation and Learning Strategies Scale developed by Pintrich et al. (1993) and adapted into Turkish by Büyüköztürk et al. (2004) was administered to measure students' motivation levels and learning strategies.

The mathematics achievement test developed by Başün (2017) was designed to assess five specific objectives under the "Multipliers and Multiples" sub-learning area of the 6th grade mathematics course, specifically within the "Numbers and Operations" learning area. The test comprises 28 questions in a multiple-choice format, and the reliability coefficient, measured using Cronbach Alpha, was determined to be .828. The achievement test was selected by a mathematics teacher and a mathematics education specialist based on the evaluation of criteria such as school type, student readiness and socio-economic level.

The scale adapted by Büyüköztürk et al. (2004) consists of two main sections: motivation and learning strategies. The motivation section consists of 6 subscales: intrinsic goal orientation, extrinsic goal orientation, task value, control beliefs about learning, self-efficacy for learning and performance, test anxiety, and the learning strategies section consists of 9 subscales: rehearsal, organization, elaboration, critical thinking, help seeking, peer learning, metacognitive self-regulation, effort regulation, time and study environment. The scale is Likert-type and is graded from 1 to 7 on a scale from "Absolutely wrong for me" (1) to "Absolutely right for me" (7). Cronbach's alpha values ranged between .59 and .86 for the sub-dimensions of the motivation scale and between .41 and .75 for the sub-dimensions of the learning strategies scale. This scale was utilized because it can measure both motivation and learning strategies at the same time and in detail with a total of 15 sub-dimensions.

Data Analysis

To evaluate the normality assumption for the study group of less than 50 students, the Shapiro-Wilks test was used. Additionally, homogeneity of variances was also tested. Since the data were not normally distributed and the sample size was small, the Mann-Whitney U test was used for intergroup comparison and the Wilcoxon signed-rank test was used for intragroup comparison. The statistical significance level was set at $p<.05$ for the analyses. Bindak (2014) compared Mann-Whitney U and t-test in terms of type 1 error and power and found that Mann-Whitney U test gives less error in small samples ($n\leq30$), while t-test gives the same result over 98% in other sample sizes.

Experimentation

The experimental implementation lasted for four weeks and 20 lesson hours. Mathematics instruction was conducted with CT activities in the experimental group. Four of these activities were designed as real-life problems and one was designed as a mathematics game. The distributions of CT-based lesson activities according to week and outcome are presented in Table 1. During the development of these activities, a team of experts consisting of a computer and instructional technology, a mathematics teacher and a mathematics education collaborated. The first activity used in the experimental implementation is presented in the appendix.

Table 1.
Distribution of CT Activities According to Weeks and Learning Outcomes

Week	Learning Outcome	Activity name
1	Determines the factors and multiples of natural numbers.	How can I withdraw my money from the ATM?
2	Explains and utilizes the rules of divisibility by 2,3,4,4,5,5,6,9 and 10 without remainders.	Efficiency work in the factory
3	Identify prime numbers with their properties.	Game

4	Determines the prime factors of natural numbers. Determines the common divisors and common multiples of two natural numbers and solves related problems.	Forestry week Is it possible for the planets to align?

Common characteristics of the learning processes in both the experimental and control groups include:

1. The mathematical sessions cover the same objectives.

2. The duration of the learning outcomes, including the starting and finishing dates, as well as the time dedicated to teaching, are similar.

The learning processes of the experimental and control groups differed in several ways:

1. The control group received lessons based on the defined curriculum, whereas the experimental group acquired lessons based on the instructions provided in the activity sheets.

2. About fifty percent of the instructional sessions in the experimental group were conducted using block-based coding software in the computer laboratory.

Findings

Before the experiment, the Mann-Whitney U tests were used to see if there was a significant difference in the experimental and control groups' Mathematics Achievement Test, motivation, and learning strategies scale scores. No difference was found between the groups (Table 2, Table 3, Table 4).

Table 2.
Mathematics Achievement Pre-Test Scores Mann-Whitney U Test Results

Group	**N**	**Mean Rank**	**Sum of Ranks**	**U**	**p**
Experimental	19	16.71	317.50	127.50	.075
Control	20	23.13	462.50		

Table 2 shows that the significance value (p) is greater than .05. Therefore, it can be asserted that there is no significant difference between the Mathematics Achievement Test scores of the experimental and control groups before the implementation.

Table 3.
Mann-Whitney U Test Results of Motivation Scale Pre-Test Scores

Dimensions	Group	N	Mean Rank	Sum of Ranks	U	p
Intrinsic Goal Orientation	Experimental	19	23,21	441,00	129.00	.085
	Control	20	16,95	339,00		
Extrinsic Goal Orientation	Experimental	19	20,42	388,00	182.00	.820
	Control	20	19,60	392,00		
Task Value	Experimental	19	20,63	392,00	178.00	.734
	Control	20	19,40	388,00		
Control Beliefs About Learning	Experimental	19	23,24	441,50	128.50	.082
	Control	20	16,93	338,50		
Self-Efficacy For Learning And Performance	Experimental	19	18,53	352,00	162.00	.429
	Control	20	21,40	428,00		
Test Anxiety	Experimental	19	17,92	340,50	150.50	.266
	Control	20	21,98	439,50		

It is observed that the significance value (p) of the sub-dimensions of the motivation scale in Table 3 and the sub-dimensions of the learning strategies scale in Table 4 is greater than .05. Thus, it can be argued that there is no significant difference between the motivation and learning strategies scores of the experimental and control groups before the application.

Table 4.
Mann-Whitney U Test Results of Learning Strategies Scale Pre-Test Scores

Dimensions	**Group**	**N**	**Mean Rank**	**Sum of Ranks**	**U**	**p**
Rehearsal	Experimental	19	17,97	341,50	151.50	.277
	Control	20	21,93	438,50		
Organization	Experimental	19	21,05	400,00	170.00	.573
	Control	20	19,00	380,00		
Elaboration	Experimental	19	18,66	354,50	164.50	.472
	Control	20	21,28	425,50		
Critical Thinking	Experimental	19	19,32	367,00	177.00	.714
	Control	20	20,65	413,00		
Metacognitive Self-Regulation	Experimental	19	22,55	428,50	141.50	.173
	Control	20	17,58	351,50		
Help Seeking	Experimental	19	20,74	394,00	176.00	.693
	Control	20	19,30	386,00		
Effort Regulation	Experimental	19	18,68	355,00	165.00	.481
	Control	20	21,25	425,00		
Peer Learning	Experimental	19	20,47	389,00	181.00	.799
	Control	20	19,55	391,00		
Time And Study Environment	Experimental	19	20,89	397,00	173.00	.632
	Control	20	19,15	383,00		

Following the experiment, a Mann-Whitney U Test was performed to evaluate whether there was a significant difference between the experimental and control groups' Mathematics Achievement Test posttest scores (Table 5). According to the test results, there was a significant difference between the experimental (Mdn = 45.83, n = 19) and control (Mdn = 33.33, n = 20) groups in terms of academic achievement (U=116, Z=-2.09 p=.037, r=.335). It is revealed that the Mathematics Achievement Test scores differed significantly in favor of the experimental group. The effect size for this significant difference was r=.335. Cohen's recommendations on the r-value are interpreted as a small effect size if it is 0.1, a medium effect size if it is 0.3, and a large effect size if it is 0.5 (Cooligan, 2009). Thus, it was deduced that the significant difference between the experimental and control groups on the achievement test had a medium effect size.

Table 5.
Mathematics Achievement Post-Test Scores Mann-Whitney U Test Results

Group	**N**	**Mean Rank**	**Sum of Ranks**	**U**	**p**
Experimental	19	23,89	454,00	116.00	.037
Control	20	16,30	326,00		

According to the results of the Mann-Whitney U test conducted to determine the difference between the students' post-test scores on the Motivation Scale after the experimental implementation, a significant difference was found only in the control belief about the learning dimension (Table 6). No significant differences were found in the other dimensions motivation scale. The Mann-Whitney U test results demonstrated a significant difference between the experimental group (Mdn =18.00, n=19) and the control group (Mdn =16.50, n=20) concerning control beliefs about learning (U=117.50, Z=-2.054 p=.040, r=.329). In other words, the experimental group received significantly higher scores in relation to control beliefs about the learning dimension. The effect size value for the control belief about learning was calculated as r=.329. This value indicated a medium effect size. In addition to this finding, in-group analysis of the experimental and control groups was performed with the Wilcoxon signed-rank test. As a result of the analysis, a significant difference was found in the mathematics achievement test of the control group with Z=-2.375, p<.05, and in the experimental group with Z=-3.825, p<.05.

Table 6.
Mann-Whitney U Test Results of Motivation Scale Post-Test Scores

Dimensions	**Group**	**N**	**Mean Rank**	**Sum of Ranks**	**U**	**p**
Intrinsic Goal Orientation	Experimental	19	22,45	426,50	143.50	.190
	Control	20	17,68	353,50		
Extrinsic Goal Orientation	Experimental	19	20,45	388,50	181.50	.809
	Control	20	19,58	391,50		
Task Value	Experimental	19	22,87	434,50	135.50	.123
	Control	20	17,27	345,50		
	Experimental	19	23,82	452,50	117.50	**.040**

Control Beliefs About Learning	Control	20	16,38	327,50		
Self-Efficacy For Learning And Performance	Experimental	19	22,97	436,50	133.50	.111
	Control	20	17,18	343,50		
Test Anxiety	Experimental	19	20,13	382,50	187.50	.944
	Control	20	19,88	397,50		

The Mann-Whitney U test was implemented to evaluate the difference between the post-test scores of the Learning Strategy Scale, and a significant difference was found in the time and study environment management dimensions (Table 7). No significant differences were found in elaboration, rehearsal, critical thinking, organization, metacognitive self-regulation, help-seeking, effort regulation, or peer learning strategies. The Mann-Whitney U test results revealed a significant difference between the experimental group (Mdn =36.00, n=19) and the control group (Mdn =32.00, n=20) in terms of time and working environment management (U=117.00, Z=-2.056 p=.040, r=.329). It is seen that the time and study environment management scores differed in a manner in favor of the experimental group. The effect size for time and study environment management dimensions was r=.329. This value can be interpreted as a significant difference, with a medium effect size. In the within-group comparison, the sub-dimensions of the control group motivation scale were calculated as intrinsic goal orientation Z=-.427, p>.05, extrinsic goal orientation Z=.-721, p>.05, task value Z=--.664, p>.05, control beliefs about learning Z= -.167, p>.05, self-efficacy perception Z=-.729, p>.05 and test anxiety Z=-1.414, p>.05, respectively. The sub-dimensions of the experimental group motivation scale were calculated as goal orientation Z=-.198, p>.05, extrinsic goal orientation Z=.-404, p>.05, task value Z=-.000, p>.05, learning control belief Z= -.378, p>.05, self-efficacy for learning and performance Z=-1.465, p>.05 and test anxiety Z=-.142, p>.05.

Table 7.
Mann-Whitney U Test Results of Learning Strategies Scale Post-Test Scores

Dimensions	**Group**	**N**	**Mean Rank**	**Sum of Ranks**	**U**	**p**
Rehearsal	Experimental	19	19,50	370,50	150.50	.789
	Control	20	20,48	409,50		
Organization	Experimental	19	18,29	347,50	157.50	.359
	Control	20	21,63	432,50		
Elaboration	Experimental	19	20,47	389,00	181.00	.800

	Control	20	19,55	391,00		
Critical Thinking	Experimental	19	19,39	368,50	178.50	.746
	Control	20	20,58	411,50		
Metacognitive Self-Regulation	Experimental	19	20,97	398,50	171.50	.603
	Control	20	19,08	381,50		
Help Seeking	Experimental	19	20,61	391,50	178.50	.746
	Control	20	19,43	388,50		
Effort Regulation	Experimental	19	19,92	378,50	188.50	.966
	Control	20	20,08	401,50		
Peer Learning	Experimental	19	19,66	373,50	183.50	.855
	Control	20	20,33	406,50		
Time And Study Environment	Experimental	19	23,84	453,00	117.00	**.040**
	Control	20	16,35	327,00		

When within-group comparisons were examined, it was found that in the sub-dimensions of learning strategies in the control group, rehearsal Z=-.826, p>.05, organization Z=.-303, p>.05, elaboration Z=-.047, p>.05, critical thinking Z=-. 383, p>.05, metacognitive Z=-1.178, p>.05, help seeking Z=-.693, p>.05, effort management Z=-.851, p>.05, peer learning Z=-.898, p>.05, time and study environment Z=-.443, p>.05. In the experimental group learning strategies sub-dimensions, rehearsal Z=-.000, p>.05, organization Z=.-762, p>.05, elaboration Z=-.939, p>.05, critical thinking Z=-.437, p>.05, metacognitive Z=-. 961, p>.05, help seeking Z=-1.140, p>.05, effort regulation Z=-.678, p>.05, peer learning Z=-.601, p>.05, time and study environment Z=-.192, p>.05.

Results and Discussion

In regards to the results, significant differences were found in mathematics achievement, control beliefs about the learning dimension in the motivation scale, and time and study environment management dimension in the learning strategies scale. Many studies report a positive relationship between academic achievement and CT (Bounou et al., 2023; Lei et al., 2022; Chongo, Osman, & Nayan, 2020; Mindetbay et al., 2019). Differences in students' motivations and learning strategies should be recognized to explain this success.

Motivation plays an essential part in education because it influences the learning outcomes and academic performance of students. Motivated students are more likely to engage in learning activities, persevere in the face of obstacles, and attain their academic objectives. Several studies have demonstrated that motivation is strongly associated with academic achievement. Liu, Shi, and Wang (2022) stated that intrinsic motivation has a positive correlation with academic achievement across all age groups, whereas extrinsic motivation has a greater impact on student performance as students grow older. Motivation is also important for student engagement (Fredricks, Blumend & Paris, 2004). Motivated students are more likely to participate actively in class, which can improve their comprehension and retention of course material.

Surprisingly, our results only showed a statically difference in the control belief about the learning dimension of the motivation scale. We anticipated significant differences in the other dimensions of the motivation scale. Although belief in the control of learning was the only significant difference, it is an important factor that activates learning strategies (Beletti & Vaillant, 2022). Students' perceptions that their learning efforts will result in positive outcomes are referred to as learning control. This is related to the belief that one's own performance is more important than external variables such as the teacher. Students are more inclined to study strategically and effectively if they believe their study efforts make a difference in their learning (Pintrich, Garcia, & McKeachie, 1991). We can argue that this result is an important motivational benefit for subjects such as mathematics, which are considered difficult. This is because control beliefs about learning have a favorable impact on students' self-efficacy in the face of hurdles and problems. (Manavipour & Saeedian, 2016) or that students will be more successful in initiating and maintaining behaviors for learning purposes (Schunk & DiBenedetto, 2016). Schunk (1991) stated that self-efficacy is similar to control beliefs, whereas Bandura (1997) stated that self-efficacy is an important component of perceived control. This relationship between control beliefs and self-efficacy makes our research results valuable.

On the learning strategy scale, significant differences were observed only in the time and study environment dimensions. According to Pintrich et al. (1991), in addition to cognitive self-regulation, students should be able to control and arrange their time and study environment. Planning and controlling study time is part of time management. This includes not only allocating time slots for studying but also using the study time effectively and setting realistic goals. The management of the study environment refers to the environment in which students perform classroom work. Tadese et al. (2022) define time and study environment management as students' ability to manage when, where, and for how long they engage in the activities required to attain their academic goals. The management of the study environment is critical for completing learning activities and accomplishing learning goals, as noted by Yang et al. (2023). According to Chen (2009), only time and work environment management predicted laboratory assignment scores, with the computer laboratory serving as the learning environment.

The findings suggest that using computer labs as a classroom for mathematical instruction is a viable option. As students develop their own coding projects through individual or collaborative learning, time and work environment management have become increasingly important. In addition, considering that students learn outside the classroom (Pintrich, 2004), it is believed that they can continue to learn mathematics through block-based coding on personal computers at home. Since time management includes schedules for studying and other activities, students' ability to decide on the intensity of their work, and their ability to control distractions in their work environment (Pintrich, 2000) indicates that CT thinking and mathematics instruction can produce positive results together.

Another surprising result was that there were no significant differences in the cognitive or metacognitive strategies on the learning strategy scale. Studies have identified critical thinking as an important component of ICT (Korkmaz, Çakır, & Özden, 2017; ISTE, 2011). However, important differences between critical thinking and CT are also emphasized in the research (Walden et al., 2013). According to DePryck (2016), CT is based on a series of metacognitive strategies across disciplines. Yadav, Ocak and Oliver (2022) stated that CT can be an effective tool for teaching metacognitive strategies.

We believe that the research period was effective in not achieving these expectations. The effects of the pandemic on education should be considered when evaluating the results of research conducted during the period after schools opened in Turkey. According to Reimers (2022), the Covid-19 pandemic is a crisis that deprived many students of educational opportunities, although the level of deprivation varies across countries. This crisis has caused students to lose not only their current educational lives, but also their knowledge and skills. Another important problem in the immediate aftermath of the pandemic is the effects of the stress and trauma it induced. As Fong (2022) stated, the motivational changes expected after the pandemic were also reflected in the research results. In addition, the learning deficit in mathematics is higher than in reading (Betthäuser et al., 2023).

In conclusion, according to Caeiro-Rodríguez et al. (2022), current digital technologies and tools offer solutions for providing an effective and lasting learning experience for both students and teachers. In addition, a potential solution to the pandemic's negative impacts on students is to integrate CT activities into learning. Finally, overall, we believe that positive learning outcomes can be achieved by shifting traditional mathematics teaching to different classroom environments and ways of thinking.

Limitations and Further Research

This research was carried out in a Turkish secondary school. Therefore, it is important to repeat similar studies in different countries to consider the possibility of cross-cultural differences. In addition, when the current results and the duration of the study are considered together, longer studies may reveal more positive results. Therefore, it can be stated that further research at different grade levels will provide important insights into mathematics instruction in which CT is integrated. In addition, research on the efficacy of technology-based activities, such as unplugged coding for students with limited access to digital tools, can play an essential role in ensuring educational equality.

Research and Publication Ethics Statement

This study was carried out with the approval and under the scrutiny of the Educational Research Ethics Committee of Aydın Adnan Menderes University (07.08.2021-60454). There are no conflicts of interest between the authors.

References

Akkuş-Çakır, N., & Senemoğlu, N. (2016). Analytical thinking skills in higher education. *Kastamonu Eğitim Dergisi*, *24*(3), 1487-1502.

Angeli, C., Voogt, J., Fluck, A., Webb, M., Cox, M., Malyn-Smith, J., & Zagami, J. (2016). A K-6 computational thinking curriculum framework: Implications for teacher knowledge. *Journal of Educational Technology & Society, 19*(3), 47-57.

Aslan, Ö. (2007). *Bilgi toplumunda teknolojinin ve teknoloji politikalarının yeri* (Tez No. 217574) (Doktora Tezi, İstanbul Üniversitesi- İstanbul). Yükseköğretim Kurulu Başkanlığı Tez Merkezi.

Atmatzidou, S., & Demetriadis, S. (2016). Advancing students' computational thinking skills through educational robotics: A study on age and gender relevant differences. *Robotics and Autonomous Systems, 75*, 661–670. https://doi.org/10.1016/j.robot.2015.10.008.

Bandura, A. (1997). *Self-efficacy: The exercise of control.* W H Freeman/Times Books/ Henry Holt & Co.

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: what is Involved and what is the role of the computer science education community?. *Acm Inroads, 2*(1), 48-54.

Başün, A. R. (2016). *Oyunla Öğretimin Çarpanlar ve Katlar Alt Öğrenme Alanında Başarı ve Kalıcılığa Etkisi.* (Tez No. 442978) (Yüksek Lisans Tezi, Ondokuz Mayıs Üniversitesi-Samsun). Yükseköğretim Kurulu Başkanlığı Tez Merkezi.

Beletti, C., & Vaillant, D. (2022). Self-regulation and learning strategies of beginner and advanced university students. *Cuadernos de Investigación Educativa, 13*(2). https://doi.org/10.18861/cied.2022.13.2.3255.

Betthäuser, B. A., Bach-Mortensen, A.M., & Engzell, P. A. (2023). Systematic review and meta-analysis of the evidence on learning during the COVID-19 pandemic. *Nat Hum Behav. 7*(3), 375-385. https://doi.org/10.1038/s41562-022-01506-4.

Bindak, R. (2014). Mann-whitney u ile student's t testinin i.tip hata ve güç bakımından karşılaştırılması: Monte carlo simülasyon çalışması. *Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi. 14*, 5-11. https://doi.org/ 10.5578/fmbd.7380.

Bounou, A., Lavidas, K., Komis, V., Papadakis, S., & Manoli, P. (2023). Correlation between high school students' computational thinking and their performance in stem and language courses. *Educ.Sci.,13,* 1101. https://doi.org/10.3390/educsci13111101

Büyüköztürk, Ş., Akgün, Ö. E., Özkahveci, Ö. & Demirel, F. (2004). Güdülenme ve öğrenme stratejileri ölçeğinin Türkçe formunun geçerlik ve güvenirlik çalışması. *Kuram ve Uygulamada Eğitim Bilimleri, 4*(2), 207-239.

Brynjolfsson, E., & McAfee, A. (2014). The second machine age: Work, progress, and prosperity in a time of brilliant technologies. WW Norton & Company.

Cansu, S., & Cansu, F. (2019). An overview of computational thinking. *International Journal of Computer Science Education in Schools, 3*(1), 1-.11. https://doi.org/10.21585/ijcses.v3i1.53.

Caeiro-Rodríguez, M., Manso-Vázquez, M., Jesmin, T., Terasmaa, J., Tsalapata, H., Heidmann, O., Okkonen, J., White, E., de Carvalho, C.V., & Stefan, I.-A. (2022). Students and teachers' need for sustainable education: Lessons from the pandemic. *Computers, 11*, 157. https://doi.org/10.3390/ computers11110157.

Chen, C. (2009). Self-regulatedl strategies and achievement in an introduction to information systems course. *Information Technology, Learning, and Performance Journal, 20*(1), 11–25.

Chongo, S., Osman, K., & Nayan, N. (2020). Level of computational thinking skills among secondary science student: Variation across gender and mathematics achievement. *Science Education International, 31*(2), 159-.163. https://doi.org/10.33828/sei.v31.i2.4.

Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2009). *Introduction to algorithms* (3rd ed.). MIT Press.

Cooligan, H. (2009). *Research Methods and Statistics in Psychology* (5th ed). Hodder Education Group. https://doi.org/10.4324/9780203769836.

Christensen, L. B., Johnson, R. B. & Turner, L. A. (2015). *Araştırma yöntemleri desen ve analiz.* (A. Aypay, Çeviri Editörü). Anı Yayıncılık.

Curzon, P., Bell, T., Waite, J., & Dorling, M. (2019). Computational thinking. In S. A. Fincher & A. Robins (Eds.) *The Cambridge handbook of computing education research*. (pp. 513-- 546). Cambridge University Press.

Çetin, Y., & Mirasyedioğlu, Ş. (2019). The effects of the technology Supported problem-based learning activities on students' achievement in mathematics. *Journal of Computer and Education Research, 7*(13), 13-.34. https://doi.org/ 10.18009/jcer.494907.

Çubukçu, Z. (2011). *Düşünme becerileri*. S. B. Filiz (Ed.), Öğrenme öğretme kuram ve yaklaşımları. (ss.281-331). Pegem Akademi.

Çetin, İ. & Toluk Uçar, Z. (2020). Bilgi İşlemsel Düşünme Tanımı ve Kapsamı. In Y. Gülbahar (Eds.), *Bilgi İşlemsel Düşünmeden Programlamaya* (pp. 41-78). Pegem Akademi. https://doi.org/10.14527/9786052411117

Davenport, T. H., & Kirby, J. (2015). Beyond automation: Strategies for remaining gainfully employed in an era of very smart machines. *Harvard Business Review, 93*(6), 58-65.

Denning, P. (2009). The profession of IT beyond computational thinking. *Communications of the ACM, 52*(6), 28-30. https://doi.org/10.1145/1516046.1516054.

DePryck, K. (2016, November 2-4). From computational thinking to coding and back. *Fourth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'16),* Salamanca, Spain.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School Engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. https://doi.org/10.3102/00346543074001059.

Fong, C. J. (2022). Academic motivation in a pandemic context: A conceptual review of prominent theories and an integrative model. *Educational Psychology, 42*(10), 1204-1222. https://doi.org/10.1080/01443410.2022.202689.1.

Gliner, J. A., Morgan, G. A. & Leech, N. L. (2016). *Uygulamada Araştırma Yöntemleri.* (S. Turan, Çeviri Editörü). Nobel Yayıncılık.

Grover, S., & Pea, R. (2013). Computational thinking in K–12: A review of the state of the field. *Educational Researcher, 42*(1), 38-43.

Grover, S., & Pea, R. (2018). Computational thinking: A competency whose time has come. In S. Sentance, E. Barendsen, & C. Schulte (Eds.), *Computer Science Education: Perspectives on Teaching and Learning in School* (p. 20-38). Bloomsbury Publishing.

Guzdial, M. (2008). Education paving the way for computational thinking. *Communucations of the ACM,* 25-27. https://doi.org/10.1145/1378704.1378713.

Güneş, F. (2012). Öğrencilerin düşünme becerilerini geliştirme. *Türklük Bilimi Araştırmaları, 32*, 127-146.

Helsa, Y., Superman., Juandi, D., Turmudi., & Ghazali, M. B. (2023). A meta-analysis of the utilization of computer technology in enhancing computational thinking skills: Direction for mathematics learning. *International Journal of Instruction, 16*(2), 735-758. https://doi.org/10.29333/iji.2023.16239a.

Hoppe, H., & Werneburg, S. (2019). Computational thinking—more than a variant of scientific inquiry!. In A. C. Kong & H. Abelson (eds), *Computational thinking education*. Springer. https://doi.org/10.1007/978-981-13-6528-7_2

Husnah, A. U., Hidayat, M. A., & Jannah, M. (2021). The Journey of a math: As a mathematics learning innovation. *Indonesian Journal of Multidiciplinary Research, 1*(1), 129-136. https://doi.org/10.17509/ijomr.v1i1.33814.

ISTE (2011). Computational Thinking. Operational Definition. Retrieved October 13, 2023, from https://cdn.iste.org/wwwroot/Computational_Thinking_Operational_Definition_ISTE.pdf.

Israel-Fishelson, R., & Hershkovitz, A. (2022). Studying interrelations of computational thinking and creativity:A scoping review (2011–2020). *Computers & Education, 176*, 104353. https://doi.org/10.1016/j.compedu.2021.104353.

Kakavas, P., & Ugolini, F. (2019). Computational thinking in primary education: a systematic literatüre review. *Research on Education and Media, 11*(2), 64-94. https://doi.org/10.2478/rem-2019-0023.

Kanaki, K., & Kalogiannakis, M. (2022). Assessing algorithmic thinking skills in relation to age in early childhood stem education. *Educ. Sci., 12*, 380. https://doi.org/10.3390/educsci12060380.

Kelleher, C., & Pausch, R. (2005). Lowering the barriers to programming: A taxonomy of programming environments and languages for novice programmers. *ACM Computing Surveys, 37*(2), 83-137.

Kert, S. B. (2020). Bilgisayar bilimi eğitimine giriş. In Y. Gülbahar (Eds), *Bilgi işlemsel düşünmeden programlamaya* (pp. 1-22). Pegem Akademi Yayınları. https://doi.org/10.14527/9786052411117.

Korkmaz, Ö., Çakir, R., & Özden, M. Y. (2017). A validity and reliability study of the Computational Thinking Scales (CTS). *Computers in Human Behavior, 72*, 558–569. https://doi.org/10.1016/j.chb.2017.01.005

Kızılkaya, G., & Aşkar, P. (2009). Problem çözmeye yönelik yansıtıcı düşünme becerisi ölçeğinin geliştirilmesi. *Eğitim ve Bilim, 34*(154), 82-92.

Kramer, J. (2007). Is abstraction the key to computing? *Commun. ACM, 50*, 36–42. https://doi.org/10.1145/1232743.1232745.

Lei, H., Chiu, M.M., Li, X., Wang, X. & Geng, Y. (2022). Computational thinking and academic achievement: A meta-analysis among students, *Children and Youth Services Review, 118,* 105439. https://doi.org/10.1016/j.childyouth.2020.105439.

Liu, C., Shi, Y., & Wang, Y. (2022, May 27-29). Self-determination theory in education: The relationship between motivation and academic performance of primary school, high school, and college students. *3rd International Conference on Mental Health, Education and Human Development,* Dalian, China.

Lv, L., Zhong, B. & Liu, X. (2023) A literature review on the empirical studies of the integration of mathematics and computational thinking. *Educ Inf Technol, 28, 8171-8193*. https://doi.org/10.1007/s10639-022-11518-2.

Manavipour, D., & Saeedian, Y. (2016). The role of self-compassion and control belief about learning in university students' self-efficacy. *Journal of Contextual Behavioral Science, 5*(2), 121–126. https://doi.org/10.1016/j.jcbs.2016.02.003.

Mindetbay, Y., Bokhove, C., & Woollard, J. (2019). What is the relationship between students' computational thinking performance and school achievement*?. International Journal of Computer Science Education in Schools, 2*(5), 3–19. https://doi.org/10.21585/ijcses.v0i0.45

Mirolo, C., Izu, C., Lonati, V., & Scapin, E. (2022). Abstraction in computer science education: An overview. *Informatics in Education, 20*(4), 615-639. https://doi.org/10.15388/infedu.2021.27.

Nordby, S. K., Bjerke, A. H., Mifsud, L. (2022). Computational thinking in the primary mathematics classroom: A systematic review. *Digital Experiences in Mathematics Education, 8,* 27-49. https://doi.org/10.1007/s40751-022-00102-5.

Pintrich, P., Smith, D., García, T., & McKeachie, W. (1991). A manual for the use of the motivated strategies for learning questionnaire (MSLQ). Ann Arbor, MI: University of Michigan.

Pintrich, P. R., Smith, D. A., Garcia, T., Mckeachie, W. J. (1993). Reliability and predictive validity of the motivated strategies for learning questionnaire (MSLQ). *Educational and Psychological Measurement, 53*(3), 801-813. https://doi.org/10.1177/0013164493053003024.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 451–502). Academic Press. https://doi.org/10.1016/B978-012109890-2/50043-3.

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and selfregulated learning in college students. *Educ. Psychol. Rev. 16*, 385–407. https://doi.org/ 10.1007/s10648-004-0006-x.

Rabiee, M., & Tjoa, A.M. (2017, May 22-24). From abstraction to implementation: Can computational thinking improve complex real-world problem solving? A Computational Thinking-Based Approach to the SDGs. *Information and Communication Technologies for Development. ICT4D 2017*, Yogyakarta, Indonesia.

Refvik, K. A. S. & Bjerke, A. H. (2022). Computational thinking as a tool in primary and secondary mathematical problem solving: a literature review. *Nordic Studies in Mathematics Education, 27*(3), 5–27.

Reimers, F. M. (2022). Learning from a Pandemic. The Impact of COVID-19 on education around the world. In: Reimers, F.M. (eds) *Primary and Secondary education during Covid-19.* Springer. https://doi.org/10.1007/978-3-030-81500-4_1.

Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist, 26*, 207-231.

Schunk, D. H., DiBenedetto, M. K. (2016). Self-efficacy theory in education. In K. R., Wentzel & D. B. Miele, (Eds.), *Handbook of motivation at School.* Routledge.

Seymour, P. (1980). Mindstorms: Children, computers, and powerful ideas. Basic Books.

Shute, V.J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review, 22*, 142–158. https://doi.org//10.1016/j.edurev.2017.09.003.

Solomon, C., Harvey, B., Kahn, K., Lieberman, H., Miller, M. L., Minsky, M.,. Silverman, B. (2020). History of Logo. *Proceedings of the ACM on Programming Languages, 4*(HOPL), 1-66. https://doi.org/10.1145/3386329

Taslibeyaz, E., Kursun, E. & Karaman, S. (2020). How to Develop Computational Thinking: A Systematic Review of Empirical Studies. *Informatics in Education, 19*(4), 701–719. https://doi.org/ 10.15388/infedu.2020.30.

Tok, E., & Sevinç, M. (2010). Düşünme Becerileri Eğitiminin Eleştirel Düşünme ve Problem Çözme Becerilerine Etkisi. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 27*(27), 67-82.

Tadese, M., Yeshaneh, A. & Mulu, G.B. (2022) Determinants of good academic performance among university students in Ethiopia: a cross-sectional study. *BMC Med Educ, 22,* 395. https://doi.org/10.1186/s12909-022-03461-0.

Top, E. (2020). Düşünme Becerilerinin Önemi. Y. Gülbahar (Ed.), *Bilgi İşlemsel Düşünmeden Programlamaya* (4. baskı, s. 23-40). Pegem Akademi Yayınları. https://doi.org/10.14527/9786052411117.

Tosik-Gün, E. & Güyer, T. (2019). Bilgi İşlemsel Düşünme Becerisinin Değerlendirilmesine İlişkin Sistematik Alanyazın Taraması. *Ahmet Keleşoğlu Eğitim Fakültesi Dergisi (AKEF), 1*(2), 99-120. https://doi.org/10.38151/akef.597505.

Üzümcü, Ö. & Bay, E. (2018). Eğitimde Yeni 21. Yüzyıl Becerisi: Bilgi İşlemsel Düşünme. *Uluslararası Türk Kültür Coğrafyasında Sosyal Bilimler Dergisi, 3*(2), 1-16.

Üzümcü, Ö. (2019). *Bilgi İşlemsel Düşünme Becerisine Yönelik Program Tasarımının Geliştirilmesi ve Etkililiğinin Değerlendirilmesi*. (Tez No. 541874) [Doktora Tezi, Gaziantep Üniversitesi - Gaziantep]. Yükseköğretim Kurulu Başkanlığı Tez Merkezi.

Voon, X., Wong, S., Wong, L-H., Khambari., M., & Syed-Abdullah, S. (2022). Developing Computational Thinking Competencies through Constructivist Argumentation Learning: A Problem-Solving Perspective. *International Journal of Information and Education Technology, 12*(6), 529–539. https://doi.org/10.18178/ijiet.2022.12.6.1650.

Walden, J., Doyle, M., Garns, R., & Hart, Z. (2013. July 1-3). An informatics perspective on computational thinking. *18th ACM conference on Innovation and technology in computer science education,* Canterbury, England.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM, 49*(3), 33-35.

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society A, 366*, 3717-3725. http://doi.org/10.1098/rsta.2008.0118.

Wing, J. M. (2011). Research Notebook: Computational thinking—what and why. *The link Magazine, 6*, 20-23.

Yadav, A., Mayfield, C., Zhou, N., Hambrusch, S., & Korb, J. T. (2014). Computational thinking in elementary and secondary teacher education. *ACM Transactions on Computing Education (TOCE), 14*(1), 1-5.

Yadav, A., Ocak, C., & Oliver, A. (2022). Computational thinking and metacognition. *TechTrends 66,* 405–411. https://doi.org/10.1007/s11528-022-00695-z.

Yaman S., & Yalçın, N. (2005). Fen Bilgisi öğretiminde probleme dayalı öğrenme yaklaşımının yaratıcı düşünme becerisine etkisi. *İlköğretim Online, 4*(1), 42-52.

Yang Y, Du J, Teo T, Xue, S., & Liu, F. (2023). Effects of goal orientation on environment management in technology-based physics learning. *Front. Psychol. 13*:1048143. https://doi.org/10.3389/fpsyg.2022.1048143.

Ye, J., Lai, X. & Wong, G. (2022). The transfer effects of computational thinking: A systematic review with meta-analysis and qualitative synthesis. *Journal of Computer Assisted Learning, 38,* 1620–1638. https://doi.org/10.1111/jcal.12723.

Genişletilmiş Özet

Günümüz problemleri sadece bir disiplin ile çözülemeyecek boyutlara ulaşmıştır. Bu durum farklı disiplinlerin birlikte çalışmasını ve özellikle bilişim sistemlerinin problem çözümündeki katkısını önemli kılmaktadır. Çağımızda problemlerin çözümünü kolaylaştıran, hızlandıran hatta bazen problemi tespit edebilen araçların geliştirilmesinde bilgisayar bilimlerinin önemli rol üstlendiği söylenebilir. Bu nedenle öğrencilere problem çözme becerisi kazandırmada değişen dünyaya ve gelişen teknolojiye uygun yeni yöntemlere ihtiyaç duyulmaktadır. Bunun yanında bilgiyi öğrenciye aktarmaktan ziyade öğrencinin bilgiyi nasıl öğreneceğini öğreten, değişen ve daha da karmaşıklaşan problemlere çözüm üretebilen, aynı zamanda da üst düzey becerilerinin işe koşulmasını sağlayan eğitim sistemleri öne çıkmaktadır. Kavramsal temelleri eskiye dayansa da ülkemizde ve dünyanın büyük bir kısmında henüz yeni bir beceri olan Bilgi İşlemsel Düşünme, 21. yüzyıl problem çözme becerileri arasında önemli bir seçenek olarak yer almaktadır. Bu araştırmada matematik dersi ile bilgisayar bilimlerinin, bilgi işlemsel düşünme bağlamında bir araya getirilerek yeni bir matematik öğrenme sürecinin geliştirilmesi ve uygulanması hedeflenmiştir.

Araştırmanın amacı; ortaokul 6. sınıf öğrencilerinin "Çarpanlar ve Katlar" konusunda bilgi işlemsel düşünme etkinlikleriyle desteklenmiş matematik öğretiminin, matematik başarısı ile güdülenme ve öğrenme stratejileri üzerindeki etkisinin incelenmesidir. Yapılan çalışmada ön test – son test kontrol gruplu yarı deneysel desen kullanılmıştır. Dersler, deney grubunda bilgi işlemsel düşünme etkinlikleriyle yürütülürken kontrol grubunda ise ders kitabındaki etkinliklere dayalı geleneksel yaklaşımla işlenmiştir. Araştırmanın bağımsız değişkeni bilgi işlemsel düşünme etkinlikleri iken bağımlı değişkenleri ise; matematik başarısı, güdülenme ve öğrenme stratejileridir.

Araştırma Ege Bölgesinde bir devlet ortaokulunda 6. sınıf öğrencileriyle matematik dersinde gerçekleştirilmiştir. Deneysel süreç; 2021 – 2022 eğitim-öğretim yılı güz dönemi, matematik dersi çarpanlar ve katlar konusunda, 4 hafta sürmüştür. Uygulama; deney grubunda 19, kontrol grubunda 20 olmak üzere toplam 39 öğrencinin katılımıyla gerçekleştirilmiştir.

Çalışma kapsamında, öğrencilerin matematik başarılarını ölçmek üzere Başün (2016) tarafından geliştirilen Matematik Başarı Testi kullanılmıştır. Araştırmada öğrencilerin güdülenme düzeylerini ve öğrenme stratejilerini ölçmek üzere Pintrich, Smith, Garcia ve McKeachie (1993) tarafından geliştirilen ve Büyüköztürk, Akgün, Özkahveci, Demirel (2004) tarafından Türkçeye uyarlanan Güdülenme ve Öğrenme Stratejileri Ölçeği kullanılmıştır.

Deneysel uygulama süreci, toplam 4 hafta ve 20 ders saatinden oluşmaktadır. Süreçte, 6. sınıf matematik dersinde Çarpanlar ve Katlar konusunu işlenmiştir. Deney grubunda bilgi işlemsel düşünme etkinlikleri ile matematik dersleri yürütülürken kontrol grubunda ise geleneksel öğrenme yaklaşımı ve mevcut ders kitabı etkinlikleri

ile dersler işlenmiştir. Deney grubu öğrencileri için geliştirilen bilgi işlemsel düşünme etkinliklerinin dördü gerçek bir hayat problemi etrafında gelişmekteyken biri ise bir matematik oyunundan oluşmaktadır.

Deneysel uygulama sonrasında deney ve kontrol gruplarının Matematik Başarı Testi son test puanları arasında anlamlı bir fark olup olmadığını belirlemek için yapılan Mann-Whitney U Testi yapılmıştır. Test sonuçlarına göre, deney grubu lehine akademik başarı açısından anlamlı bir fark olduğunu sonucuna ulaşılmıştır (U=116, Z=-2.09 p=.037, r=.335). Matematik Başarı Testi puanlarının deney grubu lehine anlamlı düzeyde farklılaştığı anlaşılmaktadır. Güdülenme Ölçeği son test puanları arasındaki fark incelendiğinde, içsel hedef yönelimi, dışsal hedef yönelimi, görev değeri, özyeterlik algısı ya da sınav kaygısı boyutlarında anlamlı bir farklılığa ulaşılmamıştır. Öğrenme Kontrolü İnancı Mann-Whitney U Testi sonuçları deney grubu (Md=18.00, n=19) ve kontrol grubu (Md=16.50, n=20) arasında Öğrenme Kontrolü İnancı açısından anlamlı bir fark olduğunu ortaya koymuştur (U=117.50, Z=-2.054 p=.040, r=.329).

Öğrenme Stratejileri Ölçeği bağlamında ise yineleme, düzenleme, ayrıntılandırma, eleştirel düşünme, metabilişsel, yardım arama, çaba yönetimi ve akran işbirliği öğrenme stratejilerinde herhangi farka ulaşılmamıştır. Zaman ve Çalışma Ortamı Mann-Whitney U Testi sonuçları deney grubu (Md=36.00, n=19) ve kontrol grubu (Md=32.00, n=20) arasında zaman ve çalışma ortamı alt boyutu puanlarının deney grubu yönünde farklılaştığı görülmektedir. (U=117.00, Z=-2.056 p=.040, r=.329).

Araştırma sonucunda bilgi işlemsel düşünmeye dayalı geliştirilen ders etkinliklerinin, bireylerin matematik başarısını arttırdığı görülmektedir. Bu noktada deney grubunda uygulanan bilgi işlemsel düşünme süreçleri içeren gerçek yaşam problemlerinin matematik başarısı üzerinde etkili olduğu düşünülmektedir. Güdülenme Ölçeği son test puanları karşılaştırıldığında, gruplar arasında yalnızca öğrenme kontrolü inancı alt boyutunda deney grubu lehine anlamlı bir fark olduğu görülmüştür. Bu sonuç, deney grubu öğrencilerinin çalışma çabalarının işe yaradığına ve öğrenmelerinde bir fark yarattığına ilişkin inançlarının, kontrol grubuna oranla daha fazla geliştiği şeklinde yorumlanabilir. Öğrenme stratejileri değerlendirildiğinde ise zaman ve çalışma ortamı alt boyutunda, deney grubu lehine anlamlı bir fark olduğu sonucuna ulaşılmıştır. Söz konusu farkı açıklamada deneysel uygulama boyunca bilgisayar laboratuvarında işlenen derslerin; öğrencileri heyecanlandırdığı, öğrencilerin ders öncesinde laboratuvarın kapısında bekledikleri, geliştirdikleri algoritmalar ve yazacakları kodlara ilişkin hazırlıklar yapmalarının etkili olduğu düşünülmektedir. Hem güdülenme hem de öğrenme stratejileri ölçeğinde sadece birer alt boyutun anlamlı çıkmasında deneysel sürecin gerçekleştirildiği tarihin etkili olduğu düşünülmektedir. Covid-19 pandemisinin hemen ardından gerçekleştirilen deneysel uygulamada, öğrencilerin pandemi sürecinin olumsuz etkilerini üzerlerinden atamadıkları düşünülmektedir. Özetle, bilgi işlemsel düşünme etkinlikleri ile desteklenen matematik öğretiminin öğrencilerin matematik başarılarını artırmada etkili olduğunu göstermektedir. Ayrıca, öğrencilerin çalışma zamanlarını ve ortamlarını etkili bir şekilde düzenlemelerine yardımcı olmaktadır. Aynı zamanda öğrenme hedeflerinin başarılı sonuçlar sağladığı inancını da pekiştirmektedir. Bu nedenle, bilgisayar laboratuvarları matematik öğretimi için önemli alternatif olarak düşünülmelidir.

Ek

Etkinlik 1: Paramı nasıl çekebilirim?

Sınıfı: 6. Sınıf

Ünite: Sayılar ve İşlemler

Konu: Çarpanlar ve Katlar

Terimler / Kavramlar: Çarpan, kat, bölen, asal sayı, ortak bölen, ortak kat

Kazanımlar: M.6.1.2.1. Doğal sayıların çarpanlarını ve katlarını belirler.

(Kat kavramına son hafta etkinliğinde yer verilmiştir.)

Süre: 5 ders saati

Etkinliğin Uygulama Aşamaları

1. Problemi tanımla

Senaryo:

Bir bankanın bilişim departmanında çalıştığınızı düşünün. Bankamatiklerden para çeken banka müşterilerinden yoğun bir şekilde şikayetler gelmesi üzerine şikayetlerin neler olduğuna ilişkin bir rapor hazırlamanız ve çözüm sunmanız isteniyor. Bankaya gelen bazı şikâyet e-postaları aşağıdaki gibidir:

“Buradan ne zaman para çeksem büyük kâğıt paralarla para çıkışı oluyor; çektiğim parayı daha sonra bir bakkalda bozdurmak zorunda kalıyorum. Daha küçük değerli kâğıt paralarla ödeme yaparsanız sevinirim.” - İsmail V…

“Bayramda akraba ziyaretlerinde çocuklara harçlık vermek için bankamatikten para çektim. Ancak hepsini farklı cins kâğıt paralarla ödedi. Bankamatikleriniz para çıkışını -mümkünse- tek çeşit kâğıt para olarak versin. Örneğin, 400 TL çekiyorsam 2x200 TL veya 4x100TL olarak para çıkışı yapsın.” - Berna Ç…

“Geçen gün 2000 TL para çekmek istedim, bankamatik hepsini 10 TL’lik kâğıt paralarla ödedi. Paralar cüzdana sığmadı, poşetle götürmek zorunda kaldım.” - Yusuf Z…

"200 TL çekmeye çalıştığımda bankamatik bana 1 tane 200 TL'lik kâğıt para veriyor. 200 TL'yi bakkalda bozdurmak zorunda kalmamak için kartımı 5 defa bankamatiğe takarak her seferinde 40 TL çekiyorum. Böyle bir çözüm buldum ancak çok zaman kaybettiriyor. Ayrıca sırada bekleyen diğer insanlar homurdanmaya başlıyor. Bunun bir çözümü yok mu?" - Atilla İ…

*(Bankamatiklerde yalnızca 200, 100, 50, 20 ve 10 TL değerinde kâğıt paralarla ödeme yapıldığı bilgisi uygulayıcı tarafından verilmeli ya da öğrencileri bu konuda araştırmaya yönlendirmelidir.)

*(Ödemelerin tek çeşit kâğıt parayla yapılması istendiği vurgulanmalıdır.)

1.a. Soyutlama: Şikayetlerin ne ile ilgili olduğunu e-postaları inceleyerek birkaç cümle ile ana problemin ne olduğunu ifade ediniz. Bunu yaparken sizi oyalayacak ayrıntıları görmezden gelmeye çalışınız. (Öğrenciler senaryoyu okuduktan sonra asıl problem olan "Belli bir miktardaki parayı tek bir çeşit kâğıt parayla kaç farklı şekilde çekebiliriz?" sorusuna ulaşmaları beklenir.

1.b Ayrıştırma: Bu basamakta şikayetlerde yer alan sorunları ayrı ayrı ele alarak inceleyiniz. Bunun için:

• Çok miktarda para çekmek isteyen birisinin hangi çeşit kâğıt paraları isteyebileceği

• Az miktarda para çekmek isteyen bir müşterinin hangi çeşit kâğıt paraları isteyebileceği

(Burada çok miktarda para çeken müşterilerin büyük değerli kâğıt paraları, az miktarda para çeken müşterilerin ise küçük değerli kâğıt paraları tercih etmek isteyecekleri vurgulanmalıdır.)

• Tek çeşit kâğıt paralarla para çekmenin hangi avantajları ve dezavantajları olduğu

• Farklı kâğıt paralarla para çekmenin hangi avantajları ve dezavantajları olduğu üzerine düşünmeniz faydalı olacaktır.

(Senaryonun mantıklı ve tutarlı olması hedeflendiğinden öğrenciler, tek çeşit kâğıt para kullanımının daha avantajlı olduğu sonucuna yöneltilmeli ya da bu problemin sınırları gerekçe gösterilerek tek tip kâğıt paranın kullanılması gerektiği belirtilmelidir.)

2. Veri toplama, temsil ve analiz

Bu aşamada fark ettiğiniz problemin çözümünde nelere ihtiyaç duyacağınızı belirlemek üzere araştırma yapmanız beklenmektedir. Topladığınız verileri tablo ile göstermeniz çok daha iyi olacaktır. Tablonuzu oluştururken Microsoft Excel'i kullanabilir ya da defterinize kendiniz de çizebilirsiniz.

(Öğrencilerin problemdeki değişkenleri "çekilmek istenen para miktarı", "kâğıt para sayısı" ve "kâğıt çeşidi" biçiminde sütunlara ayırması ve aşağıdaki durumlar için tabloyu doldurması istenir.

• "Berna Ç." isimli müşteriden gelen e-postayı tekrar inceleyiniz ve bu e-postadaki duruma uygun olarak Excel tablosuna verileri yerleştiriniz.

• Berna Ç. isimli müşterinin kâğıt para çeşitlerinin her birinden (10, 20, 50, 100 ve 200'lük kâğıt paralar) kaç tane kullanarak para çekebileceğini ayrı ayrı tabloya yazınız.

Berna Ç.		
Çekilmek İstenen Para Miktarı	Kâğıt Para Sayısı	Kâğıt Paranın Değeri
400	2	200
400	4	100
400	8	50
400	20	20
400	40	10
Kurala Uymayan Diğer Gösterimler		
400	80	5
400	400	1
400	25	16

(Öğrencilerin olası tüm alternatif para çekme yöntemlerini yukarıdakine uygun yazması beklenir. İşlem sonunda 1, 5, 16, 25, 80 ve 400 TL değerindeki kâğıt/madeni paraların bulunmaması/bankamatikte yer almaması nedeniyle para çekme işlemi yapılamayan ancak 400 ün çarpanları biçiminde yazılabilen sayılar da öğrencilere gösterilir. Bankamatikte kullanılmasa da gösterimin mümkün olduğu ifade edilir.)

• Çekeceğimiz para miktarı, kâğıt para sayısı ve kâğıt para değeri arasında nasıl bir ilişki olduğunu inceleyiniz.

(Çekilmek istenen para miktarının kâğıt para sayısına ve çeşidine tam bölünebildiği belirtilir.

• Son olarak "Kâğıt Para Sayısı" ve "Kâğıt Para Değeri" bileşenlerinin hangi kavrama karşılık geldiğini araştırınız.

(Söz konusu bileşenlerin çarpan ya da bölen kavramlarına karşılık geldiği belirtilir ve öğrencilerin bu kavramları anlamlandırmaları beklenir.)

• Atilla İ. isimli müşterinin para çekme yöntemini yeni bir tabloya işleyiniz. Bileşen sayısında nasıl bir değişiklik olduğunu ifade ediniz. Alternatif diğer para çekme şekillerini de tabloya yazınız.

Çekilmek İstenen Tutar	Para Çekme Sayısı (Yeni Bileşen)	Kâğıt Para Sayısı	Kâğıt Paranın Değeri
200	1	1	200
200	5	2	20
200			

(Bir sayının yalnızca iki çarpandan oluşmadığı, istenildiği taktirde daha fazla çarpan kullanılarak da yazılabileceği belirtilir.)

• Bu yeni bileşenin hangi kavrama karşılık geldiğini belirtiniz.

• Daha fazla bileşen oluşturulabilir mi? Fikirlerinizi belirtiniz.

3. Çözümleri üret, seç ve planla

Önceki aşamalarda problemi belirledik ve cümlelerle ifade ettik. Ardından veriler toplayarak tabloda gösterdik. Çekilen para, kâğıt para sayısı ve çeşidi arasındaki ilişkiyi belirledik ve deneme-yanılma yoluyla tabloyu doldurmaya çalıştık. Sonuç olarak "çarpan-bölen" ve "kat" kavramlarını keşfettik.

Şimdi ise müşterilerin sorunlarını çözen en uygun çözüm yolunu bulmaya çalışacağız. Bu aşamada her bir grup kendi çözüm önerisini geliştirebilir ve birden fazla çözüm yolu kullanabilir.

• Çözüm önerileri arasında en uygun olanı seçiniz ve neden uygun olduğunu açıklayınız.

• Seçtiğiniz çözüme ulaşırken yapılan tüm işlemleri ayrıntılı olarak sırayla belirtiniz. Bu ayrıntılı çözüm basamaklarını oluşturma işlemine "algoritma oluşturma" adını vereceğiz. *(Öğrencilerin algoritma kavramına ilişkin bilgisi yoksa yemek tarifi, adres tarifi vb. gibi basit ve somut örneklerle algortima kavramı açıklanabilir.)

**(Bir sayının bölenlerinin, -kendine eşit ya da kendinden daha küçük doğal sayılar- olduğunu fark etmesi sağlanır. Bunun için hesaplaması kolay ve asal olmayan sayılardan örnekler verilebilir. Daha sonra istenirse asal sayılardan da örnekler verilebilir.

4. Çözümleri uygula

4.a. Algoritmanın test edilmesi ve iyileştirilmesi

• Algoritmanızı adım adım takip ederek doğru bir şekilde çalışıp çalışmadığını kontrol ediniz.

• Hata ya da eksiklik varsa düzeltiniz.

• Düzeltme için bir akran (sınıf arkadaşınız) ya da uzman(öğretmeniniz) yardımı alabilirsiniz.

Bir doğal sayının bölenlerini bulan algoritma

Basit Algoritma	Kodlamaya Hazır Algoritma
1)Sayınızı yazınız. 2) Sayınızı her seferinde 1 eksilterek eksilttiğiniz sayıya bölünüz. 3) Tam bölünüyorsa bu sayıyı not ediniz. 4) Böldüğünüz sayı 0 olduğunda durunuz.	1) Programı başlat 2) Kullanıcıdan "Bir Sayı Giriniz" diye bilgi al. 3) Bu bilgiyi "Sayı" adında bir değişkenle hafızada tut. 4) Aynı bilgiyi "Sayaç" adında başka bir değişkenle hafızada tut. 5) "Sayının Bölenleri" adında bir liste oluştur. 6)Eğer "Sayı", "Sayaç" ile tam bölünüyorsa; "Sayaç" değerini "Sayının Bölenleri" listesine ekle "Sayaç" değerini 1 azalt Eğer "Sayaç" = 0 ise 7. Adıma git 6. Adıma git. Değilse; "Sayaç değerini 1 azalt. Eğer "Sayaç" = 0 ise 7. Adıma git 6. Adıma git 7) Programı durdur.

4.b. Algoritmanın kodlanması (Otomasyon)

• Scratch Uygulamasını kullanarak geliştirdiğiniz çözüme yönelik algoritmayı kodlayınız.

• Zorlandığınız taktirde yine bir akran ya da uzmandan yardım isteyebilirsiniz.

• Benzer uygulamaları internetten araştırarak kod bloklarını inceleyebilir ve fikir edinebilirsiniz.

(Algoritmaya uygun aşağıdaki kod bloğu örneğinden yararlanılabilir. Bu sınıf düzeyinde tam bölünebilme durumu, sonucun ondalık sayı olup olmaması kontrol edilerek sağlanmıştır. Bir sayı, diğer bir sayıya tam bölünemiyorsa bu işlemin sonucunun virgül içereceği (Scratch için nokta) düşünülerek yola çıkılmıştır. Arzu edilirse "Sayıyı Yuvarla" ya da "mod" kavramı da kullanılabileceği alan uzmanı tarafından belirtilmiştir.)

5. Çözümleri değerlendirme ve genelleme

5.a. Çözümlerin değerlendirilmesi

Oluşturduğunuz programınızı farklı değerler için deneyerek tutarlı ve verimli bir şekilde çalışıp çalışmadığını kontrol ediniz. Ayrıca programınızı, görsel olarak daha düzenli hale getirebilirsiniz.

5.b. Genelleme

Geliştirdiğiniz çözüm yöntemi ve program, farklı problemlerin çözümünde kullanılabilir mi?

Hangi problemlerin çözümünde bu programı kullanabileceğinizi sınıf arkadaşlarınızla tartışınız.

(Uygulayıcı bu noktada farklı bir problem örneğini öğrencilere sunarak aynı algoritma ile çözüme ulaşabileceğini öğrencilere gösterebilir.

Örneğin: Alanı 400 m2 olduğu belirtilen dikdörtgen biçimindeki bir bahçenin kenar uzunluklarının hangi doğal sayı değerlerine sahip olabileceğinin bulunması için senaryodaki problemin çözümünde kullanılan algoritma kullanılabilir.)

6. Değerlendirme

• Problemin çözümü için size göre en uygun çözüm yöntemine ulaşabildiniz mi?

• Bir sayının çarpanları ne anlama gelmektedir?

(Bir sayıyı tam bölen tüm sayılara, o sayının çarpanı ya da böleni adı verildiğini, öğrencilerin kendi cümleleriyle yeniden ifade etmesi beklenir.)

- Çarpan kavramı, gerçek hayatta nerede ve hangi amaçlarla kullanılabilir?