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Author Contribution Statement

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This study eliminates students' misconceptions about decimal notation with the teaching method implemented according to the 5E model enriched with Digital Concept Cartoons (DCCs). The study was conducted with eight sixth grade students. In this study conducted using the action research method, lesson plans were designed based on the 5E model enriched with DCCs to eliminate misconceptions. The data were collected from Misconception Identification Forms 1 and 2, observation notes, and interviews conducted during the implementation process. Qualitative data analysis techniques were employed to analyze the data. Consequently, it was revealed that most students' misconceptions about decimal notation decreased with the application of the 5E model enriched with DCCs. After the implementation, it was observed that most of the students' misconceptions about sorting, place value, addition–subtraction, marking the numbers on the number line, and rounding in decimal notation were largely eliminated. In contrast, it was observed that students' misconceptions regarding the multiplication/division operations and problems in decimal notation did not decrease.

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Research Article

Can Students' Misconceptions regarding Decimal Notation be Eliminated with the 5E Model Enriched with Digital Concept Cartoons?*

Tuba YENİL [1] **Burçin GÖKKURT ÖZDEMİR** [2]

Abstract

This study eliminates students' misconceptions about decimal notation with the teaching method implemented according to the 5E model enriched with Digital Concept Cartoons (DCCs). The study was conducted with eight sixth grade students. In this study conducted using the action research method, lesson plans were designed based on the 5E model enriched with DCCs to eliminate misconceptions. The data were collected from Misconception Identification Forms 1 and 2, observation notes, and interviews conducted during the implementation process. Qualitative data analysis techniques were employed to analyze the data. Consequently, it was revealed that most students' misconceptions about decimal notation decreased with the application of the 5E model enriched with DCCs. After the implementation, it was observed that most of the students' misconceptions about sorting, place value, addition–subtraction, marking the numbers on the number line, and rounding in decimal notation were largely eliminated. In contrast, it was observed that students' misconceptions regarding the multiplication/division operations and problems in decimal notation did not decrease.

Keywords: Decimal notation, digital concept cartoons, mathematics education, misconception, 5e model

1. INTRODUCTION

With the rapid development of science and technology, technological developments have entered the 21st-century educational environment, and the use of technology in teaching has become a pedagogical tool (Naidoo, 2014). The need for people who can generate information and use it functionally in life, think critically, solve issues, and contribute to society and community has increased with the evolving needs of individuals and society (Ministry of National Education [MoNE], 2018). In this process, skills such as reasoning, critical thinking, creativity, and problem-solving are of great importance. Mathematics plays an important role in acquiring these skills (National Council of Teachers of Mathematics [NCTM], 1989). In recent years, the use of technology has increased rapidly in learning environments (Shallcross & Harrison, 2007), and the use of technology-based materials as a pedagogical tool has brought positive developments in teaching (Arvanitaki & Zaranis, 2020). However, these pedagogical tools were insufficient in teaching mathematics (Drijvers, Doorman, Boon, Reed, & Gravemeijer, 2010).

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Mathematics is perceived as abstract and difficult by many students (Mohd-Rustam & Azlina, 2016) because it comprises several abstract concepts and spiral structures. Mathematical concepts are essential components of the teaching and learning process (Zaslavsky & Shir, 2005). Therefore, concept teaching has an important role in understanding mathematics (Arnaodin & Mintzes, 1985). To ensure learning, concepts must be fully understood and associated with each other (Baki, 2008). In a math class, it can be difficult to define a concept. To describe a concept, it is sometimes necessary to explain the concepts associated with it. For example, defining a fraction is required to understand the decimal notation. Therefore, in mathematics lessons, students learn new information by building on previous knowledge. Incorrectly learned concepts create problems for students over time and cause misconceptions. The concept of misconception defined differently by many researchers in literature. For example, Hashweh (1988) defined misconception as an immature concept, Elby (2001) explained it as misapplication, Fisher (1983) called it as erroneous ideas, and Smith, Disessa, and Roschelle (1994) defined it as student understanding that systematically produces errors. It is important for teachers to be aware of misconceptions and to eliminate misconceptions that students have. If the teachers know the misconceptions and their reasons, they can prevent students' possible misconceptions (Köken, 2020). Elimination of misconceptions is vital for effective mathematics teaching. Hewson and Hewson (1984) stated that misconceptions negatively affect students' learning. Türkdoğan, Güler, Bülbül, and Danışman (2015) stated that because of the 45 articles that they examined, there were studies generally aimed at determining misconceptions and that there were a limited number of studies on eliminating them. When international literature is examined, it is observed that the studies conducted to detect misconceptions are more than the studies conducted to eliminate them (Ang & Shahrill, 2014).

Moreover, students have misconceptions in several mathematics-related aspects. Adıgüzel, Şimşir, Çubukluöz and Gökkurt-Özdemir (2018) in their study examining 138 theses, revealed that students at the secondary school level have misconceptions about each learning field (Adıgüzel et al., 2018). It is possible to come across studies in which teachers and teacher candidates have misconceptions as well as students (Bursalı & Gökkurt-Özdemir, 2019). One of the topics that students have misconceive options about is decimal notation. Some studies (Yılmaz, 2007) have revealed that the decimal notation issue is the most difficult and complex topic at the secondary school level, and students have misconceptions about it. Decimal notation features less in (MoNE, 2018) compared to other subjects, but it is important for percentages, length measurements, currencies, and other similar subjects. Russell (1945) emphasis on the use of decimal notation in many professions supports this explanation. For this reason, it is thought that giving the necessary importance to decimal notation from the initial years of secondary school and learning it in a way that minimizes misconceptions as much as possible will contribute to the learning of the other related topics. In this context, this study focused on eliminating misconceptions about decimal notation, in particular.

1.1. Objectives of the Study

The following is the Research Question (RQ) addressed in this study: Can Grade 6 students' misconceptions about decimal notation be eliminated with the teaching method implemented according to the 5E model enriched with Digital Concept Cartoons (DCCs). In line with this RQ, the misconceptions of the students in decimal notation were determined in Stage I. In Stage II, it was investigated whether these misconceptions were eliminated by the teaching method implemented according to the 5E model enriched with DCCs.

1.2. Theoretical Framework

The literature review for this study has been arranged under the titles "The use of concept cartoons as a pedagogical tool in mathematics classrooms" and "The use of the 5E model in mathematics classrooms.

1.2.1. The use of concept cartoons as a pedagogical tool in mathematics classrooms

Students who attend mathematics classes face many misconceptions about various subjects. Some techniques are used to reveal those misconceptions. While questionnaires and interviews are used mostly by researchers, teachers generally use practical methods such as written documents by students, their drawings, and discussions (Chin & Teou, 2009). One of the alternative techniques used by teachers is concept cartoons (Naylor & Keogh, 2000). Concept cartoons are the materials that consist of dialogues of cartoons. Only one of the ideas presented in those cartoons is accepted as scientifically right, and all the others represent scientifically wrong ideas (Keogh, Naylor & Wilson, 1998). When the literature is examined, it is possible to come across studies in which concept cartoons are used for different purposes. Among them, there are studies that aim to structure ideas (Keogh & Naylor, 1996), make clear the concepts (Taslidere & Yıldırım, 2023), and remediate the misconceptions (Chin Siong et. al., 2023; Erdoğan & Ozsevgec, 2012; Yong & Lee, 2017) and use them as an assessment tool (Chin & Teou, 2009; Çavaş et. al., 2023; Keogh, Naylor, de Boo & Rosemary, 2002). For example, Yürekli and Gökçek (2019) found that concept cartoons were effective in eliminating Grade 7 students' misconceptions about integers (Yürekli & Gökçek, 2019). Conversely, Genç (2020), as a result of a compilation of studies made with concept cartoons, found that they increase students' interests in the lesson, motivate and encourage them to think, and facilitate permanent learning (Genç, 2020). According to the Önal and Çilingir-Altiner (2022) results a significant difference was determined in terms of the academic achievement in the mathematics course between the experimental group in which concept cartoons were used and the control group in which the classic approach was used. Kaplan, Altaylı, and Öztürk (2014) in their study with grade 8 students, found that students' misconceptions about square-rooted expressions were eliminated with concept cartoons, and they were more effective than traditional teaching methods. Therefore, in this study, concept cartoons were used to overcome misconceptions about decimal notation. Concept cartoons have gained more popularity, and parallel to this, they have been transferred to the digital environment as a result of advancing technology. The concept cartoons used in this research were designed digitally for reasons such as the remarkable nature of DCCs, easier preparation in terms of visualization, and ease of making changes in the digital environment.

1.2.2. Use of the 5E model in mathematics classrooms

The education system is constantly evolving in developed countries. Because of this aspect, constructivism, which is the information theory, was implemented in Turkey in 2005 and emerged as a Constructivist Teaching Approach (CTA). At the same time, CTA has not only been a static approach, but many educational models also have been developed based on this approach. One of them is the 5E model. The origins of this model used at secondary education levels since the 1980s are based on the viewpoints of Johann Herbart, John Dewey, and Jean Piaget (Jobrack, 2013). It emerged as a 5E model with the revision of the curriculum and education model developed in the 1980s as a result of the Biological Sciences Curriculum Studies conducted by The American Institute of Biological Sciences (Bybee, 2009). This model includes five stages (Carin, Bass & Contant, 2005; Jobrack, 2013). These are given in Figure 1.

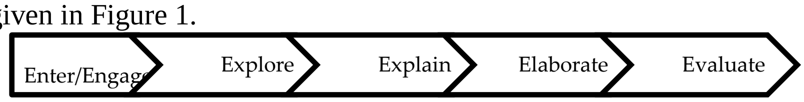

Figure 1. The 5E model

Each phase has specific functions. This model contributes to students learning scientific knowledge in the best way (Bybee, et al., 2006). The 5E model was created based on the conceptual change model and constructivist learning. In this model, it is suggested that the student should integrate a new subject with his previous learning (Tanner, 2010). Previous studies investigated the usability of the 5E model in teaching mathematics and obtaining positive results (Başer, 2008; Ertem-Akbaş & Kılıç, 2023; Tuna, 2011). This model, which is based on CTA, does not only emphasize learning but also highlights the importance of teaching in which information and communication technologies are integrated (Bülbül, 2010). In this study, the 5E model enriched with DCCs was applied to overcome the students' misconceptions. Birisci, Metin, and Karakas (2010) stated that teachers' use of concept cartoons in their lessons supports the constructivist learning approach, which reveals the reason for the integration of the 5E model and concept cartoons in this study (Birisci et al., 2010). Previous studies support the rationale for using this method. Many researchers used the 5E model enriched with DCCs (Şahin, 2018; Yılmaz, 2018) or concept cartoons (Jobrack, 2013; Yürekli & Gökçek, 2019), Previous studies that revealed that it has a positive effect on students' academic achievement, problem-solving skills, or attitudes (Uğurel & Moralı, 2006). Teaching conducted according to the 5E learning model helps increase academic achievement, eliminate misconceptions, and improve positive attitudes (Çepni & Şahin, 2012).

In the literature review, although there are many studies (Guven, Kozcu Cakir, Sulun, Cetin & Guven, 2020) in which science teaching and the 5E model are handled together, there are a limited number of studies using teaching activities based on the 5E model. For example, Teltik-Başer (2008) concluded that students who learn about circles and cylinders with activities in line with the 5E model are more successful than students who study using traditional methods. In this study, Tuna (2011) with Grade 10 students, found that the mathematical thinking and academic achievement post-test scores of the experimental group were significantly higher than the control group (Tuna, 2011). Hiçcan (2008) revealed that teaching based on the 5E model on equations with a first-order unknown has a positive effect on the academic success of Grade 7 students (Hiçcan, 2008). Although there are few implementations in mathematics teaching, it is concluded that this is an effective method when looking at the findings of the study. Therefore, it is thought that this research will fill the gap in this area to some extent. Furthermore, the design of lesson plans following the 5E model enriched with DCCs that can be used by teachers in decimal notation is another matter that reveals the importance of the research.

2. METHOD

2.1. Research Design

In this study based on a qualitative approach, the action research method was implemented. Action research is a method used to eliminate a problem faced by practitioners or improve the current situation (Mills, 2003). First, the researcher observed that the students who took his course during his teaching career often made mistakes in decimal notation. In this context, thinking about an action plan for eliminating students' misconceptions and an answer for the RQ was sought. For this reason, this method was preferred to eliminate the misconceptions of middle school Grade 6 students related to decimal notation with lesson plans designed with DCCs based on the 5E model. In this study, the researcher worked with Grade 6 students who had been taking his classes since Grade 5 and had misconceptions, a determinant deduced as a result of the observation notes. This study was classroom action research, because the researcher focused on the problem he experienced and set a goal for developing his teaching practices. Such action research studies are conducted by teachers to develop their teaching practices in classroom settings (Hendricks, 2009).

2.2. Participants

This study was conducted with eight students (five girls and three boys) studying in Grade 6 of a public secondary school for the 2018–2019 academic year. These students continued their education at a socioeconomically low state high school in the center of a province in the western region of Turkey. An easily accessible sampling method, one of the purposeful sampling methods, was used in the selection of participants. Misconception Identification Form (MIF) 1 and teacher observation notes were considered in the selection of the participants. Two of these students were integration students with mild mental and learning disabilities. The participants' real names were not used, and they were given codes, namely, P1… P8. Additionally, permission was obtained from the students and their parents to participate in the study based on ethical grounds.

2.3. Procedure

In this study, before working with the participants, a pilot study was conducted for the researcher to gain experience and for the validity and reliability of the study. The data collection process in the pilot study was conducted in four stages. In Stage I, a pool of questions was created by the researcher to detect students' misconceptions in decimal notation. In the preparation of the questions, the objectives about decimal notation in the MoNE (2018) and the observation notes about the misconceptions as a result of the researcher's previous experiences were considered. Additionally, in case of the possibility that misconceptions in the literature might exist in the students who participated in this study, the questions about those misconceptions were included in the data collection tool. MIF-1, which consists of 25 questions, was submitted to an academic member and a mathematics teacher, an expert in the field of mathematics education, for content validity. In line with the expert opinions, as the implementation period is limited and the question items were similar, four questions were removed from the abovementioned form, and it was finalized with 21 questions. To examine the explanations of the participants in detail, a directive was added to the end of some question items, such as "Explain why." For the question items, codes such as Q1… Q21 were used. Since there are sub-questions in the question items, these sub-question items are named a1, a2, b1, b2, a,b,c,d etc. In Stage II, MIF-1 was applied. Students were given sufficient time to solve MIF-1. The implementation process took approximately 3 lesson hours (120 minutes). For the MIF-1, semi-structured interviews of 25–35 minutes were conducted with each student in the environment they desired. Because the question set was large, interviews were conducted twice for each student.

2.3.1. Process of creating lesson plans

As a result of the pilot implementation, students' misconceptions were determined, and DCCs were designed with the web tool (https://www.storyboardthat.com/tr). The fact that both the researchers had publications in the field of misconceptions and one of the researchers had taught the course for 1.5 years helped them identify misconceptions. While preparing the lesson plans, DCCs were used at every stage of the 5E model. As for the stages, they were mostly used in the deepening stage to determine whether the students' misconceptions had been eliminated and understand how permanent the learned information was. An example of the lesson plans designed within the scope of this research is given in the appendices section (A1). In Stage III, the prepared lesson plans were applied for five weeks. In Stage IV, MIF-2 (which measures the same misconceptions), which was prepared to be like MIF-1 in Stage I, was used to find out whether the misconceptions had been eliminated. In addition, semi-structured interviews were conducted according to the answers given to these forms. In the pilot study, as a result of the observation that this teaching method was effective in eliminating the misconceptions students had about decimal notation, the researcher decided to use this teaching method for his students who had misconceptions in the actual implementation. Lesson plans designed for the reliability of the study were validated by two experts in the fields of mathematics education and computer technology and informatics. The lesson plans were corrected in line with the opinions of the experts (e.g., the discovery phase was not understandable, some materials were added to the lesson plans, and the cartoons were named). After the pilot study, the main implementation was initiated. The process of the research is included in Figure 2.

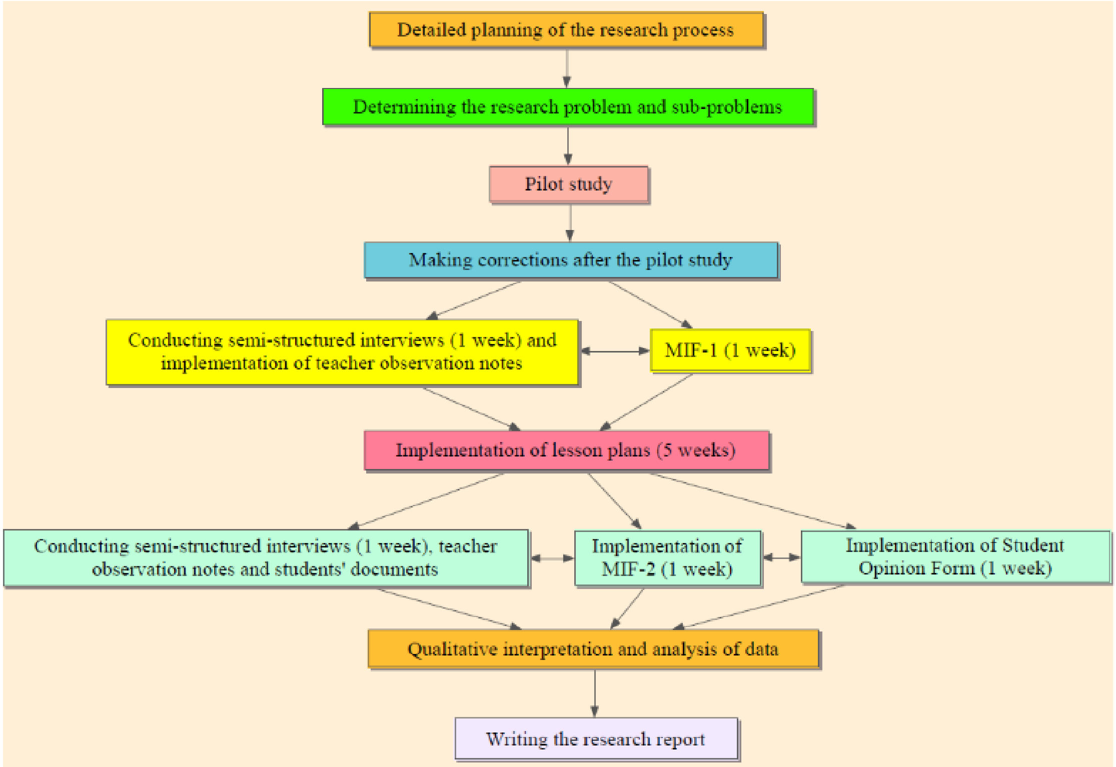

Figure 2. The process of the research

Similarly, steps in the pilot study were followed in the original implementation. The data diversity (triangulation) method was used for the reliability of the study, and interview, observation, and document analysis techniques were also conducted. The data of the interview process are given in Table 1.

Table 1. Interview process

	Interview date		Interview time		Location	
Ps	MIF-1	MIF-2	MIF-1	MIF-2	MIF-1	MIF-2
P1	05.02.2019	19.02.2019	30	35	Teachers' room	Classroom environment
	08.02.2019	21.02.2019	27	32	Teachers' room	Classroom environment
P2	05.02.2019	21.02.2019	29	38	Classroom environment	Classroom environment
	07.02.2019	20.02.2019	30	33	Classroom environment	Classroom environment
P3	06.02.2019	19.02.2019	25	30	Teachers' room	Classroom environment
	07.02.2019	20.02.2019	26	32	Classroom environment	Teachers' room
P4	06.02.2019	20.02.2019	29	35	Classroom environment	Teachers' room
	08.02.2019	22.02.2019	30	33	Classroom environment	Classroom environment
P5	05.02.2019	20.02.2019	35	35	Classroom environment	Teachers' room
	07.02.2019	21.02.2019	30	32	Classroom environment	Teachers' room
P6	06.02.2019	19.02.2019	28	30	Classroom environment	Classroom environment
	08.02.2019	23.02.2019	30	25	Classroom environment	Classroom environment
P7	07.02.2019	21.02.2019	32	35	Teachers' room	Classroom environment
	08.02.2019	24.02.2019	31	34	Teachers' room	Teachers' room
P8	07.02.2019	20.02.2019	25	30	Teachers' room	Classroom environment
	08.02.2019	24.02.2019	27	29	Teachers' room	Classroom environment

*Ps: Participants

In the analysis of the data obtained from MIF-1 and MIF-2, the framework of Karaoglan-Yılmaz et al. (2018) was used, and descriptive analysis was performed. The reason for the use of this framework may be to eliminate concept misconceptions, as in this study, and the emergence of data following the codes given in Table 2.

Table 2. Categories

Answer Categories (AC)	Explanations
Completely correct (Cc)	The question has been answered correctly and the description of the student is correct.
Correct (C)	The question has been answered correctly, but the student's description is superficial or there are minor deficiencies in the description.
Somewhat correct (Sc)	The question is answered close to the true answer, but there are false statements in the student's description.
Somewhat incorrect (Si)	The question has been answered close to be false, but there are also correct statements in the description of the student.
Incorrect (I)	The question is answered incorrectly, the student's description has irrelevant statements that are not related to the question, or the student has misconceptions.
Blank (B)	The question has been left blank.

After the coding process was completed by the researcher, the data were re-encoded by another researcher, and the percentage of agreement of Miles and Huberman (1994) was calculated. The consistency between coders was calculated as 0.95 at the end of the ×100 process. In all, 95% consistency of codes was obtained from the study, a discussion environment was established with an expert in 5% different coding, and a common decision was reached.

3. FINDINGS

The distribution of the findings regarding the answers given by the participants in the MIFs for the questions related to associating the concept of division and fraction in decimal notation before and after the implementation is presented in Table 3.

Table 3. Frequency and percentage table of the answers given by the students on associating the concept of division and fraction in decimal notation before and after the implementation

AC	**Pre-implementation**				**Post-implementation**			
	Q1				***Q1***			
	a1	***a2***	***b1***	***b2***	***a1***	***a2***	***b1***	***b2***
	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)
Cc	8(100)	8(100)	3(37.5)	2(25)	8(100)	7(87.5)	7(87.5)	3(37.5)
C	-	-	-	-	-	-	-	-
Sc	-	-	-	-	-	-	-	-
Si	-	-	-	-	-	-	-	-
I	-	-	5(62.5)	6(75)	-	-	1(12.5)	3(37.5)
B	-	-	-	-	-	1(12.5)	-	2(25)
Total	8(100)							

Q1: First Question

By observing Table 3, it was perceived that the students gave the correct answer to the questions, i.e., they had no problem converting the figures they saw into fractions but had trouble associating fractions with the division. After the implementation, it was revealed that the students corrected these misconceptions. The answers of P2, who corrected the misconceptions, are given in Figure 3.

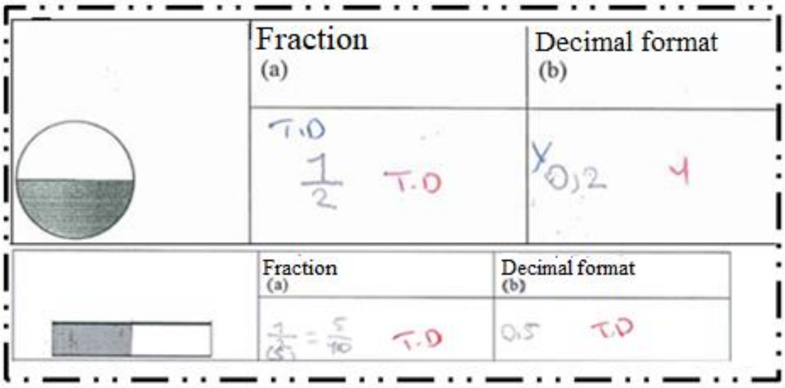

Figure 3. The answers of P2

When the solution of P2 is examined, it is seen that the problem provides the correct solution to Option A; for Option B, it was seen that the student thought of the denominator as the part after the comma and misinterpreted the problem. Interview data with the student also support this. To eliminate this misconception, an activity was conducted with the students in the discovery phase of the lesson plan prepared according to the 5E model. In this activity, a table of 100 was distributed to the students, and they were asked to paint 35 identical squares out of 100. They were asked to write down how many 1/100 pieces they got and were directed to answer the questions. As a result of this activity, it was observed that most of the students associated the concept of the fraction with the division process. To ensure full learning, an activity was conducted about concept cartoons and decimal notations that they may encounter in daily life. In Table 4, the frequency and percentage distribution of the codes for the answers given by the students to the questions about the reading subject in decimal notation before and after the implementation are given.

Table 4. Frequency and percentage table of the answers given by the students on reading decimal representations before and after the implementation

AC	**Pre-implementation**				**Post-implementation**			
	Q2				***Q2***			
	a	***b***	***c***	***d***	***a***	***b***	***c***	***d***
	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)
Cc	7(87.5)	7(87.5)	6(75)	4(50)	7(87.5)	7(87.5)	7(87.5)	7(87.5)
C	-	-	-		-	-	-	-
Sc	-	-	-	-	-	-	-	1(12.5)
Si	-	-	-	-	-	-	1(12.5)	-
I	1(12.5)	1(12.5)	2(25)	3(37.5)	1(12.5)	1(12.5)	-	-
B	-	-	-	1(12.5)	-	-	-	-
Total					8(100)			

Q2: Second Question

When Table 4 is examined, it is seen that almost all of the students read the decimal notation correctly. A small number of students who had misconceptions about this outcome corrected them after the lesson with concept cartoons was taught. It was observed that P2 had the misconception of incorrect cascading and did not know that 7 was the tenths digit. On the contrary, the answers of P2, who gave the correct answer after the implementation, are given in Figure 4.

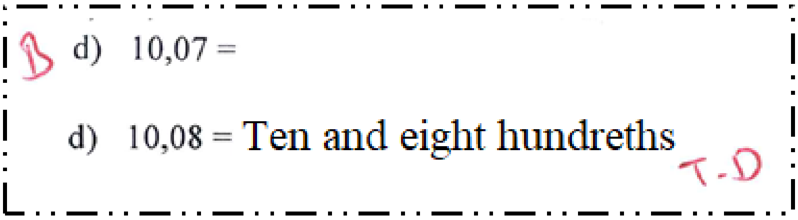

Figure 4. Answer to option d of question 2 before and after the implementation by P2

Figure 4 shows that the student had a lack of knowledge before the implementation, and this deficiency was eliminated as a result of the lessons taught according to the 5E model. When asked why he did not answer this question in MIF-1 during the interview with P2, it was revealed that he left the question blank because he did not want to give an incorrect answer. As a result of the lessons taught with the 5E model, it was observed that the students' misconceptions decreased. The frequency and percentage distribution of the codes related to the writing in decimal notation are given in Table 5.

Table 5. Frequency and percentage table of the answers given by students on writing decimal notations before and after the implementation

AC	Pre-implementation				Post-implementation			
	Q3				*Q3*			
	a	***b***	***c***	***d***	***a***	***b***	***c***	***d***
	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)
Cc	8(100)	6(75)	6(75)	8(100)	8(100)	7(87.5)	7(87.5)	7(87.5)
C	-	-	-	-	-	-	-	-
Sc	-	-	-	-	-	-	-	1(12.5)
Si	-	-	-	-	-	1(12.5)	1(12.5)	-
I	-	2 (25)	2 (25)	-	-	-	-	-
Blank	-	-	-	-	-	-	-	-
Total	8(100)							

Q3: Third Question

When Table 5 is examined, it is revealed that students generally do not have trouble writing simple decimal notations (e.g., two seven tenths = 2.7). The frequency and percentage distribution of the codes related to the issue of sorting decimal notations are given in Table 6.

Table 6. Frequency and percentage table of the answers given by the students to the subject of ranking in decimal notation before and after the implementation

AC	Pre-implementation					Post-implementation				
	Q4				*Q5*	*Q4*				*Q5*
	a	***b***	***c***	***d***		***a***	***b***	***c***	***d***	
	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)
Cc	1(12.5)	1(12.5)	1(12.5)	1(12.5)	-	6(75)	6(75)	7(87.5)	6(62.5)	5(62.5)
C	1(12.5)	1(12.5)	1(12.5)	1(12.5)	1(12.5)	-	-	-	-	-
Sc	-	-	2(25)	1(12.5)	4(50)	1(12.5)	1(12.5)	1(12.5)	-	2(25)
Si	-	1(12.5)	2(25)	1(12.5)	-	-	1(12.5)	-	1(12.5)	1(12.5)
I	4(12.5)	4 (12.5)	1(12.5)	3(37.5)	1(12.5)	1(12.5)	-	-	1(12.5)	-
B	2(25)	1(12.5)	1(12.5)	1(12.5)	2(12.5)	-	-	-	-	-
Total	8 (100)									

Q4: Fourth Question, Q5: Fifth Question

According to Table 6, the misconceptions regarding the issue of ranking in decimal notation were mostly eliminated by DCCs prepared according to the 5E model. Seven students could not give the correct answer to Option A of Question 4 before the implementation. After the implementation, two students could not give the correct answer. According to the answers given by the students to this question before the implementation, the misconception of the concept that the long number is greater when sorting came to the forefront. In the introduction of the lesson plan prepared to eliminate this misconception, the teacher enters the classroom with a meter to draw the attention of the students. He asks the students about the usage areas of the meter in daily life and poses a problem to them with the concept cartoon he prepared in a digital environment. The introduction of the course plan prepared according to the 5E model aimed to garner the attention of students with the problem, "Who is taller?" which is quite frequent in daily life (see Figure 5).

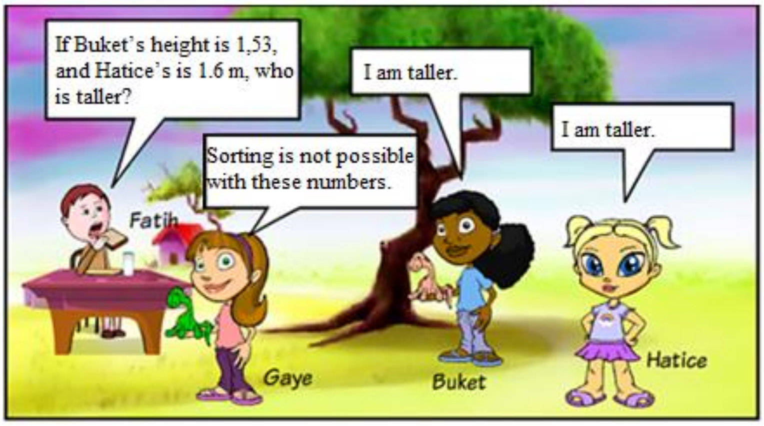

Figure 5. Concept cartoon in the lesson plan

This question is adapted to the concept cartoon and a discussion environment is created with the students. Students' existing misconceptions were revealed with DCCs. Students who chose Buket see the longer decimal notation as larger. During the discussion in the classroom, none of the students chose Gaye, and they were hesitant between Hatice and Buket. In collaboration with their peers, they moved away from comparing the height of Buket and Hatice and started to compare their height. As a result of a friend's height of 1.50 (measurements made in meters), P8 explained the incident in the following way: "If we express your height as 1.5, my height is 1.47, and I am shorter than you. Then, if we say the height of Hatice is 1.60, she is taller." As a result of this explanation, some students' misconceptions were cleared. For the remaining students, an activity was performed under the guidance of the researcher in the discovery part to observe and correct their mistakes themselves. Students understood that 0.6 is greater than 0.53 when modeling the decimal notations 0.6 and 0.53 for decimal and hundred cards. The instructor had the students conduct the activity as a guide in the discovery part. In the deepening part according to the 5E model, the students were guided by teachers, and most of the students eliminated their misconceptions. The answer of P8, who corrected his error, is given in Figure 6.

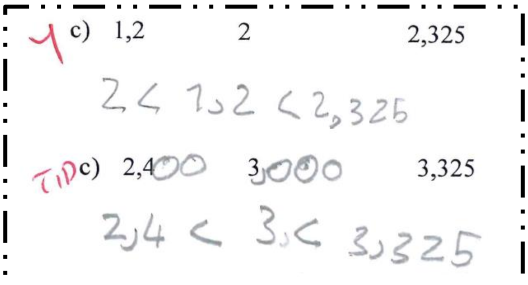

Figure 6. Answer to option c of question 4 before and after the implementation by P8

In Figure 6, it is seen that P8 responds by ignoring the comma in decimal notation and considering the number as an integer. This misconception was eliminated after the implementation, and he replied with the correct code. P8 wrote in his explanation to the question that he ordered the denominators from small to large by equalizing them. During the lesson, P8 solved the question in MIF-1 again. In Figure 7, the observational note showing P8's correction is given.

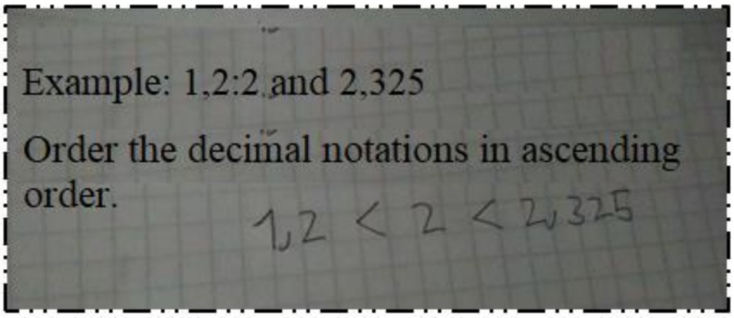

Figure 7. P8's notebook example related to the solution of the problem in MIF-1 during the implementation

While the lesson was being taught, the researcher redirected the question asked in MIF-1 to the class. Although P8 gave an incorrect answer to MIF-1, he resolved the misconception during the implementation. His response to MIF-2 also supports this aspect. In the interview, P8 explained, "When I was sorting in decimal notations, I practically sorted the parts after the comma by enlarging them." According to these findings, it is seen that the students generally understood the subject of ranking. In Table 7, the frequency and percentage distribution of the codes of the answers given by the students to the questions about the place value in decimal notation before and after the implementation are given.

Table 7. Frequency and percentage table of the answers given by the students on place value in decimal notation before and after the implementation

AC	Pre-implementation				Post-implementation			
	Q6	***Q7***		***Q8***	***Q6***	***Q7***		***Q8***
		a	***b***			***a***	***b***	
	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)
Cc	3(37.5)	1(12.5)	2(25)	-	7(87.5)	3(37.5)	3(37.5)	3(37.5)
C	-	-	-	-	-	-	-	-
Sc	-	-	-	2(25)	-	-	-	2(25)
Si	-	1(12.5)	4(50)	1(12.5)	-	-	4 (50)	-
I	4(50)	5(62.5)	1(12.5)	4(50)	1(12.5)	4(50)	-	2(25)
B	1(12.5)	1(12.5)	1(12.5)	1(12.5)	-	1(12.5)	1(12.5)	1(12.5)
Total					8(100)			

Q6: Sixth Question, Q7: Seventh Question, Q7: Eighth Question

When Table 7 is examined, it is seen that students' misconceptions are partially eliminated. Question 7, students were asked to continue the pattern. The answers given by P7 to Option A of Question 7 are given in Figure 8.

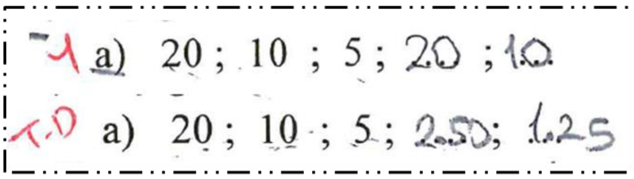

Figure 8. P7's answer to the question 7 before and after the implementation

In all, seven students could not reach the correct answer before the implementation. When the answer of P7 in Figure 8 was examined, the students thought of the numbers as symbols and came to the conclusion by returning to the beginning instead of continuing the current order. It was observed that the student who gave this answer could not think that he could use decimal notation while continuing the order in decimal notations. After the implementation, P7 was asked how he answered the question, and the answer was “I filled in the blanks by dividing the numbers into two....” It is seen that the student here associates the concept of the fraction line with division. The answers of P1, who corrected the error about the place value, are given in Figure 9.

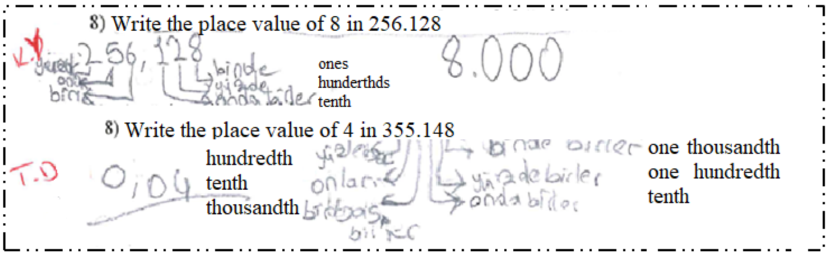

Figure 9. P1’s answers to Question 8 before and after the implementation

It is seen that P1 recognized the digit names of natural numbers before the implementation. However, it was observed that the student did not recognize the names of the digits in the decimal notation after the comma. After the implementation, the student grasped the value of the digits after the comma and answered the question correctly. The frequency and percentage distribution of the codes of P1’s answers to the questions about the relation of decimal notation with fractions before and after the implementation are given.

Table 8. Frequency and percentage table of the answers given by the students about the relationship between decimal notations and fractions before and after the implementation

AC	Pre-implementation			Post-implementation		
	Q9		***Q10***	***Q9***		***Q10***
	a	***b***		***a***	***b***	
	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)
Cc	7(87.5)	6(75)	4(50)	8(100)	7(87.5)	6(75)
C	-	-	1 (12.5)	-	-	-
Sc	-	-	-	-	-	-
Si	-	1(12.5)	-	-	-	-
I	1(12.5)	1(12.5)	1(12.5)	-	1(12.5)	1(12.5)
B	-	-	2(25)	-	-	1(12.5)
Total				8(100)		

Q9: Ninth Question, Q10: Tenth Question

In Table 8, it is seen that students’ misconceptions about associating decimal representations with fractions before the implementation were low. Upon examining the MIF-1, it can be said that the reason students tend to be mistaken about this issue is that they do not conceptually learn the decimal notation, and do not understand the place values of the decimal part after the decimal point. The students who realized that decimal notation is a different representation of fractions resolved their mistakes after the implementation. When the findings of Question 10 are examined, while four students gave incorrect answers before the implementation, the number decreased to two after the implementation. In this regard, P4, who had made an error before the implementation, was able to resolve that error after the implementation. The answers of P4 are in Figure 10.

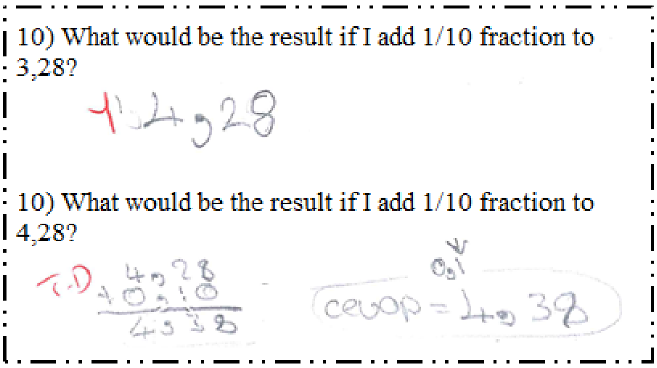

Figure 10. P4's answers to question 10 before and after the implementation

P4 found the result 4.28 by seeing the numerator of the fraction given in the question as a whole part before the implementation, adding 1 to the 3 in the full part of the decimal notation. As a result of the observations made by the researcher during the lesson, the student's repetition of this error in the questions he solved during the lesson shows that the student had a misconception about this outcome. After the implementation, P4 learned to convert fractions to decimal notation and answered Question 10 correctly. In Table 9, the frequency and percentage distribution of the codes of the answers given by the students to the questions about addition and subtraction in decimal notation before and after the implementation are given.

Table 9. Frequency and percentage table of the answers given by the students to addition and subtraction operations before and after the implementation

AC	Pre-implementation						Post-implementation					
	Q11			*Q12*			*Q11*			*Q12*		
	a	***b***	***c***	***a***	***b***	***c***	***a***	***b***	***c***	***a***	***b***	***c***
	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)
Cc	2(25)	2(25)	1(12.5)	1(12.5)	1(12.5)	1(12.5)	6(75)	7(87.5)	6(75)	5(62.5)	5(62.5)	5(62.5)
C	1(12.5)	-	-	1(12.5)	1(12.5)	2(25)	-	-	-	-	-	-
Sc	1 (12.5)	2 (25)	-	1 (12.5)	-	-	-	-	-	1(12.5)	1(12.5)	1(12.5)
Si	-	-	1(12.5)	-	-	-	-	-	-	1 (12.5)	1 (12.5)	-
I	4(50)	4(50)	6(75)	4(50)	6(75)	4(50)	2(25)	-	1(12.5)	-	1(12.5)	1(12.5)
B	-	-	-	1(12.5)	-	1(12.5)	-	1(12.5)	1(12.5)	1(12.5)	-	1(12.5)
Total	8(100)											

Q11: Eleventh Question, Q12: Twelfth Question

Upon examining Table 9, it is seen that the number of students who answered with the correct code before the implementation was low. It is noteworthy that there is an increase in the number of students who answered with the correct code after the implementation. The answers of P7 regarding this are given in Figure 11.

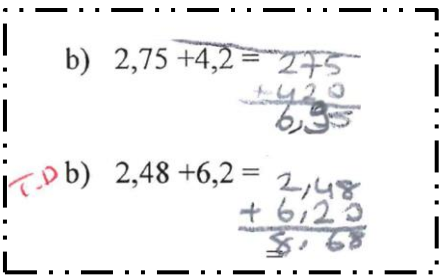

Figure 11. P7's answers to option b of question 7 before and after the implementation

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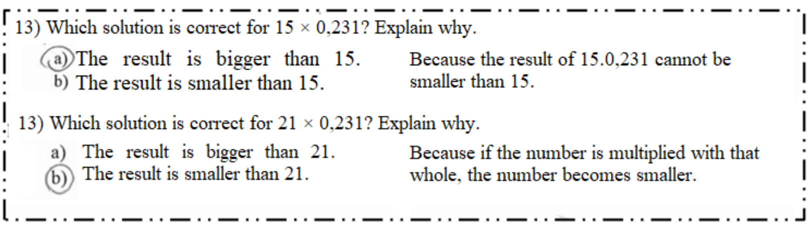
Before the implementation, P7 had partially achieved the correct response. Ignoring the comma and processing them as natural numbers, he added commas in the conclusion. In his explanation, he wrote, "I did normal addition and converted them into decimals." In the interview, the student could not explain why he put a comma after 6 at the end of the procedure before the implementation and made a superficial, memorization-based explanation such as "We do it this way, I know that..." Therefore, his answer is evaluated as partially correct. After the implementation, although the student did not write in detail, he wrote, "I filled the blanks with 0 and performed the operation." He explained how he performed the addition in decimal notation. When the student wrote the given decimal notation as a fraction, he stated that the denominators were not equal, and hence, he equalized the denominator to sum up 6.2 to 2.48 decimal notations, added 0 to 6.20, and made the denominator 100. Therefore, his answer is included among the correct ones. During the interview process, it was observed that some students did not have any misconceptions but gave wrong answers due to errors in operation. In Table 10, the frequency and percentage distribution of the codes of the students' answers regarding the effect of multiplication and division on the size of decimal notation are given.

Table 10. Frequency and percentage table of the answers given by the students to the questions regarding the effects of decimal representations on multiplication and division on the size before and after the implementation

AC	Pre-implementation		Post-implementation	
	Q13	***Q14***	***Q13***	***Q14***
	f (%)	f (%)	f (%)	f (%)
Cc	-	-	2(25)	2(25)
C	-	-	-	-
Sc	1(12.5)	2(25)	-	-
Si	-	-	-	-
I	4(50)	3(37.5)	3(37.5)	1(12.5)
B	3(37.5)	3(37.5)	3(37.5)	5(62.5)
Total		8(100)		

Q13: Thirteenth Question, Q14: Fourteenth Question

Before implementation, students were found to have the misconception that multiplication always makes numbers bigger, and division always makes numbers smaller. As seen in Table 10, all of the students did not think that multiplication could make numbers smaller, and division could make numbers larger before the implementation. During the implementation, the students were taught one of the methods of multiplication and division in decimal notation: "We can write the number given as a decimal notation as a fraction and multiply or divide it." In addition, multiplication and division were done in the classroom environment, and the students were asked to discover them. However, when the answers after the implementation were examined, it was seen that only two students' misconceptions were eliminated. Related to this, the answers of P5 are given in Figure 12.


13) Which solution is correct for 15 × 0,231? Explain why.
a) The result is bigger than 15. Because the result of 15.0,231 cannot be smaller than 15.
b) The result is smaller than 15.

13) Which solution is correct for 21 × 0,231? Explain why.
a) The result is bigger than 21. Because if the number is multiplied with that whole, the number becomes smaller.
b) The result is smaller than 21.

Figure 12. P5's answers to question 13 before and after the implementation

When Figure 12 is examined, it is seen from the statement of P5 that the student thinks the result cannot be small because it is multiplied. It is seen that the student always falls into the misconception that multiplication always results in something larger. After the implementation, the student realized that the decimal notation subject can shrink a whole by dividing it into equal parts. When asked why he gave this answer in the interview, P5 said, “I multiplied by 0, so I have to divide 21 into 1000 equal parts and write 231 as an answer. For this reason, I thought the number would be small if 0 is multiplied by a full…” In Table 11, the frequency and percentage distribution of the codes of the answers given by the students to the multiplication and division operations on decimal notation are given.

Table 11. Frequency and percentage table of the answers given by the students to multiplication and division in decimal notation before and after the implementation

AC	**Pre-implementation**						**'Post-implementation**					
	Q15			***Q16***			***Q15***			***Q16***		
	a	***b***	***c***	***a***	***b***	***c***	***a***	***b***	***c***	***a***	***b***	***c***
	f (%)	f (%)	f (%)	f(%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)
CC	-	3(37.5)	-	2(25)	1(12.5)	1(12.5)	4(50)	1(12.5)	2(25)	4(50)	2(25)	2(25)
C	1(12.5)	-	-	-	-	-	-	-	-	-	-	-
SC	1(12.5)	-	2(25)	-	-	-	-	1 (12.5)	-	-	-	-
Si	1(12.5)	-	1(12.5)	-	-	1(12.5)	2(25)	1(12.5)	3(37.5)	2(25)	3(37.5)	3(37.5)
I	4 (50)	3(37.5)	2 (25)	2(25)	2 (25)	1(12.5)	-	3(37.5)	1(12.5)	-	1(12.5)	-
B	1(12.5)	2(25)	3(37.5)	4(50)	5(62.5)	5(62.5)	2(25)	2(25)	2(25)	2(25)	2 (25)	3(37.5)
Total						8(100)						

Q15: Fifteenth Question, Q16: Sixteenth Question

When Table 11 is examined, it is seen that students had misconceptions in multiplication and division operations before the implementation. During the implementation, activities were performed to eliminate the misconceptions of the students in the multiplication process. In the lesson plan prepared according to the 5E model, the teacher asked the students who came to the classroom with an apple, banana, and orange in their hands whether there was someone in their families who goes to the grocery store. He posed a problem to them at the beginning. In the exploration section, the activity was started under the guidance of the teacher, and this problem was asked to be solved by the students. To understand whether the students’ misconceptions were eliminated, another problem was posed by the teacher in the deepening part with concept cartoons. Incorrect answers in concept cartoons enabled the researcher to identify students who had misconceptions. DCCs, a part of the deepening phase of the lesson plan prepared according to the 5E model, provided opportunities for students to correct their mistakes. As in the multiplication process, it is seen that the concept of misconceptions cannot be eliminated in the division process by the students. In Table 12, the frequency and percentage distribution of the codes of the answers given by the students to the questions about showing the decimal notation on the number line before and after the implementation are given.

Table 12. Frequency and percentage table of the answers given by the students regarding the display of decimal notations before and after the implementation on the number line

AC	Pre-implementation						Post-implementation					
	Q17			***Q18***			***Q17***			***Q18***		
	a	***b***	***c***	***a***	***b***	***c***	***a***	***b***	***c***	***a***	***b***	***c***
	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)
CC	2(25)	3(37.5)	2(25)	3(37.5)	-	-	5(62.5)	5(62.5)	5(62.5)	6(75)	2(25)	4(50)
C	-	-	-	-	-	-	-	-	-	-	-	-
Sc	-	-	-	-	-	-	1(12.5)	1(12.5)	1(12.5)	1(12.5)	2(25)	2(25)
Si	1(12.5)	2(25)	1(12.5)	-	2(25)	2(25)	-	1 (12.5)	1 (12.5)	1 (12.5)	2 (25)	1 (12.5)
I	5(62.5)	3(37.5)	5(62.5)	5(62.5)	6(75)	6(75)	2(25)	1(12.5)	1(12.5)	-	2(25)	1(12.5)
B	-	-	-	-	-	-	-	-	-	-	-	-
Total	8(100)											

Q17: Seventeenth Question, Q18: Eighteenth Question

When Table 12 is examined, it is seen that the number of students who gave the correct answer before the implementation is small. After the implementation, the number of students who gave the correct answer increased. During the discovery phase of the lesson plan, two students were asked to show the distance they traveled on the number line. The observation note about the activity is given in Figure 13.

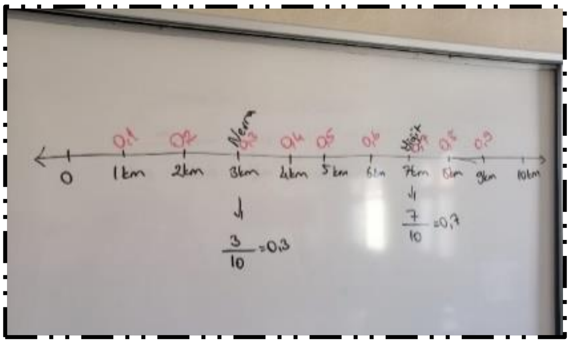


Figure 13. Observation notes for the activity in lesson plan 3

When the answers given by the students after the implementation were examined, it was revealed that most of the students' misconceptions were eliminated. The answers of P2, who corrected the error after the implementation, are given in Figure 14.

Figure 14. P2's answer to option b of question 17 before and after the implementation

As seen in Figure 14, the student had the misconception of dividing the 0.7 decimal notation into 11 equal parts between 0 and 1. Instead of separating 0 to 1 into 10 matching parts, the student focused on the number of lines and drew 10 lines between 0 and 1. During the interview process, the student emphasized that he had to draw 10 lines because the denominator was 10. The student realized that he should correct this mistake after the implementation and focus on the number of identical parts and not the number of lines. When evaluated in general, it is seen that the misconceptions about showing decimal notations on the number line have been largely eliminated. Based on the statements made by some students during the interviews, it was found that the errors they made in showing the number line were due to carelessness. In Table 13, the frequency and percentage distribution of the codes for the answers given by the students to the problems in decimal notation are given.

Table 13. Frequency and percentage table of the answers given to the questions related to the problem subject in decimal notations before and after the implementation

AC	Pre-implementation		Post-implementation	
	Q19	***Q20***	***Q19***	***Q20***
	f (%)	f (%)	f (%)	f (%)
Cc	-	1(12.5)	-	2(25)
C	-	-	-	-
Sc	-	-	-	-
Si	-	2(25)	1(12.5)	2(25)
I	6(75)	3(37.5)	2 (25)	4(50)
B	2(25)	2(25)	5(62.5)	-
Total		8(100)		

Q19: Nineteenth Question, Q20: Twentieth Question

In Table 13, it was seen that almost all of the students' misconceptions and mistakes could not be eliminated compared to other subjects. During the lectures, the researcher noticed that the students had difficulty understanding what they read in line with the observation notes. Some expressions of students, such as "I could not fully understand the problem" and "I could not understand what you mean," supported this explanation. It was also observed that some students left the questions blank. Although some students could not correct their mistakes after the implementation, it was determined that they understood the problem and correctly determined the procedures to be conducted to solve the problem. In Table 14, the frequency and percentage distribution of the codes of the answers given by the students to the questions about rounding in decimal notation before and after the implementation are given.

Table 14. Frequency and percentage table of the answers given by the students to the questions related to rounding in decimal notations before and after the implementation

AC	Pre-implementation					Post-implementation				
			Q21					***Q21***		
	a	b	c	d	***e***	***a***	***b***	***c***	***d***	***e***
	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)	f (%)
Cc	2(25)	1(12.5)	1(12.5)	2(25)	1(12.5)	7(87.5)	3(37.5)	3(37.5)	4(50)	5(67.5)
C	-	-	-	-	-	-	-	-	-	-
Sc	1 (12.5)	-	-	-	-	-	-	-	-	-
Si	-	1 (12.5)	1(12.5)	-	1(12.5)	-	2(25)	1(12.5)	-	1(12.5)
I	3(37.5)	3 (37.5)	4(50)	4(50)	3(37.5)	1(12.5)	3(37.5)	4(50)	4(50)	2(25)
B	2(25)	3 (37.5)	2(25)	2(25)	3(37.5)	-	-	-	-	-
Total						8(100)				

Q21: Twenty-First Question

Upon examining Table 14, most of the students had reached the correct answer post the implementation. The answers of P8, who gave the correct answer after the implementation, are given in Figure 15.

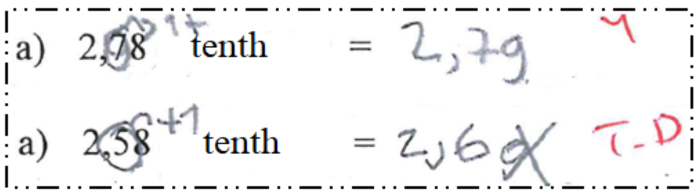


Figure 15. P8's answers to option a of question 21 before and after the implementation

As seen in Figure 15, before the implementation, the student knew the tenth digit to be rounded. However, the student reached the wrong answer by adding 1 to 8 in one digit. After the implementation, he reached the right answer.

In summary, when the results are evaluated, it is seen that the misconceptions were largely eliminated after the teaching based on concept cartoons based on the 5E model.

4. DISCUSSION and CONCLUSION

In this study, it was observed that with the 5E learning model enriched with DCCs, students' misconceptions regarding decimal notation, especially ranking, place value, addition–subtraction operation, marking numbers on the number line, and rounding on the number line, were largely eliminated. In this study, most of the students made mistakes or had misconceptions, especially in ordering. When the literature was examined, it was found that many researchers had found similar results. That is, they stated that students had errors or misconceptions in decimal notation (Kaya, 2015; Yılmaz, 2007). The most obvious misconception detected among the students is the misconception of "assuming that the longer number is bigger." After the implementation, most students were able to identify their mistakes. The following is the reason the teaching method using the 5E model is effective: While the use of concept cartoons helps identify students who have misconceptions, the 5E learning model enables them to realize their misconceptions based on their own experiences. Gökkurt-Özdemir (2019) stated that by using concept cartoons, teachers will not only get feedback about students' thoughts but also reveal any misunderstandings that they have (Gökkurt-Özdemir, 2019). They argued that students participated more actively in the lesson because the discussions created by concept cartoons provided an environment for students to express themselves. In addition, the 5E learning model has been effective in eliminating errors related to decimal notation, because in the 5E learning model, the learning individual compares the information received with their previous learning and examines and interprets the same to develop their own knowledge and information (Hanley, 1994). Considering the developmental characteristics of young children, it can be said that the 5E learning model enriched with concept cartoons is effective in teaching decimal notation, which is an abstract and difficult topic for students. The fact that Grade 6 students are in a transition period, i.e., from the concrete to abstract, two students are inclusive and the low socioeconomic level of the school where the students were studying reveals the importance of the selection of appropriate teaching methods for teaching mathematics. Considering some difficulties in the acquisition of mathematical concepts, it is an issue that should be emphasized in lesson plans suitable for inclusive students or students with low mathematics achievements. Understanding the importance of gaining mathematical knowledge and skills for daily life, mathematics teaching should be organized according to these students and presented in accordance with their requirements. The DCCs used in this study contained visual elements and were remarkable, and the 5E learning model gave students effective participation and problem-solving opportunities, thus helping in eliminating students' misconceptions. The 5E learning model entails remarkable activities and enables students to develop and learn concepts easily through implementations. Therefore, the fact that there are activities in addition to DCCs in the lesson plans prepared with the 5E learning model and the enrichment of these activities with materials has positively affected the learning of the students. Many researchers in the literature using the 5E model enriched with DCCs (Şahin, 2018; Yılmaz, 2018) or concept cartoons (Kaplan et al., 2014; Yürekli & Gökçek, 2019), Balım et al. (2008) and Korucu (2009) revealed that it has a positive effect on students' academic achievement, problem-solving skills, or attitudes.

One of the topics where misconceptions were eliminated was the addition–subtraction operations in decimal notation. The most common mistake committed by students is "putting the comma in the wrong place." This mistake has been largely corrected. While performing the addition–

subtraction operations, it was observed that some students reached the wrong results due to the operation error. Yorulmaz (2018) highlighted that students often make a mistake in subtraction (Yorulmaz, 2018). When the results regarding the multiplication–division operations were examined, it was found that compared to other topics, the 5E learning model is not effective in eliminating misconceptions on the abovementioned topic. In this study, it was found that students experienced more difficulties performing the multiplication process compared to the addition and subtraction process. The fact that the students expressed their negative attitudes or difficulties in the interviews supports this explanation. Because of the difficulties that students faced with multiplication (Üçüncü, 2010), course plans prepared to address their misconceptions in the multiplication process are not considered effective. Similarly, the complex nature of the division process did not allow misconceptions to be eliminated. Usta's (2018) statement that students who cannot multiply also have difficulty in division supports this result. Hence, the multiplication operation is a prerequisite for the division operation. The misconception evident in the multiplication–division process is the error that "multiplication always increases the result; division always makes it smaller." Yavuz-Mumcu (2015) found that students make the same mistake. After the implementation, very few students realized this error. Another result of the study is that students have misconceptions before the implementation while showing the decimal notations on the number line. In the beginning, it was observed that the students had problems in converting decimals to fractions and could not establish a relationship between the numerator and denominator. After the implementation, it was noticed that while students showed the fraction on the number line, they drew a line between 0 and 1 as much as the denominator in the given fraction. It is possible to find studies that report the same mistake in the literature (Karaoglan-Yılmaz, Gökkurt-Özdemir, & Yasar, 2018). It was observed that the 5E learning model was effective in eliminating this error after the implementation. Another consequence of the study is that in decimal notation, students struggle to solve problems. The reason for their failure was revealed through interviews with students. Most students stated that they did not try to solve the problems asked for in the interviews as they did not understand them. It was understood that students who solved the problem incorrectly did not understand the question and therefore did so incorrectly. Upon examining the literature, many studies revealed that students have difficulty in understanding the content of mathematical problems (Gökkurt, Örnek, Hayat & Soylu, 2015; Sezgin-Memnun, 2015). The reason the 5E learning model is not effective in this regard, at the expected level, could be insufficient activities focusing on problem-solving steps in lesson plans. In this study, with the 5E learning model enriched with DCCs, students' misconceptions about most issues related to decimal notation were eliminated. Researchers are recommended to use this model in eliminating students' misconceptions in other mathematics-related topics. This study is action research, and it is limited to eight students. Thus, it is recommended that future studies examine the effect of this method on student achievement using quantitative methods on larger samples.

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Ethics Committee Decision

This research was carried out with the permission of Bartın University Publication Ethics Board with the decision numbered 2019/013 dated 28.01.2019.

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APPENDIX

A1. *Lesson plan example*

Subject: Math
Class: Grade 6
Learning area: Numbers and Operations
Time: 2 lesson hours
Achievements regarding the misconceptions that students have about decimal notation
M.5.1.5.3. Understands the relationship between the whole part and the value of the decimal place in decimal notation.
M.5.1.5.4. Writes and reads the decimal notation of fractions that can be expanded or simplified to a denominator of 10, 100, or 1000.
M.6.1.6.2. Decimal notation decodes the given numbers.
Examples of the misconception's students have
Thinking of the part after the comma as an integer, wrong cascading, consider the decimal part as a numerator, the full part as a denominator, ignoring the zero after the comma, incorrect cascading after the comma, incorrect naming the decimal notation, thinking the comma as a separator, thinking the part after the comma as a whole number, incorrect naming, inability to name the digits in the decimal notation part correctly, and using the concept of digits instead of the concept of place value.
Enter
First, students are asked who has the task of going from home to the grocery store. A scenario is presented to one of the students who have undertaken this task: They are asked if they go to the market and buy chocolate for 1.5 TL, how many 25 kurus they should give. When this student answers, their friends are also asked to calculate, and the results are compared. When comparing these results, attention is drawn to how many 25 kurus they used to get 1 TL.
Exploration
Students generally ignore zero after the comma. Students are presented with an activity to explore the values of the digits after the comma. Students are expected to create their information by giving two different decimal notations like each other at the same time.

Activity Let's analyze the decimal notation 0.50 with events. a) Students are asked to convert the given decimal notation to a fraction. 0.50 = $\frac{50}{100}$ A table of 100 and a table of 1000 are distributed to students who have converted both. They are asked to paint both fractions. The students who finish the painting are asked the difference between these two cards and whether they are equal. Students are expected to discover that two fraction numbers are different from each other. Students are asked to simplify these two fractions so that they can be written with a different decimal notation. b)$\frac{50}{100}$ simplifying the fraction number. $\frac{50:10}{100:10} = \frac{5}{10}$ You are asked how many unit fractions this simplified fraction number is equal to. c)writing $\frac{5}{10}$ fraction as $\frac{1}{10}$ or 0.1 written as $\frac{5}{10}$ = 5 units$\frac{1}{10}$ or 0.1 From here; As a result of simplification; $\frac{5}{10}$ = 0.5 = 5 deciles are obtained. The students are asked whether 5 deciles are equal to the initial decimal notation. At this stage, students are expected to realize that the value of the fraction does not change as a result of simplification and that the decimal notation given at the beginning is equal to 5 deciles. e) They are asked to write how the fraction is read in the last state. $\frac{5}{10}$ = five-tenths or five divided by ten f) They are asked to write the reading of the decimal notation in the last state. 0.5 = zero whole five-tenths	Let's analyze the decimal notation 0.050 with events. a) Students are asked to convert the given decimal notation to a fraction. 0.050 = $\frac{50}{1000}$ A table of 100 and a table of 1000 are distributed to students who have converted both. They are asked to paint both fractions. The students who finish the painting are asked the difference between these two cards and whether they are equal. Students are expected to discover that two fraction numbers are different from each other. Students are asked to simplify these two fractions so that they can be written with a different decimal notation. b)$\frac{50}{1000}$ simplifying the fraction number. $\frac{50:10}{1000:10} = \frac{5}{100}$ You are asked how many unit fractions this simplified fraction number is equal to. c)writing $\frac{5}{10}$ fraction as $\frac{1}{10}$ or 0.1 written as $\frac{5}{100}$ = 5 units$\frac{1}{100}$ or 0.01 From here; As a result of simplification; $\frac{5}{100}$ = 0.05 = 5 centesimals are obtained. The students are asked whether 5 centesimal are equal to the initial decimal notation. At this stage, students are expected to realize that the value of the fraction does not change as a result of simplification and that the decimal notation given at the beginning is equal to 5 centesimal. e) They are asked to write how the fraction is read in the last state. $\frac{5}{100}$ = five percent or five divided by one hundred f) They are asked to write the reading of the decimal notation in the last state. 0.05 = zero whole five percent

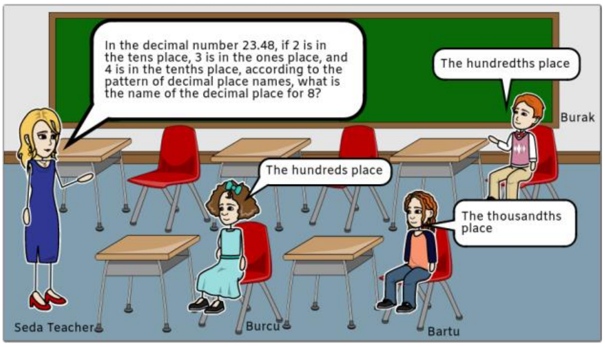
With this activity, students discovered the value of zero after the comma. At the same time, they are expected to consolidate the information they already know (when the fraction number is simplified and expanded, its value does not change). The reading of decimal notation is discovered with students who know how to read the fraction number.

Explanation
The teacher asks the students to express the information they have learned as a result of the activity in one sentence. The teacher expresses the information in a scientific language.

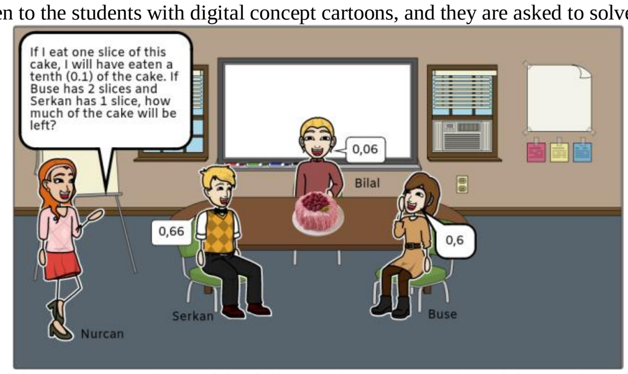
Information box
Decimal notations are a different notation where fractions are expressed using commas.
Fractions with denominators 10, 100, 1000 can be expressed as decimal notation.
The comma separates the decimal notation from the whole and into smaller parts (the decimal).
Sample:
While a fraction is written as decimal notation, if the denominator of the fraction is 10, the decimal part is one digit, if 100, the decimal part is two digits, and if the decimal part is 1000, the decimal part is written with three digits.
While reading decimal notation
First, the number in the whole part is read, and then the "full" expression is used. The number in the fraction is read after using the expression "tenths" if the decimal part is one digit, "percent" if it has two digits, and "per thousand" if it has three digits.

87,236					
Full part			**Decimal Part/Fraction Part**		
Number value	8	7	2nd	3	6
Place value	80	7	0.2	0.03	0.006
Digit names	Ten's digit	One's digit	Tenths digit	One-hundredths digit	The ones in a thousand digit

Considering this information, the decimal representation of 87,236 is analyzed with students.
Decimal Notation Analysis
Eloboration
The teacher asks a question prepared with a digital concept cartoon to the students to use the solutions they have discovered and learned in different problem situations.



Students are given time to solve the question individually. The students are asked who gave the correct answer. They are expected to reach the correct result by creating a discussion environment in the classroom.
Evaluation
At this stage, a problem is given to the students with digital concept cartoons, and they are asked to solve the questions.



1) Let's expand it and simplify it to make the denominator 10, 100, or 1000 into decimal notation.

a) $\frac{3}{5}$

b) $\frac{7}{20}$

c) $\frac{48}{100}$

d) $1\frac{113}{250}$

e) $5\frac{135}{500}$

2) Which of the following is the expression of the number "five hundred thousand 32 whole one percent" in numbers?
a) 532,01
b) 50032,01
c) 500032,01
d) 5000032,01

3) In decimal notation 36,145 what digit is the number 4?
a) In the hundreds
b) In tenths digit
c) In hundredths
d) thousandths digit

4) Which of the following analyzes is correct?
a) $0,205 = \frac{2}{10} + \frac{5}{100}$
b) 5.14 = (5 x 1) + (4 x 0.1) + (1 x 0.001)
c) $20.67 = (2 \times 10) + (6 \times \frac{1}{10}) + (7 \times \frac{1}{100})$
d) $3,089 = (3 \times 1) + (8 \times \frac{1}{10}) + (9 \times \frac{1}{100})$

883