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How Concept Cartoons-Supported 5E Model Affects Mathematics Performance and Motivation of Secondary School Students

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Abstract

This study investigates how the concept cartoons-supported 5E model affects secondary school students' mathematics performance and motivation. A pre-and post-test design with a control group (CG) and experimental group (EG), a quasi-experimental quantitative method, was employed in the study. The participants of the study were 7th-grade students of a public secondary school in the Western Black Sea region in the academic year 2021-2022. EG had 16 students, and CG had 18. Concept cartoons prepared according to the 5E learning model were used in EG. On the other hand, CG was instructed according to the curriculum, and there was no concept cartoons-supported exercise. In the study, the 20-question multiple-choice Mathematic Achievement Test prepared by Özkan (2019) and the Mathematics Motivation Scale developed by Üzel et al. were administered to the groups twice as a pre-test and post-test. Mann-Whitney U and Wilcoxon signed-rank tests were employed in the data analysis. As a result of the study, no significant differences were found between EG and CG regarding "mathematics performance" and "mathematics motivation" variables. Several suggestions were made based on study results.

Keywords: 5E Learning Model, concept cartoons, mathematics achievement, motivation, ratio/proportion

Kavram Karikatürleri Destekli 5E Modelinin Ortaokul Öğrencilerinin Matematik Başarılarına ve Motivasyonlarına Etkisi

Öz

Bu araştırmanın amacı kavram karikatürleri destekli 5E öğrenme modelinin ortaokul öğrencilerinin matematik başarılarına ve matematiksel motivasyonlarına etkisini incelemektir. Araştırmada nicel araştırma yöntemlerinden ön test-son test kontrol gruplu yarı deneysel desen kullanılmıştır. Araştırmanın örneklemi 2021-2022 öğretim yılında Batı Karadeniz Bölgesinin bir il merkezinde bulunan resmi bir devlet ortaokulunun 7. sınıf öğrencilerinden oluşmaktadır. Deney grubunda 16, kontrol grubunda 18 öğrenci bulunmaktadır. Deney grubuna 5E öğrenme modeline göre hazırlanan kavram karikatürleri uygulanmıştır. Kontrol grubuna ise öğretim programında belirtilen şekilde uygulama gerçekleştirilmiş olup kavram karikatürlerinin kullanıldığı herhangi bir uygulama yapılmamıştır. Araştırmada Özkan (2019) tarafından hazırlanan 20 soruluk çoktan seçmeli matematik başarı testi ve Üzel ve diğerleri (2018) tarafından geliştirilen matematiksel motivasyon ölçeği kullanılmış olup gruplara ön-son test olmak üzere 2 kez uygulanmıştır. Verilerin analizinde Mann Whitney U testi ve Wilcoxon işaretli sıralama testi kullanılmıştır. Araştırma sonucunda matematik başarısı ve matematiksel motivasyon değişkenleri açısından deney ve kontrol grupları arasında anlamlı bir fark bulunmamıştır. Ayrıca matematik başarı testi ve matematiksel motivasyon ölçeğinden alınan puanlar arasında korelasyon analizi yapılmış ve iki grup arasında anlamlı bir farkın olmadığı görülmüştür. Araştırma sonuçlarına dayalı olarak çeşitli önerilerde bulunulmuştur.

Anahtar kelimeler: 5E öğrenme modeli, kavram karikatürü, matematik başarısı, motivasyon, oran-orantı

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INTRODUCTION

Currently, the methods of the constructivist approach, which involves students taking an active role, are used in teaching (Asan & Güneş, 2000). The constructivist approach is based on students' independent and self-directed learning under the teacher's guidance and structuring the knowledge in mind (Büyükkarcı, 2019). The constructivist approach encourages children to structure knowledge in their minds into something that carries meaning. Students satisfy their curiosity by asking questions about the things that pique their interest and engage in the scientific method through open-ended inquiry (Martin, 2000). Today's information and technology societies need teaching methods, techniques, and approaches that aim to raise individuals who can develop solutions to problems, who can reason, and who have the ability to think freely without rote learning (Ünal, 2003). Among these, the 5E Learning Model has an important place. The 5E Learning Model is a five-stage model developed by Rodger Bybee, namely, Enter, Explore, Explain, Elaborate, and Evaluate (Bybee, 2002). Most of the studies conducted in Turkey on the 5E model are concentrated in natural sciences (Hiçcan, 2008).

Fish (1999) states that the 5E learning model significantly improves learning, increases retention in concept learning, develops positive attitudes toward science, enhances the ability to make comparisons, and improves scientific process skills (as cited in Bıyıklı, 2013). Studies using concept cartoons-supported 5E learning models have attracted attention in recent years. They showed that concept cartoons teach concepts effectively and eliminate misconceptions about science. Taşlıdere (2021) conducted a study examining the 5E learning model with concept cartoons in natural science education. In this study, he showed that using concept cartoons with enriched conceptual change texts effectively increased conceptual understanding and reduced misconceptions. According to Çetinkaya et al. (2022), using concept cartoons based on multicultural education in natural science education is an effective educational tool for increasing students' academic performance. Webb et al. (2008) found that concept cartoons can be used in natural science lessons to initiate and enrich classroom discussions. They created a conceptual framework that facilitates the discussion process, making this framework available to students by relating it to concept cartoons. The study's results showed that such an approach improved students' reasoning processes.

Regarding the studies on the 5E learning model, especially those in which concept cartoons support this model, most focus on natural sciences, and the number of studies addressing mathematics and geometry is limited (Yılmaz, 2018). Mathematics education aims to develop students' understanding of mathematics concepts and the ability to make connections between them (Van de Walle et al., 2012). Students must be provided with appropriate learning settings and opportunities to achieve this. Students' failure to construct meaning can lead to various difficulties and misconceptions in learning (Özmantar et al., 2008). Considering this situation and the perception that the mathematics course is challenging, it should be made enjoyable and understandable. Conceptual teaching can be realized with students' active participation in the learning process. One of the ways to do this is to use concept cartoons in mathematics teaching, which have been used in recent years, especially in natural science lessons. Concept cartoons help students develop different ideas and encourage them to research by relating things to their prior knowledge (Kılınç, 2008). Kabapınar (2005) defines concept cartoons as the pictorial illustration of the discussion of three or more characters on a topic. Concept cartoons have many benefits (Dabell, 2004), including revealing students' prior knowledge and ideas, making them critically approach thoughts, letting them develop alternative perspectives, increasing interest and motivation towards the course, enabling them to make self-criticism by creating a discussion environment, developing the skill of advocating their ideas and self-expression, initiating and maintaining discussions, and overcoming misconceptions. A concept cartoon is a method for teaching a concept; it prevents misunderstandings and conveys a scenario through characters (Yurtyapan et al., 2017). Concept cartoons are used to question and criticize knowledge, create discussions, and reach a conclusion by structuring the knowledge (Ören, 2009). Concept cartoons can be used to reveal students' misunderstandings and misconceptions. A teacher who knows his/her students' misconceptions helps them create discussions and scientific research to get detailed information about the concepts using concept cartoons. This way, learning can be maximized, and misconceptions can be corrected (Creswell, 2003).

According to Çelik and Gündoğdu (2016), using concept cartoons in IT courses increases student performance. It ensures retention of what has been learned. Gomez (2014) argues that cartoons, caricatures, and comics are essential tools for developing learning and creativity, making learning enjoyable, and encouraging students to think outside the box. Çil (2014) states that using conceptual change texts supported by concept cartoons significantly affects the development of primary school students' views about the nature of science. Concept cartoons provide students with different perspectives. Students are allowed to defend their views using practical reasoning. These features and the learning environment created by concept cartoons, which are very effective in initiating discussions, also facilitate student evaluation (Çil, 2014). Atasoy et al. (2020) emphasized that concept cartoons in school hallways effectively improved pre-service teachers' perceptions of informal physics learning, promoted scientific literacy, created an alternative learning environment, and helped them overcome prejudices towards physics courses. Aydın (2015) found that using computer-based concept cartoons positively affected 7th-grade students' light pollution awareness. Özmen et al. (2012) found that laboratory activities enriched with concept cartoons effectively explained acid-base concepts and captured students' attention. Similarly, Balım et al. (2014) took the views of science and technology teachers on implementing a problem-based and concept cartoons-supported learning approach. They found that concept cartoons effectively encourage students' participation in the lesson, create an environment for discussion, and ensure learning retention because they contain visual elements and capture students' interest. Meriç (2014) stated that concept cartoons in science and technology classes have a positive impact on secondary school students' conceptual understanding and motivation related to academic performance and are effective in identifying misconceptions. On the other hand, Meriç (2014) stated in the same study that the groups did not significantly differ according to the use of concept cartoons regarding students' motivation toward research, communication, collaboration, and participation. Similarly, Atasayar Yamık (2015) concluded that concept cartoons did not significantly increase students' motivation to learn natural sciences. Teaching methods supported by concept cartoons, which are more common in natural science, can also be used in mathematics teaching. Concept cartoons can be used in teaching concepts and developing various skills, such as mathematical reasoning and problem-solving.

Research shows that mathematics is one of the most challenging subjects for students to understand and perform. The fact that the mathematics courses are relatively abstract compared to other courses and that young students encounter this class for the first time makes it difficult for them to comprehend. Therefore, using concept cartoons is an excellent way to make mathematics more enjoyable and retain what is learned. (Batdal Karaduman & Elgün Ceviz, 2018). Studies on using concept cartoons in mathematics education have intensified recently (Aygün et al., 2020; Pekel, 2021; Yılmaz, 2018; Yürekli, 2020). However, their number is still low compared to the ones in natural sciences. Dereli (2008) conducted studies on integers, Erdağ (2011) on decimal fractions, Göksu and Köksal (2016) on lines, angles, and polygons, Korucu (2009) on polygons, and Yılmaz (2018) on area and land measurements. Şengül (2011) reported that concept cartoons significantly affected secondary school students' perceived self-efficacy in mathematics, Kaplan et al. (2014) reported that concept cartoons were effective in resolving misconceptions encountered in square roots, and Karahan and Çağanağa (2017) reported that concept cartoons made concepts approachable and increased interest in geometry classes. Göksu and Köksal (2016) emphasized that applying constructivist teaching approaches with concept cartoons in geometry lessons improved students' problem-solving skills, and they could demonstrate what they had learned in performance tasks. The study also concluded that concept cartoons-supported lessons contributed to the development of students' affective, social, and cognitive characteristics through results obtained from interviews with students.

Marques et al. (2023) conducted a concept cartoons-supported STEM experience in a mathematics class with 10th-grade students. The study results showed that the cartoons effectively helped students to learn new concepts in STEM domains. The same study suggested that concept cartoons have pedagogical potential to promote the STEM approach and can be considered an innovative communication source. Pekel (2021) examined how usual and argumentation-based concept cartoons affected students' performance and found a significant difference in favor of the experimental groups. He revealed that the academic performance of the group using argumentation-based concept cartoons was higher than that of the group using usual ones. Aygün et al. (2020) found that applications with concept cartoons contributed positively to students' use of mathematics terms, symbols, and concepts, and using concept cartoons in learning environments is beneficial. In her study on identifying and eliminating misconceptions of secondary school students about integers using concept cartoons, Yürekli (2020) found that concept cartoons partially eliminated misconceptions. On the other hand, based on her observations, she found that concept cartoons increased students' motivation and positively affected their interest in mathematics. Students' motivation is as important as the methods and techniques used in learning. Studies (Glynn et al., 2005; Palmer, 2007) have shown that motivation influences learning. Motivation is the degree of continuity in an individual's attempt to take action and realize his/her goal (Adler et al., 2001). İspir et al. (2007)

defined mathematics motivation as students' active participation in mathematics and willingness to learn. Regarding Palmer (2007), highly motivated students are happy, attentive, and aware of their tasks and responsibilities.

In separate studies conducted with a quasi-experimental model, Yağıcı (2019) and Batdal Karaduman and Elgün Ceviz (2018) reported that effective use of concept cartoons increased 3rd & 4th-grade primary school students' mathematics performance. Yılmaz (2018) found that EG's mathematics performance, in which the concept cartoons-supported 5E model was used, was significantly higher than CG's mathematics performance, in which the instruction was made within the scope of the curriculum. Katipoğlu (2016) used entertaining and humorous cartoons to teach natural numbers to 6th-grade students, concluding that they effectively increased students' mathematics performance. Kaplan and Öztürk (2015) found that using concept cartoons in teaching divisibility and prime numbers to secondary school students increased their mathematics performance. Samkova (2018) stated that concept cartoons were more effective than written texts in eliminating misconceptions about fractions. Regarding secondary school students' mathematics performance, Önal and Çilingir Altiner (2022) found a significant difference between EG and CG, in which concept cartoons and the classical approach were used, respectively. On the other hand, Gökkurt Özdemir et al. (2021) conducted a mixed-methods study using concept cartoons to eliminate misconceptions among secondary school students in mathematics courses. There was no significant difference between groups in eliminating misconceptions. However, qualitative findings indicated that using concept cartoons in mathematics courses made the lesson entertaining; the cartoons captured attention, increased interest in the class, and allowed the visualization of the topics. Güler (2010) used concept cartoons in teaching natural numbers and found that using concept cartoons did not affect 6th-grade students' mathematics performance. Similarly, Korucu (2009) compared the impact of cartoons-used and computer-assisted instruction methods on students' mathematics performance while teaching polygons. The groups did not significantly differ regarding students' mathematics performance.

The feature distinguishing this study from the others in the literature is using a concept cartoons-supported 5E learning model in ratio/proportion teaching. The concept of ratio and the ability to think proportionally are present in every aspect of life. The concept of ratio is mentioned in the relationship between the amount of water and other substances in the human body, the amount of oxygen and hydrogen in the air, and the relationship between force and mass. The concepts of ratio, proportion, and proportional thinking form the basis of many natural science and mathematics concepts (Karagöz Akar, 2010). Therefore, it is crucial to understand this topic. Thompson and Thompson (1994) defined the concept of ratio as "a measurement obtained as a result of the multiplicative comparison of two multiplicities belonging to different measurement spaces." The concept of proportion has been defined by Lamon (1995) as "the equality of two ratios showing the same relationship" (as cited in Karagöz Akar, 2010). The concept of ratio/proportion in mathematics is the basis of many subjects. Most topics in the mathematics curriculum (MoNE, 2018), such as motion problems, measurement, fractions, probability, percentages, and similarity, are related to ratio/proportion. Secondary school students' mathematics skills related to ratio/proportion affect their success in other courses. Therefore, it is crucial to explore students' level of associativity in ratio/proportion topics (Yakar, 2020). MoNE (2005, 2009) states that the concept of proportion in mathematics curricula should not only be considered as equalizing two ratios or finding the term that is not given; it also includes recognizing proportional quantities and multiple representations of relationships between quantities as numbers, tables, graphs, and equations. In addition, these curricula also include statements that proportion is an essential tool for integrating many basic mathematics concepts and that students use proportion in some linear equations, scales, and finding the ratio of circumference to diameter. Therefore, this study is significant in using concept cartoons in mathematics education and visualizing the topic of ratio/proportion through concept cartoons. In this study, the topic of ratio/proportion was illustrated through concept cartoons and made attractive to students. No study was conducted with 7th-grade students using concept cartoons-supported 5E model on ratio/proportion in the relevant literature. Based on the thought that using different methods in teaching mathematics, in which students are active and learn by having fun, is essential, this study aims to investigate how concept cartoons-supported 5E model in teaching ratio/proportion topics affects students' performance and motivation. In addition, it is hoped that the concept cartoons, the teaching materials proposed in this study, would be used by students, pre-service teachers, and teachers. In this regard, this study contributed to the relevant literature in this context.

This study focuses on the effect of teaching ratio/proportion using the concept cartoons-supported 5E model on 7th-grade secondary school students' mathematics performance and mathematics motivation.

Research Problem

How does using the concept cartoons-supported 5E model in teaching ratio/proportion topics affect the mathematics performance and motivation of 7th-grade students?

Sub-problems of the study:

1.Is there a statistically significant difference between the MAT scores of EG taught with the concept cartoons-supported 5E model and that of CG taught according to the current curriculum (MoNE, 2018)?

2.Is there a statistically significant difference between the MMS scores of the EG taught with the concept cartoons-supported 5E model and that of the CG taught according to the current curriculum (MoNE, 2018)?

3.Is there a statistically significant difference between the MAT and MMS scores of EG taught with the concept cartoons-supported 5E model?

4.Is there a statistically significant difference between the MAT and MMS scores of CG, taught according to the current curriculum (MoNE, 2018),

5.Is there a significant relationship between EG's and CG's MAT and MMS scores?

METHOD

Research Design

This study used a pretest-posttest quasi-experimental model with a CG. In this model, measurements are made before and after the application (Büyüköztürk et al., 2013). This method was chosen because the study examined the effect of lesson plans and activities prepared according to the concept cartoons-supported 5E model on students' mathematics performance and motivation. The study included experimental and control groups, intra-group (experimental-control), and in-group (pretest-posttest) measurements. The groups' mathematics performance and motivation were measured twice, before and after the application, using the same tools. The independent variable was implementing the concept cartoons-supported 5E model, and the dependent variable was students' mathematics performance and motivation. The study design is displayed in Table 1.

Table 1. Study Design

		Pre-Test			Post-Test	
	N	Mathematics Performance	Mathematics Motivation Scale	Operation	Mathematics Performance	Mathematics Motivation Scale
EG	16			Teaching with Concept Cartoons-supported 5E Learning Model		
CG	18			Teaching according to the Current Curriculum		

Study Group

The study was conducted with 7th-grade students at a public secondary school located in the Western Black Sea region, with similar socio-economic levels, in the academic year 2021-2022. EG and CG were randomly selected from two equivalent 7th-grade classes. 16 students (7 girls, 9 boys) in EG and 18 students (10 girls, 8 boys) in CG participated in the study. Both groups were instructed within the gains framework in the 7th-grade mathematics course, the "ratio/proportion" sub-learning area of the "numbers and operations" learning area. In EG, lesson plans and activities were prepared according to the concept cartoons-supported 5E model. In CG, only the activities of the mathematics curriculum (MoNE, 2018) were taught, and no other application took place. The analysis of EG and CG students' mathematics performance and motivation pre-test scores showed that the two groups were initially equivalent in mathematics performance and motivation.

Data Collection Tools

The Mathematics Achievement Test and the Mathematics Motivation Scale were used as data collection tools.

Mathematics Achievement Test (MAT)

In this study, 20-question MAT developed by Özkan (2019), with tested validity and reliability, was used to measure students' mathematics performance. This test was prepared to measure 7th-grade students' mathematics performance in ratio/proportion, and the reliability coefficient was 0.82. It was administered twice to both groups, once before and once after the application. MAT is given in Appendix 1.

Mathematics Motivation Scale (MMS)

MMS was developed by Üzel et al. (2018) for secondary school students; its Cronbach's alpha reliability coefficient was 0.88. It was used in this study to measure the mathematics motivation of the students. The scale consists of 26 items, 8 negative and 18 positives. The highest and lowest scores that can be obtained are 98 and 58, respectively. Higher scores mean higher student motivation toward the mathematics course. The scale was administered twice to the groups, before and after the application. MMS is given in Appendix 2.

Lesson Plans and Activities Prepared According to Concept Cartoons-supported 5E Learning Model

After getting expert opinions, the researchers developed lesson plans and activities related to ratio/proportion. The gains of the 7th-grade ratio/proportion topic in the mathematics curriculum (MoNE, 2018) and the names of the concept cartoons used in EG are given in Table 2. The lesson plans and activities used in EG were prepared within the scope of these gains.

Table 2. Name of the Concept Cartoons Used in EG and Related Gains

Concept Cartoon/Activity	Learning Outcome
Grocery Shopping	Determines the value of one of the multiplicities in the ratio if the other is 1.
The Mona Lisa painting	If the ratio of one of two given multiplicities is given, finds the other.
Oven	Analyses real-life situations and decides whether two multiplicities are proportional.
Aquarium-Fish	Expresses the relationship between two directly proportional multiplicities.
Tea Glass	Determines and interprets the ratio between two multiplicities that are directly proportional to each other.
Cargo Vehicle Wheel Size and Rotation Rate	Analyzes real-life situations and decides whether two multiplicities are inversely proportional.
Lemonade Recipes	Solves direct and inverse proportion problems.

The 5E learning model consists of five stages: Engage, Explore, Explain, Elaborate, and Evaluate. As per the name, engagement is about getting students interested in the lesson. In the exploration stage, students make predictions and test them. At this stage, the teacher acts as a guide. He/she asks questions and provides clues to help students identify incorrect or incomplete answers. Students are allowed to generate answers by using blank answer bubbles above the characters in the cartoon. Then, a discussion environment is established by allowing them to compare their answers with the answers of the characters in the cartoon. The Explanation stage is where the teacher gives explanations and information about the subject after getting students' own explanations. In the Elaboration stage, students apply their learnings to new events and problems. At this stage, it is critical to create a discussion environment, share ideas, and expect students to advocate their ideas. Finally, in the Evaluation stage, the teacher makes an assessment based on students' answers and his/her observations. One of the lessons plans prepared using the concept cartoons-supported 5E model is given in Appendix 3 as an example. This lesson plan was prepared according to the learning outcome of the ratio/proportion topic: "If the ratio of one of two given multiplicities is given, find the other."

Experimental Study Process

In the study, including EG and CG, one of the researchers taught EG, and the current mathematics teacher taught CG. The same teacher has taught mathematics to EG and CG for a long time. This feature was critical, ensuring that the study results were not biased. As the study started, one of the researchers taught EG. In contrast, CG was taught by the usual mathematics teacher. MAT and MMS were administered twice as s to both groups and completed in 4 classroom hours. Apart from the tests, both groups were taught for 18 course hours. The concept cartoons-supported 5E model was instructed to EG, and the current curriculum was taught to CG. The current mathematics curriculum (MoNE, 2018) recommends using teaching methods and techniques based on the constructivist approach, such as the explanatory lecture method (Ausubel, 2000; Ausubel & Robinson, 1969), mathematical activities, and problem-solving; thus, CG was taught accordingly. The researcher attended CG's lessons as an observer. The activities prepared using concept cartoons according to the 5E learning model were projected using a Smart Board in the classroom. Cartoons' print-outs were distributed to students. A total of 35 concept cartoons were prepared to use at each stage of the model. Researchers generated concept cartoons on the Canva program, a free educational program used by teachers and students worldwide (https://www.canva.com/tr_tr/). They prepared concept cartoons using cartoon templates consistent with their objectives. During the preparation of the cartoons, attention was paid to possible copyright infringements and the features a concept cartoon should have. The prepared concept cartoons were presented to the experts, errors such as spelling mistakes and insufficient font size were corrected, and the cartoons were finalized. Photos from the implementation in EG are shown in Figure 1.

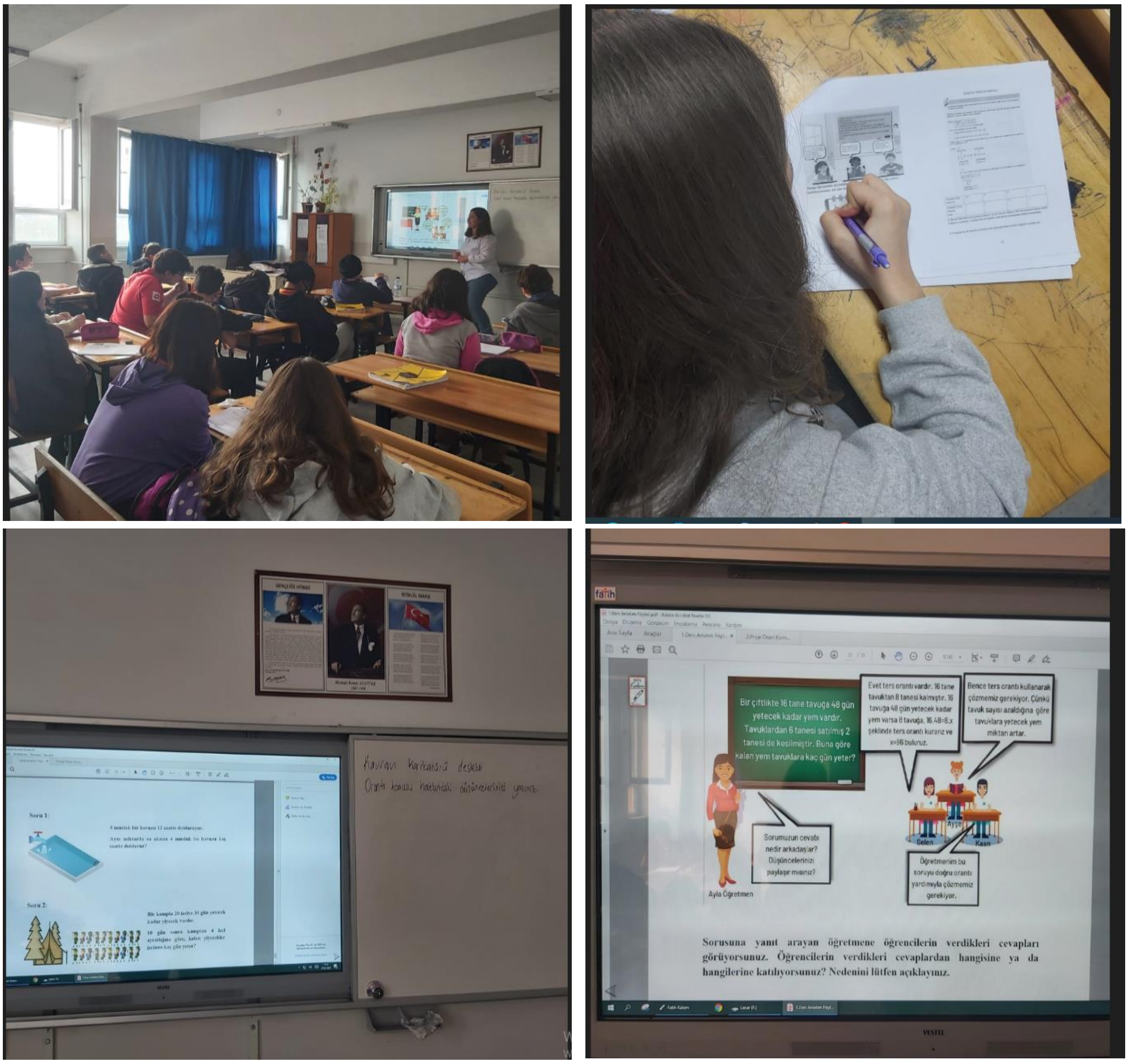

Figure 1. *Photos from the Implementation in EG*

Data Analysis

Analysis of Data Obtained from MAT and MMS

The data obtained from MAT and MMS administered to EG and CG before and after the implementation were analyzed using quantitative methods, using SPSS 22.00. Nonparametric methods should be employed in small samples to analyze the data instead of parametric methods. The sample size of this study was insufficient for parametric analysis (n<30); nonparametric tests - Mann-Whitney U-test and Wilcoxon Signed Ranks Test - were used without checking normal distribution. (Büyüköztürk, 2011, 2019).

Correlation analysis was conducted to describe the relationship between MAT and MMS. Since the normality assumption was not satisfied due to the low number of students, Spearman-Brown Rank Difference correlation analysis was employed (Büyüköztürk, 2019). Here, a correlation coefficient between 0.00 and 0.25 indicates a very weak relationship between variables, 0.26 and 0.49 indicates a weak relationship and a correlation coefficient between 0.50 and 0.69 indicates a moderate relationship (Kalaycı, 2010).

Research Ethics

This research has ethics committee permission, which was obtained by the decision of Bartın University Social and Human Sciences Ethics Committee with protocol number 2022-SBB-0278, dated 14.06.2022 and numbered E-23688910-050.01.04-2200055837.

FINDINGS

Descriptive Statistics

The descriptive statistics of this study are shown on Table 3.

Table 3. Descriptive Statistics of EG and CG

Groups	Test	$\bar{X}$	sd	Shapiro-Wilk (p)
CG (N=18)	MAT Pre-Test	7.28	2.421	.314
	MAT Post-Test	14.89	2.587	.067
	MMS Pre-Test	82.11	4.825	.846
	MMS Post-Test	86.06	7.432	.814
EG (N=16)	MAT Pre-Test	6.81	1.328	.211
	MAT Post-Test	15.19	1.797	.245
	MMS Pre-Test	78.56	10.482	.087
	MMS Post-Test	84.50	5.099	.306

Table 3 shows that EG's mean MAT post-test scores ($\bar{X}$ =15,19) were higher than pre-test scores ($\bar{X}$ =6,81), and CG's mean post-test scores of ($\bar{X}$ =14,89) were higher than pre-test scores ($\bar{X}$ =7,28). Similarly, EG's mean MMS post-test scores ($\bar{X}$ =84,50) were higher than pre-test scores ($\bar{X}$ =78,56), and CG's mean MMS post-test scores ($\bar{X}$ =86,06) were higher than pre-test scores ($\bar{X}$ =82,11).

Findings Related to the Mathematics Performance Sub-problems of the Study and Interpretation

The first sub-problem of the study, "Is there a statistically significant difference between the MAT scores of EG taught with the concept cartoons-supported 5E model and that of CG taught according to the current curriculum (MoNE, 2018)?" was addressed by comparing EG's and CG's MAT pre-and post-test scores.

MAT Pre-Test Scores of EG and CG

The results of the Mann-Whitney U-test for the difference between EG's and CG's MAT pre-test scores are shown in Table 4.

Table 4. Mann-Whitney U-Test Results for EG's and CG's MAT Pre-test Scores

Group	N	Mean Rank	Sum of Ranks	U	p
EG	16	16.19	259.00	123.00	.461
CG	18	18.67	336.00		

Table 4 shows no significant difference between EG's and CG's pre-test scores (U= 123.00, p>.05), indicating that CG and EG were equivalent in mathematics performance before the implementation.

MAT Post-Test Scores of EG and CG

The results of the Mann-Whitney U-test for the difference between EG's and CG's MAT post-test scores are shown in Table 5.

Table 5. Mann-Whitney U-Test Results for EG's and CG's MAT Post-test Scores

Group	N	Mean Rank	Sum of Ranks	U	p
EG	16	17.34	277.50	141.500	.930
CG	18	17.64	317.50		

According to Table 5, at the end of the 4-week experimental study, there was no significant difference between EG and CG students' mathematics performance (U=141.500, p>.05). Regarding mean ranks, CG students' mathematics performance is higher than that of EG students. Accordingly, implementing the concept cartoons-supported 5E model did not cause a significantly higher increase in EG students' mathematics performance. Tables 4 and 5 together show that using the concept cartoons-supported 5E model and the explanatory lecture method did not create a significant difference between EG and CG in mathematics performance.

Wilcoxon Signed Rank Test Results of EG and CG's MAT Pre-and Post-test Scores

EG's MAT scores were compared using the Wilcoxon signed rank test for the first sub-problem of the study, "Is there a statistically significant difference between the MAT scores of the EG taught with the concept cartoons-supported 5E model and that of CG taught according to the current curriculum (MoNE, 2018)?" The results are given in Table 6.

Table 6. Wilcoxon Signed Rank Test Results for EG's MAT Scores

Pre-Test-Post Test	N	Mean Rank	Sum of Ranks	z	p
Negative rank	0	.00	.00	3.526*	.000
Positive rank	16	8.50	136.00		
Equal	0				

*: Based on negative ranks

According to Table 6, the difference between EG's scores obtained before and after the experimental process was significant (z=3.526, p<.05) and is in favor of the post-test. Accordingly, the implementation of the concept cartoons-supported 5E model significantly improved EG students' mathematics performance.

CG's MAT scores were compared using the Wilcoxon signed rank test for the first sub-problem of the study, "Is there a statistically significant difference between the MAT scores of EG taught with the concept cartoons-supported 5E model and that of CG taught according to the current curriculum (MoNE, 2018)?" The results are shown in Table 7.

Table 7. Wilcoxon Signed Rank Test Results for CG's MAT Scores

Pre-Test/Post-Test	N	Mean Rank	Sum of Ranks	z	p
Negative rank	0	.00	.00	3.628*	.000
Positive rank	17	9.00	153.00		
Equal	1				

*: Based on negative ranks

According to Table 7, the difference between CG's scores obtained before and after the teaching process is significant (z=3.628, p<.05) and is in favor of the post-test. The mathematics performance of CG students, to whom the concept cartoons-supported 5E learning model was not applied, and only the explanatory lecture method was applied within the scope of the activities recommended by the current mathematics curriculum, also increased. Tables 6 and 7 together show that the methods applied in both groups created a significant difference in increasing mathematics performance.

Findings of the Mathematics Motivation Sub-problems and Interpretation

To address "Is there a statistically significant difference between the MMS scores of the EG taught with the concept cartoons-supported 5E model and that of the CG taught according to the current curriculum (MoNE, 2018)?" EG's and CG's MMS pre-and post-test scores were compared.

MMS Pre-Test Scores of EG and CG

The results of the Mann-Whitney U-test for the difference between EG's and CG's MMS pre-test scores are given in Table 8.

Table 8. Mann-Whitney U-Test Results for EG's and CG's MMS Pre-test Scores

Group	N	Mean Rank	Sum of Ranks	U	p
EG	16	16.31	261.00	125.00	.511
CG	18	18.56	334.00		

Table 8 shows no significant difference between EG's and CG's pre-test scores (U= 125.00, p>.05), indicating that CG and EG were equivalent in mathematics motivation before the implementation.

MMS Post-Test Scores of EG and CG

The results of the Mann-Whitney U-test for the difference between EG's and CG's MAT post-test scores are shown in Table 9.

Table 9. Mann-Whitney U-Test Results for EG's and CG's MMS Post-test Sores

Group	N	Mean Rank	Sum of Ranks	U	p
EG	16	16.13	258.00	122.00	.447
CG	18	18.72	337.00		

Mann-Whitney U-test results of MMS post-test scores of the EG students taught using the concept cartoons-supported 5E model and the CG students taught using the explanatory lecture method within the activities of the current curriculum are shown on Table 9. Accordingly, at the end of the 4-week experimental study, MMS scores of EG and CG students did not differ significantly (U=122.00, p>.05).

Regarding mean ranks, CG students' mathematics motivation is higher than EG students'. According to this result, it can be said that implementing the concept cartoons-supported 5E model did not significantly increase EG students' mathematics motivation. Tables 8 and 9 together show that the concept cartoons-supported 5E model and explanatory lecture method did not create a significant difference between EG and CG in mathematics motivation scores.

Wilcoxon Signed Rank Test Results of EG and CG's MMS Pre-and post-test Scores.

To address "Is there a statistically significant difference between the MMS scores of the EG taught with the concept cartoons-supported 5E model and that of the CG taught according to the current curriculum (MoNE, 2018)?" EG's MMS pre-and post-test scores were compared using the Wilcoxon signed-rank test, and the results are given in Table 10.

Table 10. Wilcoxon Signed Rank Test Results for EG's MMS Scores

Pre-Test/Post-Test	N	Mean Rank	Sum of Ranks	z	p
Negative rank	1	9.50	9.50	3.032*	.002
Positive rank	15	8.43	126.50		
Equal	0				

*: Based on negative ranks

Table 10 shows a significant difference between EG's scores obtained before and after the experimental process (z=3.032, p<.05) in favor of the post-test. Accordingly, the implementation of the concept cartoons-supported 5E model had a significant effect on increasing EG students' mathematics motivation.

Regarding the second sub-problem of the study, "Is there a statistically significant difference between the MMS scores of EG taught with the concept cartoons-supported 5E model and that of CG taught according to the current curriculum (MoNE, 2018)?" CG's MMS pre-and post-test scores were compared using the Wilcoxon signed-rank test, and the results are shown in Table 11.

Table 11. Wilcoxon Signed Rank Test Results for CG's MMS Scores

Pre-Test/Post-Test	N	Mean Rank	Sum of Ranks	z	p
Negative rank	2	16.25	32.50	2.319*	.020
Positive rank	16	8.66	138.50		
Equal	0				

*: Based on negative ranks

Table 11 shows a significant difference between CG's scores before and after the implementation (z=2.319, p<.05) in favor of the post-test. The mathematics motivation of CG students, to whom the concept cartoons-supported 5E learning model was not applied, and only the explanatory lecture method was applied within the scope of the activities recommended by the current mathematics curriculum, also increased. Tables 10 and 11 together show that the methods applied in both groups significantly increased mathematics motivation.

Results of the Correlation Analysis Between EG's and CG's MMS and MAT Scores

The sub-problem "Is there a significant relationship between EG's and CG's MAT and MMS scores?" was addressed. The results of the correlation analysis between MMS and MAT scores are given in Table 12.

Table 12. Results of the Correlation Analysis Between EG's and CG's MMS and MAT Scores

Group	Variables	Spearman-Brown (r)	MAT	MMS
EG	MAT	r	1	.447
		p	.0	.083
		N	16	16
	MMS	r	.447	1
		p	.083	.0
		N	16	16
CG	MAT	Correlation Coefficient	1	.307
		p	.0	.215
		N	18	18
	MMS	r	.307	1
		p	.215	.0
		N	18	18

r: Correlation Coefficient

The Spearman-Brown rank difference analysis was conducted to test whether there is a statistically significant difference between the MAT and MMS post-test scores of EG and CG students [rd (16) = 0.447, $p \geq 0.05$; rk (18) = -0.307, $p \geq 0.05$]. Table 12 shows that EG and CG students' MAT and MMS post-test scores did not differ significantly.

DISCUSSION & CONCLUSION

This study investigated the effect of the concept cartoons-supported 5E model on secondary school students' mathematics performance and motivation. The analysis showed that after a 4-week experimental study, MAT scores of EG students taught with the concept cartoons-supported 5E model and MAT scores of CG students to whom this method was not used did not differ significantly. From this finding, it can be concluded that the concept cartoons-supported 5E model did not increase mathematics performance more than the explanatory lecture method used within the mathematics curriculum framework. In other words, the concept cartoons-supported 5E model and the explanatory lecture method did not create a significant difference in EG and CG regarding mathematics performance. However, the within-group analysis showed a significant difference between the scores of EG and CG in favor of the post-test. Accordingly, both the concept cartoons-supported 5E model applied to EG and the explanatory lecture method applied to CG significantly improved students' mathematics performance.

In this study, the concept cartoons-supported 5E learning model applied in the mathematics course was expected to positively affect mathematics course performance and mathematics motivation of 7th-grade secondary school students more than the explanatory lecture method. However, the post-test scores of the groups did not differ significantly, concluding that both methods effectively increase mathematics performance when used effectively. Regarding the relevant literature, some studies in natural science contradict this study (Atasoy et al., 2020; Aydın, 2015; Çelik & Gündoğdu, 2016; Çil, 2014; Gomez, 2014; Meriç, 2014; Özmen et al.). Regarding the field of mathematics education, the findings of some studies involving concept cartoons-supported teaching are not similar to the mathematics performance findings of this study. Marques et al. (2023) found that concept cartoons were effective in teaching new concepts; Pekel (2021) reported that concept cartoons, especially discussion-based concept cartoons, improved students' mathematics performance, and Aygün et al. (2020) found that they were effective in improving students' understanding of mathematics symbols, terms, and concepts. Similarly, Batdal Karaduman and Elgün Ceviz (218), Dereli (2008), Erdağ (2011), Katipoğlu (2016), Kaplan and Öztürk (2015), Samkova (2018), Önal and Çilingir Altiner (20-22), and Yağıcı (2019) reported that concept cartoon-supported teaching improved students' mathematics performance. The results of these studies are not parallel with this study regarding mathematics performance. Furthermore, Yılmaz (2018) found that EG students' mathematics performance, in which the concept cartoons-supported 5E model was used to teach mathematics, was significantly higher than CG students' mathematics performance taught according to the current curriculum. In this respect, this study's results contradict our study's results. On the other hand, the studies showing that concept cartoons-supported teaching was not effective in eliminating misconceptions (Gökkurt Özdemir et al., 20-21) and improving mathematics performance (Güler, 2010; Korucu, 2009) support the results of this study.

The study's second sub-problem examines the effect of the concept cartoons-supported 5E model on students' mathematics motivation. The method used to teach EG was expected to be more effective in increasing mathematics motivation than the method used in CG. However, the analysis results did not support this. The independent samples' analyses showed that the scores of EG and CG did not differ significantly. Similarly, the analysis of the dependent sample showed no significant difference between the pre-and post-test MMS scores of EG and CG. Based on these findings, it can be concluded that the concept cartoons-supported 5E model was not more effective in increasing students' mathematics motivation in the EG. This finding is supported by a study conducted by Atasayar Yamık (2015), which showed that concept cartoons were ineffective in increasing students' motivation toward learning science. Meriç (2014) reported that concept cartoons-supported teaching did not significantly affect secondary school students' motivation scores toward participation. However, it positively contributed to their motivation toward performance. Based on her observations, Yürekli (2020) found that concept cartoons improved students' motivation and positively affected their interest in mathematics. The mathematics motivation results of Yürekli's (2020) study and this study contradicts.

The results of this study showed that EG's and CG's scores did not differ significantly. Conducting in-depth studies using qualitative methods to investigate the reasons may be advisable. Similarly, Güler (2010) concluded that using concept cartoons in the lessons did not make a significant difference in the groups' mathematics performance increase. However, the study's qualitative findings showed that most secondary school students were content with the lessons supported by concept cartoons. In the same study, a small group of students complained about the noise during the lesson and that they could not concentrate, stating that their interest in the lesson decreased because they were not used to the lesson being taught using concept cartoons.

This study also examined whether there is a relationship between MAT and MMS and its level, if any. The correlation analysis between MAT and MMS scores showed no relationship between EG and CG scores on both tests. Dede and Argün (2004) investigated the relationship between intrinsic and extrinsic motivation in mathematics courses. They found that factors that increase extrinsic motivation do not affect intrinsic motivation. In the study by Usta and Çağan (2020), the correlation analysis showed no significant relationship between performance and motivation. The results of Dede and Argün (2004) and Usta and Çağan (2020) are consistent with the results of this study regarding the lack of a significant relationship between mathematics performance and motivation. On the other hand, in their study with 5th-grade students, Bozkurt and Bircan (2015) reported a significant relationship between mathematics performance and motivation and that intrinsic and extrinsic motivation positively affect academic performance. Similarly, Middleton and Spanias (1999) showed that secondary school students' mathematics performance perceptions affect their motivational attitudes. Herges et al. (2017) showed a strong positive relationship between intrinsic motivation and performance, while extrinsic motivation has a moderate effect. The results of Bozkurt and Bircan (2015), Herges et al. (2017), and Middleton and Spanias (1999) are not parallel with the results of this study.

Several suggestions can be made based on this study's results. Some studies show that motivation has a significant effect on mathematics achievement. Our study concluded that the concept cartoons-supported 5E model did not increase secondary school students' mathematics performance and motivation more than conventional teaching. On the other hand, the analysis of related samples showed that the effective use of both methods in EG and CG increased mathematics performance. It is known that there are many reasons affecting performance and motivation. Thus, an in-depth study of the factors affecting mathematics performance and motivation with qualitative methods is recommended as a follow-up to this study. The concept of motivation can also be investigated in detail with its components. This study was conducted with 7th-grade students on ratio/proportion topics. It is recommended to conduct comparative and mixed studies at different grade levels and on different subjects. This study was conducted with a small study group. It is recommended to conduct this study on a larger sample. Readers are advised to evaluate study results in line with these suggestions.

Statements of Publication Ethics

The authors of this article declare that this research has not any ethical conflicts or problems that may limit the publication of the article.

Researchers' Contribution Rate

First author's contribution 40% , Other authors contribution 15%

Authors	Literature review	Method	Data Collection	Data Analysis	Results	Conclusion
Author 1's name	☒	☒	☒	☒	☒	☒
Author2's name	☒	☐	☒	☐	☐	☐
Author 3's name	☒	☐	☒	☐	☐	☐
Author 4's name	☐	☐	☒	☒	☐	☐
Author 5's name	☐	☐	☒	☒	☐	☐

Conflict of Interest

The authors have no conflicts of interest to disclose.

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APPENDIX

Appendix 1.

Mathematics Achievement Test (MAT)

Q.1) The ratio of Ayşe's age to Zehra's age is $\frac{3}{5}$, and the ratio of Zeynep's age to Ayşe's age is $\frac{5}{6}$. Zeynep is 15 years old; how old is Zehra?
A) 15 B) 20 C) 25 D)30

Q.2) The ratio of the number of male students to the number of female students in a theatre club is $\frac{5}{6}$. Since there are 10 male students in this theatre group, how many female students are there?
A) 11 B) 12 C) 13 D) 14

Q.3) The price of 30 pencils is 7.5 TL. How many kurush is one pencil?
A) 15 B)25 C)30 D)50

Q.4) The larger of two numbers with ratios of $\frac{3}{4}$ is 48; what is the difference between these two numbers?
A) 8 B) 10 C) 12 D) 16

Q.5) A store offers a $\frac{1}{2}$ discount on the second product if 2 of the same product are bought. How much will someone who buys 2 belts with a price of 40 TL pay for these belts?
A) 50 B) 60 C) 70 D) 80

Q.6) A landscape picture is printed as a rectangle with a length of 12 cm and a width of 10 cm. When this picture's length is enlarged to 18 cm, how many cm should its width be so the width/length ratio does not change?
A) 12 B) 13 C) 14 D) 15

Q.7) Which of the following equations expresses the relationship between the two multiplicities on the table?
A) y=4x B) x=4y C) x=4 D) y=4

x	y
2	8
3	12
4	16
5	20
6	24

Q.8)

Two connected gears move together.
The large wheel has 30 teeth, and the small wheel has 12 teeth. Which of the following is incorrect?

A) If the small wheel makes 10 revolutions, the large wheel makes 4 revolutions.
B) If the big wheel makes 2 revolutions, the small wheel will make 5 revolutions.
C) If the big wheel makes 2 revolutions, the small wheel will make 1 revolution
D) If the small wheel makes 6 revolutions, the big wheel makes 3 revolutions.

Q.9) Fatih goes to the market to buy eggs and reads the information note that says "5 eggs for 7 TL". He bought 1 egg after learning that he could buy them in pieces. How much change should Fatih get from the seller if he gave 2 TL to the seller?
A) 0,6 B) 0,8 C) 1,4 D) 1,6

Q.10) If 1250 grams of pistachio is 20 TL, how much does a kilo of pistachios cost?
A) 16 B) 15 C) 13 D) 12

Q.11) At a scout camp with 15 students, there is enough food to last them for 12 days. At the end of the 4th day, 5 more students arrive at this scout camp; how many days will the remaining food last for all the students?
A) 7 B) 6 C) 5 D) 4

Q.12)

Specs \ Model	X	Y	Z
Price (TL)	500	600	750
Length (cm)	20	24	30
Weight (gram)	100	110	160
Warranty (Year)	2	3	4

The table to the left shows the specifications of different models X, Y, Z of a tablet. According to this, which of the following specifications are directly proportional to each other?

A) Price - Length

B) Price - Weight

C) Length- Weight

Q.13) The price of a mobile phone is discounted from 360 TL to 280 TL. If the discount rate on the mobile phone is also applied to an MP3 player with an original price of 72 TL, what should be the price of the MP3 player?

A) 48 B) 54 C) 56 D)60

Q.14) $\frac{X}{6} = \frac{Y}{8}$

If the constant is 5 in the ratio given above, what is x + y?

A) 50 B) 60 C) 70 D) 80

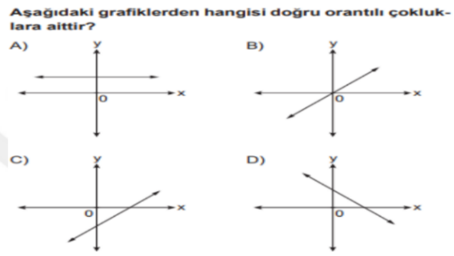
Q.15)

x	y
2	6
3	9
4	12
5	15
6	18

The table showing the relationship between two directly proportional multiplicities is shown in the figure. Which of the options below is the ratio constant for these two multiplicities?

A) $\frac{1}{2}$ B) $\frac{1}{3}$ C) $\frac{1}{4}$ D) $\frac{1}{6}$

Q.16)



Which of the graph below belongs to directly proportional multiplicities?

Q. 17)

A	1	2	4	5	y
B	120	x	30	24	15

In the table above, the numbers A and B are inversely proportional. Find the values of x and y accordingly.

A) x= 60, y=12 B) x= 50, y= 7 C) x= 60, y= 8 D) x=40, y=6

Q.18) A worker works at a certain speed and completes a job in 20 days. How many days would it take this worker to complete the same job if he doubled his speed?

A) 5 B) 10 C) 20 D) 40

Q.19) A bakery makes identical lemonade in different quantities daily. Which of the following tables shows a direct relationship between the amount of lemonade and water?

A)

Water (Litre)	5	10	15	20
Lemonade (Litre)	9	12	15	20

B)

Water (Litre)	5	10	15	20
Lemonade (Litre)	30	30	30	30

C)

Water (Litre)	5	10	15	20
Lemonade (Litre)	9	18	27	36

D)

Water (Litre)	5	10	15	20
Lemonade (Litre)	10	15	20	25

Q.20) "If 1 kg of apples costs 6 TL, how many TL are 4 kg of apples?" Which of the following ratios can be used to solve the problem?

A) $\frac{4}{1} = \frac{6}{X}$ B) $\frac{1}{4} = \frac{x}{6}$ C) $\frac{4}{1} = \frac{x}{6}$ D) $\frac{6}{4} = \frac{x}{1}$

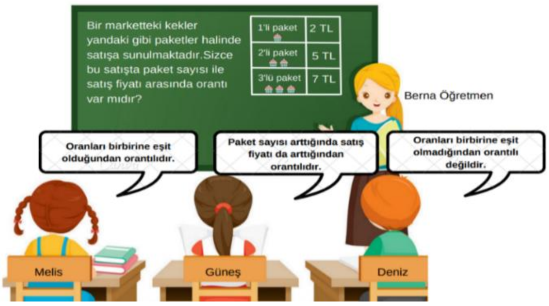
Appendix 2.

Motivation Scale for Mathematics Course

İfadeler	Hiç Katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Tamamen Katılıyorum
1.Matematik dersinde bana öğretilenler dışında bir şey öğrenmeye çalışmam.					
2.Matematik dersindeki zor soruları cevaplamaktan zevk alırım.					
3.Sınıfta öğrendiğimden daha fazlasını öğrenmek için çalışırım.					
4.Matematik dersine çalışmaktan zevk alırım.					
5.Sınav olmadığı zamanlarda bile matematik dersini tekrar ederim.					
6.Matematik dersinden önce notlarımı tekrar ederim.					
7.Matematikten düşük not almak beni mutsuz yapar.					
8.Matematik dersini anlamayı denerim.					
9.Matematik dersinden en yüksek notu almak isterim.					
10.Okulda başarılı olduğum zaman kendimi iyi hissederim.					
11.Matematik dersinde başarılı olmayı severim.					
12.Matematik derslerine ilgi duymam.					
13.Matematik dersinde öğrendiklerimizin, yaşantımızı kolaylaştıracağına inanıyorum.					
14.Matematik dersinde zamanımı boşa harcadığıma inanıyorum.					
15.Matematik dersi gerçek yaşamdaki bilgiler ile bağlantılıdır.					
16.Ders kitapları dışında matematik kitapları okumam.					
17.Matematik dersi benim için bir yüktür.					
18.Matematik dersinde konuyla ilgili tartışmalara katılmayı sevmem.					
19. Matematik ile ilgili televizyonda çıkan yayınları izlemeye çalışırım.					
20.Matematik dersleri beni ürkütür.					
21.Matematik dersinde merak ettiğim bilgileri araştırır, öğrenirim.					
22.Matematik dersine çalışmak beni dinlendirir.					
23.Matematik dersiyle ilgili yapılan uygulamaları vakit kaybı olarak görürüm.					
24.Matematik dersi sevilmese bile öğrenilmesi gereken bir derstir.					
25.Matematikteki yeni fikirleri öğrenmek isterim.					
26.Matematik dersinde çözdüğümüz soruları ilk bitiren kişi olmak isterim.					

Appendix 3.

A Sample Lesson Plan Prepared with Concept Cartoons-Supported 5E Model

Course Name	Mathematics
Grade Level	7^{th} grade
Time	3-course hours
Teaching Methods and Techniques	Concept Cartoons-supported 5E Model, question and answer, discussion
Materials	Blackboard, projector, computer
Topic	Numbers and Operations
Sub-Topic	Ratio/proportion
Gain	When one of two multiplicities whose ratio is known is given, finds the other.
Enter	Uses ratios in comparing multiplicities and shows ratios in different forms. If a whole is divided into two parts, finds the ratio of the two parts to each other or of each part to the whole, and finds the other when one of them and their ratios are given. Finds the ratio of two quantities in the same or different units.
Engage	
Explore	 Which of the answer(s) given by the students seeking answers to the question do you agree with? Please explain why.
Explain	In the exploration stage, students express their ideas and share their conclusions with their friends. The teacher then explains how to find the value of one of the two multiplicities, whose ratio is known, when the other is given, as shown below. *Information Box* To find one of the multiplicities, whose ratio is known, when the value of the other is given, the ratio is expanded by an appropriate number to find the multiplicity that is not given. The result is obtained by increasing or decreasing the ratio according to the number of multiplicities After this explanation, the following activity will be carried out with the students: *Activity.* This activity aims to intuit how to find one of the two multiplicities given the ratio of one to the other. 

Problem Situatio. Sinem, who plans to sell lemonade in her bakery, wants to make lemonade by mixing water, sugar, and lemon at two different ratios.

For this purpose, Ms. Sinem decided to prepare lemonades with two different recipes. She created the table below showing the amount of lemonade and the amounts of ingredients used.

Table 1. number of ingredients to be used according to the number of customers

Lemonade Recipes	Customers	Water	Sugar	Lemon
First Recipe	8	2 L	1 kg	4 pcs
Second Recipe	12	4 L	2 kg	6 pcs

Given this information, Sinem started making lemonade for tomorrow. Use the table to answer the following questions.

First, find out how many lemons will be needed for a birthday party for 24 people if the first recipe is preferred.

$$\frac{Number\ of\ people}{Amount\ of\ Lemon} = \frac{8}{4} = \frac{8\,.\,3}{4\,.\,3} = \frac{24}{12}$$

The answer is 12 if you write the ratio in the formula above. Answer the other questions accordingly.

a) How many liters of water are needed if the first recipe is preferred for a birthday party of 16 people?

b) How many kilograms of sugar are needed if the second recipe is preferred for a party of 36 people?

c) How many lemons will be needed if the second recipe is preferred for a party of 24 people?

Elaborate

Which of the answer(s) given by the students seeking answers to the question do you agree with? Please explain why.

Evaluate

Ozan wants to create a family tree in which the ages of the family members can be determined by a ratio.

He gives the following information about the ages of his family members.

My mother is 35 years old.

The ratio of my mother's age to my father's age is 7/8.

The ratio of my sister Ezgi's age to my father's age is 1/4.

The ratio of Ezgi's age to my age is 5/6.

The ratio of my age to my grandmother's age is 1/5.

The ratio of my grandmother's age to my grandfather's age is 12/13.

Help Ozan complete the family diagram by finding the ages of his family members.