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| Research Article / Araştırma Makalesi |

Common Knowledge Construction Model Applications: Investigating the Effects on Academic Achievement and Retention[1]

Ortak Bilgi İnşa Modeli Uygulamaları: Akademik Başarı ve Kalıcılık Üzerindeki Etkilerin İncelenmesi

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Keywords
1.Argumentation-based learning
2.Common knowledge construction model
3.PECED papers
4.Socioscientific issues
5.Three-stage achievement test

Abstract

This research investigates the effects of the Common Knowledge Construction Model (CKCM) applied to the 6th-grade "matter and heat" unit of the Science Curriculum on students' academic achievements retention. The study employed "pre-test post-test non-equivalent control group design" was adopted. The research was conducted during the 2018-2019 academic year and lasted for 9 weeks, involving a total of 72 students from a middle school located in a province in the Aegean region in Turkey. Data collection instrument was developed by the researchers. Matter and Heat academic achievement test was applied to the groups as pre-test, post-test and retention test. From the results it was determined that lessons taught according to CKCM were more effective in improving students' academic achievements and retentions compared to the instructional practices included in the Science Curriculum.

Anahtar Kelimeler
1.Argümantasyona dayalı öğrenme
2.Ortak bilgi inşa modeli
3.TAVAÇ kağıtları
4.Sosyobilimsel konular
5.Üç aşamalı başarı testi

Öz

Bu araştırmada, 6. sınıf fen bilimleri dersi "madde ve ısı" ünitesine yönelik uygulanan Ortak Bilgi İnşa Modeli'nin (OBİM) öğrencilerin akademik başarıları ve bilgilerinin kalıcılığı üzerindeki etkileri incelenmiştir. Çalışmada "ön test son test eşitlenmemiş kontrol gruplu araştırma deseni kullanılmıştır. Araştırma 2018-2019 eğitim öğretim yılında yürütülmüş ve 9 hafta sürmüş olup çalışmaya Türkiye'nin Ege Bölgesi'ndeki bir ilde bulunan bir ortaokuldan toplam 72 öğrenci katılmıştır. Veri toplama aracı araştırmacılar tarafından geliştirilmiştir. Madde ve Isı akademik başarı testi gruplara ön test, son test ve kalıcılık testi olarak uygulanmıştır. Çalışmadan elde edilen sonuçlardan, OBİM'e göre işlenen derslerin, Fen Bilimleri Dersi Öğretim Programı'nda yer alan öğretim uygulamalarına kıyasla öğrencilerin akademik başarılarını ve bilgilerinin kalıcılıklarını arttırmada daha etkili olduğu belirlenmiştir.

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586

INTRODUCTION

Situations such as keeping up with the constantly changing era and searching for solutions to global problems increase the importance of science and technology every day (Demirel, 2024a). The science course is an important resource for the development of these situations. Because science studies the phenomena in nature and tries to discover the laws and principles underlying these phenomena (Demirel & Türkmen, 2023). In addition, there are many alternative ways that provide the student with opportunities to understand and apply scientific methods in the science course. This situation allows students to become more effective thinkers (Bozkurt, Ay & Fansa, 2013). The more skills a student uses in classes, the greater the retention of knowledge. Thanks to the permanent accumulation of knowledge, students become academically successful, productive and more active (Tuysuz & Demirel, 2020). Therefore, science educators have been developing approaches and models that enable students to establish connections with real-life and acquire useful knowledge (Bakırcı & Çepni, 2012; Demirel, 2024b). The Science Curriculum implemented in 2018 is based on the research and inquiry-based learning approach (MEB, 2018). According to the research and inquiry-based learning approach, the majority of responsibility, from investigating a problem to finding a solution, lies with the students.

CKCM is a model that integrates four different perspectives: student, teacher, learning environment, and curriculum (Biernacka, 2006). In this model, a learning environment is created where scientific discourse takes place to facilitate conceptual changes and the attainment of shared knowledge as a class. In these environments, students' ideas are brought to the surface. Furthermore, students are allowed to generate arguments and express and evaluate them explicitly. At the end of the instruction, a consensus is reached on a set of views, and the construction of shared knowledge is achieved (Ebenezer & Fraser, 2001). The first stage of CKCM involves argumentation-based learning, where students explain their thoughts with various justifications and support them with different claims. Another stage focuses on the nature of science. In yet another stage, socioscientific issues are thoroughly discussed. During these discussions, students express their opinions along with their justifications. Consequently, students propose solutions to social and environmental problems at the local or national level (Ebenezer et al., 2010). CKCM is a learning model that enables students to establish connections both with their own lives and with real-life situations. In this model, students reconstruct their personal ideas by utilizing their prior knowledge. As a result, they become aware of their ability to access knowledge through exploration, research, and inquiry (Ebenezer et al., 2010). In this context, it can be said that CKCM aligns with the structure of the 2018 Science Curriculum.

CKCM emphasizes that knowledge is not only acquired through experiments, observations, or proofs, but also through social dimensions such as discussions, sharing, and negotiations (Ebenezer & Connor, 1999). Therefore, in order to interpret the views that emerge at the end of students' personal interactions with the natural environment and their social interactions with others, it is important to first determine students' perspectives on the world and establish a strong connection between personal views and scientific views (Ebenezer & Fraser, 2001). To establish this connection, classroom environments that utilize scientific language should be created. In such environments, student perspectives and scientific views converge through argumentation (scientific discussions). At the end of the process, shared knowledge is formed. Scientific discussions should be based on evidence, justifications, and inferences. Students search for evidence to either accept their own views or refute others' views during these discussions, and they obtain this evidence through experiments and research. Throughout the process of communicating with each other, they use scientific language and engage in social negotiations to reach shared knowledge (Ebenezer & Fraser, 2001). The CKCM does not focus on fitting students' thoughts about an event or concept into specific patterns or changing their beliefs. Instead, it aims to generate diverse thoughts of different qualities and focuses on constructing meanings solely related to the topic, concept, or phenomenon (Ebenezer et al., 2010).

CKCM consists of four interconnected stages: "Exploring and Categorizing," "Discussing and Constructing," "Expanding and Applying," and "Reflecting and Evaluating" (Ebenezer et al., 2010). In this model, throughout the stages, each student becomes aware of their own and their peers' conceptual understandings. Therefore, CKCM is a learning model based on cognitive awareness (Kaya, 2014).

Exploring and Categorizing Stage

In this stage, the influences of students' attitudes towards a natural or social phenomenon are revealed (Biernacka, 2006). For this purpose, students are presented with a concrete science event from their own lives, which they are very familiar with (Kaya, 2014). The aim here is to determine the students' readiness levels regarding the topic and to motivate their engagement. Additionally, attention is drawn to the topic and students are made aware of the nature of science (Bakırcı & Çepni, 2012). To achieve this, activities such as demonstrations, videos, pictures, activities, brainstorming, which reveal the relationships between natural events and students' thoughts in their minds, are included in this stage. Through these activities, students acquire knowledge about the nature of science, and alternative concepts and misconceptions related to the topic are identified (Bakırcı & Çepni, 2014). Furthermore, in this stage, students' ideas are not expressed as right or wrong with definitive judgments. Students share their personal ideas with the class, fostering a process of negotiation and idea sharing among students. Therefore, multiple ideas related to the topic are encouraged in this stage (Ebenezer et al., 2010). At the beginning of the process, students experience curiosity and exploration. By the end of the process, students realize that their own knowledge or scientific knowledge can change, that it is flexible in nature, and that science is a discipline that investigates and explains phenomena in nature (Biernacka, 2006).

The teacher, in this stage, carefully listens to and interprets the ideas that students acquire through their experiences and creates phenomenographic categories related to the topic. The teacher also takes on a supportive role by creating an environment where students can express their ideas openly (Biernacka, 2006). Another task of the teacher in this stage is to make students feel like scientists as they approach a laboratory or encounter a natural event (Kaya, 2014). For this purpose, teachers use strategies such as concept maps, class discussions, semi-structured interviews, journals, PEOE (Prediction, Explanation, Observation, Explanation), written or illustrated response questions, brainstorming, portfolios (Çavuş-Güngören, 2015).

In this study, PECED (Predict, Explain, Collect Data, Explain, Draw) paper activities were used in the exploring and categorizing stage of CKCM. These activities were developed by the researcher based on the PECED papers developed by Kaya (2016).

Consturucting and Negotiating Stage

In this stage, conducted according to argumentation-based learning, the categories obtained based on phenomena are discussed as competing theories by thought groups consisting of 3-4 individuals (Kaya, 2014). During these discussions, students explain the categories they have chosen through various justifications using arguments. Student groups opposing the views or supporting other categories develop counter arguments. Throughout the process, each category is thoroughly tested by student groups. After each category is addressed, attempts are made to reach common conclusions from the obtained perspectives. The results are determined through teacher-student collaboration. In the final part of this stage, students are asked to make drawings on PECED papers. Later, student drawings made on PECED papers during the first stage are compared with the drawings obtained from this stage. Through the differences between the drawings, students have the opportunity to evaluate both themselves and their peers (Kaya, 2014). Since students construct meaning through discussions with their peers and teachers, knowledge is socially constructed in this process (Duschl & Osborne, 2002). In this stage, while developing social skills such as understanding the thoughts of others and empathizing with them (Biernacka, 2006), students also become aware that their existing concepts can change through processes such as research, critical thinking, and peer sharing (Ebenezer & Connor, 1999). Another important aspect in this stage is that students can use their creativity and imagination (Bakırcı & Çepni, 2014).

In this stage, students also learn what scientific research studies entail. In other words, just as a scientist shares their ideas, thoughts, and results with other scientists in different locations during their research studies, students also share their own ideas and results with their peers (Kaya, 2014; Tuysuz, Demirel & Yildirim, 2013; Demirel, 2014). In this stage, students also realize that scientists are individuals open to criticism, and they gain the idea that their own ideas may be similar to the thoughts of past scientists (Kaya, 2014; Tuysuz, Yildirim & Demirel, 2014). The transfer of the historical development of science to educational environments also takes place in this stage (Ebenezer & Connor, 1999). Additionally, the awareness that many scientists in different countries contribute to the development of science and face certain challenges in accessing shared knowledge also occurs in this stage (Ebenezer & Puvirajah, 2005).

The teacher's role in this stage is to guide the process and mediate among students (Ebenezer & Connor, 1999). The teacher does not construct the knowledge obtained by students. On the contrary, they assist in students' mental development and maintain constant communication with students throughout the lesson. In doing so, the teacher discovers students' learning needs, interests, and abilities (Wood, 2012). While conducting assessments throughout the process, the teacher also assists students in maximizing their performance (Demirel, 2022).

Extending and Translating Stage

In this stage, a video, slideshow, or visual materials related to a socio-scientific topic of the lesson are presented to the class using tools such as interactive whiteboards, projectors, computers, etc., in a way that all students can see and hear comfortably. Socio-scientific topics refer to subjects concerning society that do not have definite answers or absolute truths, such as economics, health, politics, etc. (Pedretti, 1999; Sadler, 2004). Genetic cloning, euthanasia, air pollution, global warming, energy conservation, nuclear power plants, thermal power plants, and hydroelectric power plants are some examples of socio-scientific topics. Socio-scientific topics enable students to critically examine events and develop thinking skills based on scientific evidence (Walker & Zeidler, 2007). These topics often involve open-ended and complex issues, encompassing both scientific and social aspects simultaneously (Sadler, 2004). These discussion-provoking socio-scientific topics closely relate to science and have implications for people, which can lead to opposing opinions and disagreements within society (Topçu, 2015). For example, while one group of people may view thermal power plants as a threat to nature, another group may support their establishment due to the job opportunities they provide. This perspective can be economically driven, as countries may consider it a means of generating income.

In the first two stages of CKCM, students gain the opportunity to discuss socio-scientific topics and conceptualize scientific thinking based on the knowledge they have acquired (Ebenezer et al., 2010). Additionally, students can relate the newly learned information to situations they encounter in daily life and transfer their constructed views to other social issues, in other words, expand their understanding (Ebenezer & Connor, 1999). Another important aspect of the third stage of CKCM is that students are asked to design products. For this purpose, students are assigned mini-projects such as participating in a survey, interviewing experts, preparing posters or newspaper articles. The determination of these mini-project topics is done under the guidance of the teacher within the classroom. Students work in small groups together with their peers during this process. Therefore, while a part of the product design process takes place in the classroom, another part occurs in out-of-school learning environments. The groups then present their projects at an appropriate time in a different lesson. After the presentations, efforts are made to reach a common decision through argumentation (Kaya, 2014).

Reflecting and Assessing Stage

While this stage is theoretically included in CKCM, in practice, it is carried out simultaneously with the first three stages (Kaya, 2014). In other words, reflection and evaluation are conducted throughout all stages of CKCM during the learning process. In this process, the determination of whether students have learned the subject or not is achieved through alternative assessment techniques. Traditional assessment methods make it more difficult to determine whether students' misconceptions have changed, how they have learned rather than what they have learned, and whether discovery and mental structuring have occurred (Bakırcı and Çepni, 2012).

Moreover, the reflection and evaluation stage also provide an opportunity for teachers to develop classroom practices and gather regular information about students. Through this, teachers can assess students' behaviors, attitudes, scientific research skills, and social skills. In the first stage of CKCM, attempts are made to determine the prior knowledge students bring to the class. For this purpose, concept maps, semi-structured interviews, student journals, diagrams, etc., can be used (Ebenezer & Connor, 1999). In this research, in the first stage of CKCM, students' prediction, inference, observation, data collection, making explanations, and drawing skills were measured. For this purpose, PECED papers were distributed to the students. Additionally, students were asked to keep a journal at the end of each lesson to reveal their own thoughts.

In the second stage of CKCM, attempts are made to determine whether students participate in the argumentation process, whether they can form arguments, whether they can convince their peers in the opposing group using justifications, and whether they can reach common knowledge at the end of the study. In this stage, students' scientific research skills and collaboration skills are also evaluated. In the third stage, it is aimed to determine whether students can combine the knowledge they have learned with daily life and technology and whether they can discuss socioscientific issues (Biernacka, 2006). In the fourth stage, descriptions and drawings in PECED papers, mini-projects designed by students, and the presentation of these projects in the classroom can be used to make assessments regarding students' learning levels (Kaya, 2014). When we look at the research on CKCM, it is observed that studies conducted abroad stand out initially. Ebenezer and Connor (1999) introduced the philosophy, basis, and rationale of CKCM, which is a new learning model. This research demonstrated that the model is suitable for science teaching. In another study conducted by Ebenezer et al. (2004), the teacher activity in lessons taught according to CKCM was investigated, and it was revealed that the model requires extensive preparation, is time-consuming, and difficult to implement in crowded classrooms. Biernacka (2006) demonstrated the positive impact of CKCM on fifth-grade students' scientific literacy, while Ebenezer et al. (2010) showed its positive effects on conceptual change and science achievement in seventh-grade students. Wood et al. (2013) and Wood (2012) reported that the model positively contributes to the academic achievement and conceptual changes of high school students. In terms of domestic studies, Çalık and Cobern (2017) investigated the effects of CKCM on the conceptual understanding, attitudes, and scientific habits of teacher candidates in Turkey and the United States, and statistically significant differences were found in favor of Turkish teacher candidates.

When reviewing the literature, it can be seen that studies related to CKCM are limited and primarily focus on determining the theoretical content, classroom applications, conceptual change, attitudes, scientific habits, scientific literacy, and its effects on academic achievement. The research mainly focuses on university students, middle school students, and teachers. This research, however, is important in terms of examining the impact of CKCM-based science instruction on academic achievement in the context of primary school students and questioning its feasibility in the science curriculum by presenting student perspectives. By focusing on classroom implementation of the method, it is expected to fill a gap in the literature in terms of providing researchers with an example application in the country.

The aim of this study is to investigate the effects of CKCM-based science teaching, implemented in accordance with the 2018 Science Curriculum, on academic achievement in the "matter and heat" unit of the 6th-grade science course, and to reveal student perspectives on CKCM practices by comparing them with the existing method.

Research Questions:

1. Does the implementation of the 6th-grade science course unit "Matter and Heat," based on the Shared Knowledge Construction Model and the 2018 Science Curriculum, have an impact on students' academic achievement?
2. Does the implementation of the 6th-grade science course unit "Matter and Heat," based on the Shared Knowledge Construction Model and the 2018 Science Curriculum, have a long-term impact on students' academic achievement?

METHOD

Research Design

In this study, the quantitative phase employs a quasi-experimental design was used which known as the "pre-test post-test non-equivalent control group design" to determine the effectiveness of two different instructional methods: CKCM and the existing science teaching program (Creswell, 2003). The pre-test post-test non-equivalent control group design is used when it is difficult to achieve random assignment of groups in educational research (Karasar, 2010). The implementation process in the experimental and control groups is presented in Table 1.

Table 1. Implementation Process in Experimental and Control Groups.

Group	Pre-Test	Process	Post Test	Retention Test
Experimental Group	MHAT	CKCM, PECED Papers	MHAT	MHAT
Control Group	MHAT	2018 Science Curriculum	MHAT	MHAT

Table 1 shows that prior to the implementation of the interventions, a pre-test called the "Matter and Heat Achievement Test (MHAT)" was administered to the experimental and control groups to check for any pre-existing differences that could potentially affect the study. At the end of the interventions, the same test administered as the pre-test was conducted as a post-test to the same groups. Additionally, this test was administered as a follow-up test to the experimental and control group students in the next semester. These tests aimed to determine the academic achievements of students in the 6th-grade science unit "Matter and Heat." In the study, PECED papers (Appendix 1.) were administered to the experimental group students, while they were not administered to the control group students. In addition to the experimental and control groups, one class was designated as a pilot class. The reason for selecting a pilot class was to allow the researcher to gain experience in conducting the study in the experimental group. Moreover, the suitability of the stories and sample cases in the PECED papers to students' prior knowledge, the comprehensibility of the upcoming experiments, educational games, and activities by the students, and the necessary modifications in non-functional PECED papers were intended to be determined."

Population and Sampling

The study group of this research consists of a total of 72 sixth-grade students from a middle school in the Aegean Region, Turkey. Random assignment was used to determine the experimental and control groups.

Data Collection Tool

Matter and Heat Achievement Test (MHAT)

The MHAT was used to collect quantitative data in this study. A three-stage MHAT developed by the researchers was used. Twenty-one questions were prepared to measure the 14 achievements specified in the 2018 Science Curriculum. The first stage of the test included multiple-choice questions, while the second stage included multiple-choice options with different alternatives related to the choices in the first stage. In the third stage of the test, students were asked to write down the reasons for their chosen options in their own sentences. In the literature, the third stage of three-stage achievement tests usually asks students if they are confident in their chosen options. However, in this developed achievement test, students were required to provide detailed explanations for the choices they made in the first two stages during the third stage. The aim here was to minimize the chance factor during the measurement of students' acquired knowledge. For any given question in the developed achievement test to be considered correct, students needed to have chosen the correct options in the first two stages and provide accurate explanations in the third stage. Questions were not considered correct for those who only marked one option correctly or only provided the correct justification.

Validity and Reliability Analysis of the MHAT

Data used for calculating the validity analysis of the scale were obtained from a total of 72 students in three groups (Experimental Group, Control Group, and Pilot Group). To determine the content validity of the developed Matter and Heat Achievement Test, expert opinions were obtained from three faculty members specializing in science education and two science teachers. According to the expert opinions, the content validity of the test was found to be high. Additionally, the test was reviewed by one Turkish language teacher to assess its grammatical aspects. The internal consistency reliability of the test was found to be 0.78 based on the KR-20 coefficient. A reliability coefficient of 0.70 or higher is generally considered sufficient for the reliability of test scores (Büyüköztürk, 2004).

The item discrimination index, denoted as "rj," indicates the degree to which the items in a test differentiate between those who know and those who do not. The item discrimination index ranges from -1 to +1. As it approaches +1, the discrimination increases, while it decreases as it approaches 0 and -1. Items with a positive discrimination index are considered for inclusion in the test if their item discrimination index is between 0.30 and 0.40. If the index is 0.40 or higher, it is an ideal item for the test. All items with values below 0.30 are removed from the test (Ebel, 1965). The table below shows the item discrimination index (rjx) values for the 21 items in the Matter and Heat Achievement Test.

Table 2. Discrimination Index (rjx) Values of the Items in the MHAT

Item	(rjx)	Item	(rjx)	Item	(rjx)	Item	(rjx)
1	0,31	7	0,50	13	0,11	19	0,47
2	0,49	8	0,54	14	0,55	20	0,52
3	0,55	9	0,56	15	0,57	21	0,54
4	0,24	10	0,53	16	0,39		
5	0,36	11	0,51	17	0,45		
6	0,43	12	0,56	18	0,48		

When looking at Table 2, it can be seen that items 4 and 13 have discrimination indices below 0.30 (0.24 and 0.11), so they were removed from the test. The remaining 19 items have a total discrimination index of Rj (avg) = 0.49. Since this value is above 0.40, it can be said that the overall discrimination of the test is good.

The item difficulty index represents the percentage of individuals who answered an item correctly and is denoted as P. If all 100 individuals in the test answer an item correctly, the P value is 1, indicating an extremely easy item. If no one answers an item correctly, the P value is 0, indicating an extremely difficult item. Additionally, if the P value is between 0.80 and 1.00, it is a very easy item. If the P value is between 0.60 and 0.79, it is an easy item. If the P value is between 0.40 and 0.59, it is a moderately difficult item. If the P value is between 0.20 and 0.39, it is a difficult item. And if the P value is between 0.00 and 0.19, it is a very difficult item (Tekin, 2000). Table 3 presents the item difficulty index (Pjx) values and item difficulty levels for the 21 items in the MHAT.

Table 3. Item Difficulty Index (Pjx) Values of the Items in the MHAT

Item	(Pjx)	Item Difficulty Level	Item	(Pjx)	Item Difficulty Level	Item	(Pjx)	Item Difficulty Level
1	0,81	Very easy	8	0,25	Difficult	15	0,58	Middle
2	0,43	Middle	9	0,47	Middle	16	0,87	Very easy
3	0,46	Middle	10	0,16	Very difficult	17	0,45	Middle
4	***0,83***	***Very easy***	11	0,82	Very easy	18	0,47	Middle
5	0,14	Very difficult	12	0,69	Easy	19	0,66	Easy
6	0,41	Middle	***13***	***0,80***	***Very easy***	20	0,55	Middle
7	0,56	Middle	14	0,64	Easy	21	0,16	Very difficult

As seen in Table 3, the test includes 9 items at the 'Moderate' difficulty level and 5 items at the 'Very Easy' level. Due to the low discrimination of items 4 and 13, which were removed from the test, the number of items at the 'Very Easy' level decreased to 3. Furthermore, the table shows that there are 3 items each at the 'Easy' and 'Very Difficult' levels, while the number of items at the 'Difficult' level is 1. After removing items 4 and 13 from the test, the item difficulty index (Pj(avg)) for the remaining items was calculated as 0.54. Since this value falls between 0.40 and 0.59, we can say that the Matter and Heat Achievement Test has a moderate level of difficulty.

Based on all the data obtained from the analyses, it can be concluded that the Matter and Heat Achievement Test has high validity, reliability, good discrimination, and a moderate level of difficulty. The test was initially administered as a pre-test to determine whether there was a significant difference in the students' achievements in the 'Matter and Heat' unit of the science course before implementing the 'Matter and Heat Achievement Test.' After the study, it was administered as a post-test to determine whether there was a significant difference in student achievements depending on the applied methods. Additionally, this test was also administered as a follow-up test in the subsequent period for the experimental and control groups.

Application Process

The research was conducted in the academic year 2018-2019 in a middle school affiliated with the Ministry of National Education (in Turkish MEB) in Aegean Region, Turkey. All studies in the experimental and control groups were carried out by researchers who were experts in the field of the common knowledge construction model and who had not met the students before. The study consisted of 1 experimental group, 1 control group, and 1 pilot group. A total of 72 sixth-grade students, with 24 students from each group, participated in the research. While the CKCM was implemented in the experimental group, the subjects were taught according to the 2018 Science Curriculum in the control group. In the pilot group, the subjects were taught based on the CKCM, which was also applied in the experimental group. The applications in the experimental and control groups started and ended in the same week. However, the activities in the pilot group started 2 weeks earlier and ended 2 weeks earlier compared to the experimental and control groups.

Additionally, in one class hour of the following week, all students in the experimental and control groups were informed about the methods to be applied and the materials to be used in the study. In the second lesson of the same week, the “Matter and Heat Achievement Test” was applied as a pre-test under exam conditions in order to measure the prior knowledge and skills of the students in the groups. The applications were then carried out in the subsequent weeks. The applications in the experimental, control, and pilot groups, excluding the pre-test and post-test lasted a total of 28 class hours (7 weeks). The applications included PECED paper activities, socioscientific issues, and mini-projects developed by the students, while the materials specified in the 2018 Science Curriculum were used in the control group.

Application Process in the Experimental Group

In the class assigned as the experimental group, the lessons were taught according to the CKCM. Throughout the application, PECED papers prepared for the achievements in the "Matter and Heat" unit were distributed to the students. The students started their work by examining the story or sample case presented on these papers. They also recorded the data they obtained during the study on these papers. To allow extensive discussions among students during argumentation practices, a suitable environment was created in the classroom. Each argument formed based on the compilation of student predictions was developed through their collective thoughts. During the processing of socioscientific issues included in the study, the researcher utilized the smart board and computer available in the classroom. Additionally, all students were asked to keep a journal throughout the study, documenting what they learned each day.

The application of the CKCM began with the "Exploration and Categorization" phase, using PECED paper activities. After examining the sample case or story presented on the PECED paper, the researcher introduced the daily phenomenon to the class. In educational research, a phenomenon is an expression that emphasizes the objective reality of a tangible, testable, concrete event or process perceived by the senses. It is also used to reveal what different individuals understand from the same concept (Prosser & Trigwell, 1997). In this study, the phenomena were selected from events that students frequently encounter in their daily lives. The purpose of including a real-life event from their own experiences was to determine the influence of their conceptual formation on the world based on the experiences and to uncover different perspectives they might have towards an event encountered in a laboratory or in nature (Kaya, 2014). After introducing the phenomenon, the students expressed their predictions by raising their hands. They then wrote their thoughts in the "Predict" section of the PECED paper. No interference was made with the students' thoughts to allow them to make as many predictions as they desired. Meanwhile, the researcher wrote the students' predictions on the board. The students were then asked to explain the reasons for their predictions. After expressing their justifications orally, the students wrote them in the second section of the PECED paper, titled "Explain." Additionally, it was mentioned that in this section, students could make drawings or create tables in the "Draw" section of the PECED paper while expressing their justifications.

Subsequently, the researcher conducted the phenomenon to enable the students to observe and collect data. For this purpose, the experimental setups mentioned in the data collection sections of the PECED paper were prepared, educational games were played, or videos were shown. While all the experiments were conducted by the researcher, the educational games were carried out among the students. The students wrote their thoughts based on their observations in the "Explain" section of the PECED paper. In this section, they were also asked to redraw the information they obtained. Finally, the initial drawings made at the beginning of the class were compared with the final drawings, and a general conclusion was reached. Up until this section, there was no transition to argumentation in the study.

In the "Discussion and Construction" phase of CKCM, the transition to argumentation was made. During this phase of the lesson, the exchange of ideas mainly took place between students, while the researcher assumed the role of a guide. The researcher transformed the written predictions on the board into phenomenographic categories in a way that students could understand, and connected them to the specified achievements and objectives of the program. These categories were written on the board as competing theories. Subsequently, each category was given a name (label). In competing theories, students were presented with an event, observation, or problem. Then, two or more theories regarding the resolution of the situation were presented. Students, in small groups, would defend one theory based on their prior knowledge and the evidence presented, while trying to refute the other theory (Tümay, 2008). The aim of transforming predictions into phenomenographic categories was to express that even when students say similar things, what they imply can be significantly different from each other. Furthermore, students can express similar thoughts using quite different terms (Bowden, 1994).

The presented competing theories were examined by the students for a while. Then, the students who agreed on the same idea formed small thought groups consisting of 3-4 individuals, selecting theories that aligned with their ideas. The students defended their ideas through arguments they constructed with various data and justifications, aiming to persuade and refute the opposing groups' theories. Decisions on the defended or refuted competing theories were made through teacher-student collaboration. In the "Extension and Application" phase of CKCM, socioscientific issues relevant to the lesson's attainment were presented to the class through the smart board or the internet. Socioscientific issues are topics that vary according to societies and are difficult to make decisions about (Sadler, 2004). Therefore, when deciding on socioscientific issues, scientific inquiries should be made (Kolsto et al., 2006). Additionally, when selecting socioscientific issues, they should address current topics. This is because students can express their ideas better when it comes to topics that interest them and that they have seen, known, or witnessed in their surroundings. In this context, in this study, socioscientific issues were selected considering their relevance to current events, their potential for debate, and their suitability for the students' level." The distribution of socioscientific issues presented to students throughout the weeks in the study is provided in Table 4.

Table 4. Distribution of Socioscientific Issues Presented to Students by Weeks in the Study.

Weeks	Socioscientific Issues
1. Week	Hydraulic Brake System
	Water cycle
2. Week	Separation of Crude Oil
3. Week	Blood Analysis with Centrifuges
4. Week	Melting of Glaciers
	Solar panels
5. Week	Alternative Thermal Insulation Materials
6. Week	Energy-saving
	Renewable energy sources

Weeks	Socioscientific Issues
7. Week	Air pollution
	Carbon monoxide poisoning

During the "Reflection and Evaluation" phase of the Collaborative Knowledge Building Model, student PECED papers, argumentation levels, and in-class activities were used as in-class assessment tools, while student journals and mini-projects were used as out-of-class assessment tools.

Application Process in the Control Group

In the assigned control group, the lessons were conducted according to the 2018 Science Curriculum as prescribed by the Ministry of Education. In this curriculum, lessons are designed to be learner-centered in order for students to acquire knowledge permanently. The program emphasizes research-based inquiry learning strategies, aiming to develop students' skills in exploration, inquiry, and argumentation. Students in these learning environments feel comfortable expressing their ideas and can articulate themselves verbally, in writing, and visually (MEB, 2018).

During the implementation period in the control group, traditional instruction, large and small group discussions, educational games, and question-answer techniques were employed. Activities were conducted using the smart board and internet, including interactive tasks, solving online questions, and watching videos. To reinforce students' learning, question banks and online quizzes were used at the end of each topic, and puzzle activities and in-class quizzes were organized. At the end of the lessons, the researcher summarized the topic to conclude the class. Throughout these activities, students actively engaged in predicting, testing their predictions, providing explanations, and expressing their thoughts and findings. Furthermore, students demonstrated their abilities to ask questions and discover new things related to a given phenomenon.

Data Analysis

SPSS-22 software package was used for the analysis of quantitative data. An independent samples t-test was conducted to determine if there was a significant difference between the pre-test scores of the groups. Pearson correlation analysis was used to examine the relationship between pre-tests and post-tests. To determine if there was a statistically significant difference between the post-tests, ANCOVA assumptions were tested. ANCOVA is a technique that allows statistical control of another variable or variables that are related to the dependent variable and called covariates, in addition to the independent variable whose effect is investigated in a study. ANCOVA is generally used to test whether there is a significant difference between the post-test measurements of the experimental and control groups in pre-test post-test control group designs (Büyüköztürk, 1998). Pre-test measurements were defined as the common variable in this study. Given that the necessary assumptions were met, ANCOVA was employed to perform the required analyses between the post-tests. To identify the source of the difference between the post-tests, Post Hoc Bonferroni analysis was conducted as a follow-up control analysis. Bonferroni analysis is one of the commonly used multiple comparison tests.

The arithmetic means of the obtained pre-test scores and the post-test scores after the study were presented in a line graph. Then, repeated measures ANOVA analysis was conducted to determine if there was a significant difference between the pre-test, post-test, and follow-up test scores of the experimental and control group students who participated in the research. This technique is used to determine if the mean scores of two or more related measurements significantly differ from each other (Büyüköztürk, 2010).

FINDINGS

This section presents the findings and interpretations of the sub-research problem "Does the 6th-grade science lesson on the 'Matter and Heat' unit, taught according to the Common Knowledge Construction Model and the 2018 Science Curriculum, have an impact on students' academic achievement?"

Descriptive data regarding the pre-MHAT and post-MHAT scores of the experimental and control groups are provided in Table 5.

Table 5. Descriptive Statistics of the Pre-MHAT and Post-MHAT Scores for the Groups

		Pre-MHAT		Post-MHAT	
Groups	N	$\bar{X}$	sd	$\bar{X}$	sd
Experimental	24	6,37	2,65	10,54	3,32
Control	24	5,33	2,97	7,54	3,66

As seen in Table 5, the experimental group's arithmetic means and standard deviation values for the academic achievement test have shown a greater increase compared to the control group. To determine whether the data follows a normal distribution, a normality test was conducted on the pre-MHAT scores of both the experimental and control groups. The results of the normality test analyses for the pre-MHAT scores of the groups are presented in Table 6.

Table 6. Normality Test Results for the Pre-MHAT Scores of the Groups

Groups	Tests	Kolmogorov-Smirnov	Shapiro-Wilk
Experimental	Pre-MHAT	0,200	0,368
Control	Post-MHAT	0,200	0,493

As shown in Table 6, according to the Kolmogorov-Smirnov and Shapiro-Wilk values, normal distribution is observed in both the experimental and control groups (p>0.05). The analysis continued using parametric tests. Subsequently, an independent samples t-test analysis was conducted to determine whether there was a statistically significant difference between the groups in terms of pre-MHAT scores. The findings of this analysis are presented in Table 7.

Table 7. Independent Samples t-Test Analysis Results for the Pre-MHAT Scores of the Groups.

Variable	Groups	$\bar{X}$	sd	t	df	p
Pre-MHAT	Experimental	6,37	2,65	-1,281	46	0,207
	Control	5,33	2,97			

The findings in Table 7 indicate that there is no statistically significant difference in the mean scores of the experimental and control groups on the pre-MHAT (p=0.207; p>0.05). To determine if there was a difference between the groups' post-test scores while controlling for the effect of pre-tests, the data was analyzed using ANCOVA. Therefore, the assumptions of ANCOVA were examined. The assumptions of ANCOVA include the dependent variable showing a normal distribution, homogeneity of variances across groups, and a linear relationship between the dependent variable and the covariates. To have a linear relationship between the dependent variable and the covariates, there needs to be either a statistically significant difference in the means of the pre-test scores between the groups or a statistically significant relationship between the means of the pre-test and post-test scores. Therefore, the first assumption of ANCOVA, which is the normal distribution of the dependent variable, was examined in this study. The normality test analyses for the dependent variable, which is the post-MHAT, are presented in the table below.

Table 8. Normality Test Results for the Post-MHAT Data of the Groups

Groups	Tests	Kolmogorov-Smirnov	Shapiro-Wilk
Experimental	Pre-MHAT	0,187	0,191
Control	Post-MHAT	0,200	0,396

Upon examining the Kolmogorov-Smirnov and Shapiro-Wilk values in Table 8, it can be observed that normal distribution is present in both groups (p>0.05). Since the first assumption of ANCOVA has been met, the other assumptions were also examined. According to another assumption, for the pre-tests to be used as a covariate, there needs to be a statistically significant difference in the means of the pre-test scores between the groups or a significant relationship between the pre-tests and post-tests. Upon reexamining the data in Table 16, it is evident that p=0.207 (p>0.05), indicating no significant difference between the pre-tests.

According to Weinfurt (1995), for a variable to be used as a covariate, there should be a statistically significant relationship between the covariates and the dependent variables. Therefore, the relationship between the pre-test and post-test scores was examined. Table 9 presents the results of Pearson correlation analysis between the pre-MHAT and post-MHAT scores for the experimental and control groups.

Table 9. Results of Pearson Correlation Analysis between the Pre-MHAT and Post-MHAT Scores for the Experimental and Control Groups

	N	Pearson Correlation (r)	Sig. (2-tailed) (p)
Pre-MHAT and Post-MHAT	48	0,478	0,001*

According to the information provided in Table 9, the Pearson correlation analysis indicates a statistically significant relationship between the mean scores of students' pre-MHAT and post-MHAT scores (r=+0.478; N=48; *p=0.001; p<0.01). After meeting another assumption of ANCOVA, the final assumption was addressed. According to the final assumption of ANCOVA, it is necessary to determine the homogeneity of group variances. The findings of the analysis conducted to examine the homogeneity of variances are presented in Table 10.

Table 10. Results of Levene Test Analysis for the Experimental and Control Groups' MHAT Scores

F	sd1	sd2	p
1,094	1	46	0,301

According to the result of the Levene test presented in Table 10, the obtained p-value of 0.301 (p>0.05) indicates that there is no significant difference between the groups. Since all assumptions of ANCOVA have been met, the pre-MHAT scores of the experimental and control group students were taken as the covariate to control for their influence on the post-MHAT scores. Therefore, the post-MHAT data was analyzed using ANCOVA. The findings of the ANCOVA analysis regarding the scores obtained by the groups from the post-MHAT are provided in Table 11.

Table 11. Findings of ANCOVA Analysis for the Groups' Scores from the post-MHAT

Source	The dependent variable	df	Square of Means	F	P	Partial Eta Square
Pre-MHAT	Post-MHAT	1	129,969	13,540	0,001	0,231
Groups	Post-MHAT	1	65,542	6,828	0,012*	0,132

*p<0,05

Table 11 indicates that there is a statistically significant difference in the means of the students' scores obtained from the post-MHAT, depending on the applied methods ($p<0.05$). The partial eta-squared value of 0.132 suggests that 13.2% of the variation in the dependent variable is attributed to the intervention. To determine which group benefited from the intervention, the Bonferroni test was conducted, and the results are presented in Table 12.

Table 12. Results of the Bonferroni Test Analysis for the Experimental and Control Groups' Scores in the MHAT.

Group (I)	Group (J)	Difference of Means (I-J)	Standard error	Sig (p)
Experimental group	Control Group	+2,378	0,910	0,012*

*p<0,05

As seen in Table 12, there is a significant difference in terms of academic achievement variable between the experimental group where the Collaborative Knowledge Construction Model was implemented and the control group where the teaching activities were conducted according to the 2018 Science Curriculum (+2.378 in favor of the experimental group) ($p=0.012$; $p<0.05$). Based on this finding, it can be concluded that the Collaborative Knowledge Construction Model has a more positive effect on the academic achievement of 6th-grade students compared to the lessons taught using the existing program.

Findings on the Retention

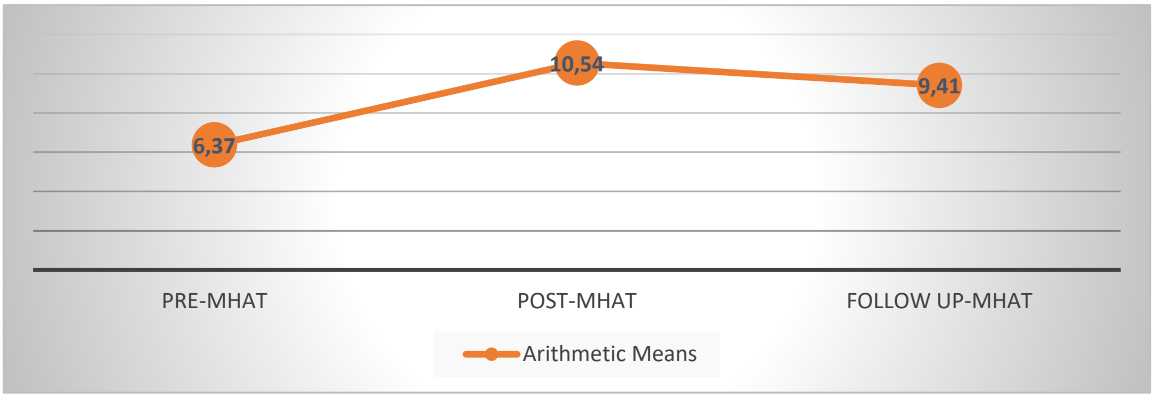
This section presents the analyses of the research problem, "Does the matter and heat unit of the 6th-grade science course, taught according to the Collaborative Knowledge Construction Model and the 2018 Science Curriculum, have a lasting effect on students' academic achievement?" Table 13 provides the descriptive statistics, including the arithmetic means and standard deviations, for the pre-MHAT scores obtained from the experimental and control groups before the intervention, the post-MHAT scores obtained after the intervention, and the follow-up MHAT scores administered to the students after a certain period.

Table 13. Arithmetic Means and Standard Deviations of the Pre-MHAT, Post-MHAT, and Follow-up MHAT Scores of the Groups

		Pre-MHAT		Post-MHAT		Follow-up-MHAT	
Groups	N	$\bar{X}$	sd	$\bar{X}$	sd	$\bar{X}$	sd
Experimental	24	6,37	2,65	10,54	3,32	9,41	2,46
Control	24	5,33	2,97	7,54	3,66	6,62	3,20

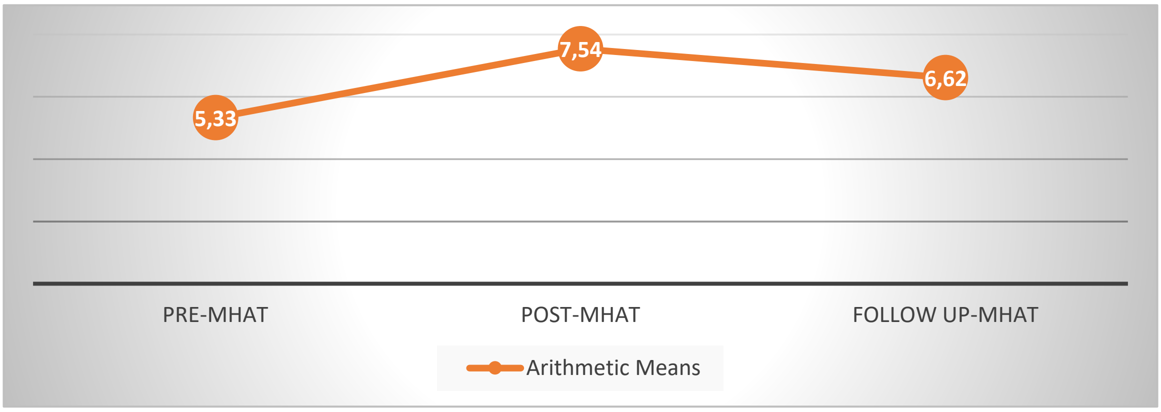
As shown in Table 13, the arithmetic means scores of both the experimental group and the control group increased in the post-MHAT compared to the pre-MHAT scores. However, the arithmetic means scores obtained from the follow-up MHAT decreased slightly compared to the post-test scores. The changes in the tests applied to the experimental group are depicted in Figure 1.

Figure 1. Arithmetic Mean Changes in Pre-MHAT, Post-MHAT, and Follow-up MHAT Scores Applied to the Experimental Group



The changes in the tests applied to the control group are presented in Figure 2.

Figure 2. Changes in Arithmetic Mean Values of Pre-MHAT, Post-MHAT, and Follow-up MHAT Scores for the Control Group



To determine whether to proceed with parametric or non-parametric tests in the study, previous normality test analyses were conducted, indicating that the pre-MHAT and post-MHAT scores of the groups followed a normal distribution. The normality test analyses for the follow-up MHAT scores of the experimental and control groups are provided in Table 14.

Table 14. Normality Test Results for the Follow-up MHAT Scores of the Groups

Groups	Tests	Kolmogorov-Smirnov	Shapiro-Wilk
Experimental	Follow-up- MHAT	0,200*	0,479*
Control	Follow-up- MHAT	0,110*	0,291*

As shown in Table 14, according to the Kolmogorov-Smirnov and Shapiro-Wilk values, both the experimental and control groups exhibit a normal distribution for the follow-up MHAT scores (*p>0.05). Since the data follows a normal distribution, parametric tests were used for further analysis. In experimental studies, when there are repeated measurements of the same participants over a specific period of time, a repeated measures ANOVA analysis is conducted (Büyüköztürk, 2010).

In this study, due to the existence of a specific time interval between the post-tests and the follow-up tests, and the use of the same participants, a repeated measures ANOVA test analysis was performed to determine whether there were significant differences among the pre-test, post-test, and follow-up test scores of the experimental and control group students. The repeated measures ANOVA test analyses for the pre-MHAT, post-MHAT, and follow-up MHAT scores of the experimental group are presented in Table 15.

Table 15. Repeated Measures ANOVA Test Results for the Pre-MHAT, Post-MHAT, and Follow-up MHAT Scores of the Experimental Group

Source	Sum of Squares	df	Square of Means	F	Sig (p)	Partial Eta Square
Sphericity Assumption	223,028	2	111,514	20,171	0,000	0,467

In the repeated measures ANOVA test analysis conducted to determine whether there were significant differences among the tests, the assumption of sphericity was examined by looking at the "Sphericity Assumed" values. This value is used to assess the homogeneity of variances.

"Homogeneity of Variance" is a term used to test whether the groups are equivalent or not (Toptaş, 2016). In this case, since the p-value is 0.000; p<0.05, we can conclude that the variances are not homogeneous. To determine which group or groups this difference favors, a Bonferroni analysis was conducted in the study. The results of the analysis are presented in Table 16.

Table 16. Bonferroni Test Results for the Pre-MHAT, Post-MHAT, and Follow-up MHAT Scores of the Experimental Group.

Test (I)	Test (J)	Difference of Means (I-J)	Standart Error	Sig (p)
Post-MHAT	Pre-MHAT	4,167	0,789	0,000*
	Follow-up- MHAT	1,125	0,585	0,200
Follow-up- MHAT	Pre-MHAT	3,042	0,647	0,000*

*p<0,05

When examining the results of the experimental group presented in Table 16, it can be observed that there is a significant difference between the post-MHAT and pre-MHAT scores, as well as between the follow-up MHAT and pre-MHAT scores (p=0.000; *p<0.05). On the other hand, the absence of a significant difference between the post-MHAT and follow-up MHAT scores (p=0.200; p>0.05) indicates that the performance of the experimental group students in these tests is similar even after a certain period of time. This suggests that the retention of the learned information persists. Furthermore, from the findings obtained from the tests applied to the experimental group, it is evident that the students achieved the highest average score in the post-test compared to both the pre-test and follow-up test scores.

The repeated measures ANOVA test analyses for the pre-MHAT, post-MHAT, and follow-up MHAT scores of the control group are presented in Table 17.

Table 17. Repeated Measures ANOVA Test Results for the Pre-MHAT, Post-MHAT, and Follow-up MHAT Scores of the Control Group.

Source	Sum of Squares	df	Square of Means	F	Sig (p)	Partial Eta Square
Sphericity Assumption	59,083	2	29,542	16,389	0,000*	0,416

*p<0,05

When examining the assumption of sphericity for the control group, as indicated in Table 17, the "p" value is found to be p<0.05. Therefore, in order to determine which group or groups the observed difference favors, a Bonferroni analysis was conducted in the study, and the results are presented in Table 18.

Table 18. Bonferroni Test Analysis Results for the Pre-MHAT, Post-MHAT, and Follow-up MHAT Scores of the Control Group

Test (I)	Test (J)	Difference of Means(I-J)	Standard Error	Sig (p)
Post-MHAT	Pre-MHAT	2,208	0,518	0,001*
	Follow-up- MHAT	0,917	0,294	0,015*
Follow-up- MHAT	Pre-MHAT	1,292	0,310	0,001*

*p<0,05

When examining the analysis results for the control group presented in Table 18, it can be observed that there is a significant difference between the pre-MHAT, post-MHAT and follow-up MHAT scores (*p<0.05).

The presence of a significant difference in test scores indicates that the control group students experience differences in terms of the retention of information, particularly in the post-test and follow-up test. This difference suggests that the learned information is forgotten after a certain period or that the applied method does not have an effective impact on the students. Additionally, from the data in Table 18, it can be understood that the control group students obtained higher scores in the post-test compared to both their pre-test scores and follow-up test scores. Therefore, similar to the students in the experimental group, the control group students have achieved the highest mean score in the post-test.

DISCUSSION AND COMMENTARY

In this section, the impact of the Collaborative Knowledge Building Model and the 6th-grade "Matter and Heat" unit, as per the 2018 Science Curriculum, on students' academic achievement was examined, and student perspectives regarding the implementation were discussed. The results of the study indicated that these practices had a positive effect on students' academic performance. These findings are consistent with previous research (Ebenezer et al., 2010; İyibil, 2011; Wood, 2012; Wood et al., 2013; Benli-Özdemir, 2014; Bakırcı and Çepni, 2014; Bakırcı et al., 2015; Ertuğrul, 2015; Akgün et al., 2016; Yıldızbaş, 2017; Bakırcı & Ensari, 2018; Bayar, 2019; Atayeter, 2019; Caymaz & Aydın, 2019; Haydari & Coştu, 2020) that examined the effects of CKCM on students' academic achievements at different grade levels. The main reason for this outcome is the student-centered nature of CKCM since students are active throughout the process in student-centered models. In this study, students actively participated in the process from the beginning of the lesson. For example, during argumentation practices, they made significant efforts to refute the claims of their peers with opposing views and assert their own claims. They utilized various pieces of evidence for this purpose. Additionally, during argumentation practices, several resources were used. For instance, internet access was utilized through tablet computers, videos were watched on interactive whiteboards, and research was conducted using books by collaborating with one another. Furthermore, through this study, students realized that they could learn in competitive environments during argumentation practices without an atmosphere of absolute winning or losing.

Another significant reason for the positive impact of CKCM on students' academic achievements may be the implementation of PECED papers throughout the process. These papers include visuals such as engaging stories, case examples, and images that capture students' attention. The main purpose of using these papers throughout the lesson is not to transfer rote knowledge to students but to develop various thinking skills in them. These papers are also used to uncover students' prior knowledge about the topic, assess their understanding of concepts, and identify the schemas in their minds before moving on to argumentation practices (Caymaz, 2018). In this study, students utilized PECED papers during the lessons and wrote down the information they acquired on these papers. The findings from the study demonstrated an increase in the number of correct answers in the explanation and drawing sections at the end of all PECED paper activities throughout the process. In other words, students utilized the information they learned during the lesson to make revisions in the "Explain" and "Draw" sections of the PECED papers. The fact that students made revisions indicates progress in their decision-making and problem-solving skills. A similar study conducted by Karabal (2018), which resembled the results of this study, examined the effects of CKCM on prospective science teachers' problem-solving and decision-making tendencies in the teaching of socioscientific issues. The study addressed socioscientific topics such as genetic studies, biological diversity, global warming, nuclear energy, and hydroelectric power plants. The results indicated that in the class where the lessons were taught based on CKCM, prospective teachers showed statistically significant improvement in their decision-making, problem-solving, and self-confidence tendencies. In another study, Haydari and Coştu (2021) investigated the impact of an education program designed in accordance with CKCM on fifth-grade students' problem identification and problem-solving skills in the science lesson on "Biodiversity." The research concluded that CKCM was effective in enhancing students' problem identification and problem-solving skills.

When comparing the academic achievement monitoring test scores of the experimental group students with their post-test scores, there was no significant difference in favor of any test. The lack of significant differences between the tests indicates that students' academic achievements in the post-test and the monitoring test were similar. Therefore, it can be concluded that the learning acquired through the CKCM practices applied to the experimental group remained sustainable even after a certain period of time. This result is parallel to the study conducted by Bakırcı et al. (2015), which examined the impact of CKCM on the sustainability of students' academic achievements. Another study by Yıldızbaş (2017) on this topic investigated the effect of CKCM-based learning on the sustainability of students' learning and found that students retained the knowledge they acquired about the topic of light even after a certain period of time. This student-centered model, which includes numerous examples from daily life, incorporates educational games during lessons, and involves activities such as experiments that enable students to learn through hands-on experiences, has also contributed to the sustainability of the learned information.

When comparing the academic achievement monitoring test scores of the control group, where the lessons were taught according to the 2018 Science Curriculum, with their post-test scores, a significant difference was found in favor of the post-test. The presence of a significant difference between the tests, favoring the post-test, can be interpreted as the information taught in the lessons based on the 2018 Science Curriculum being forgotten by students after a certain period of time or the applied method not leaving a lasting impact on students. This finding contradicts the results obtained by Caymaz (2018). In Caymaz's study, where the control group received lessons according to the 2013 Science Curriculum, which is also a student-centered program, and the experimental group received lessons based on CKCM, the findings indicated that both the control and experimental groups showed sustained achievement in the post-tests.

RESULTS AND RECOMMENDATIONS

The main result obtained from this study is that sixth-grade students' academic achievement is more effective in lessons taught according to the CKCM compared to the instructional practices included in the 2018 Science Curriculum. Therefore, conducting similar studies in different educational levels would contribute significantly to the relevant literature.

Another important result obtained from this study is the improvement demonstrated by students during argumentation practices. Initially, students were not able to reach advanced levels in the arguments they produced, but as the weeks progressed, they were able to generate arguments at higher levels. This result indicates that students lacked sufficient knowledge and experience in argumentation-based learning methods at the beginning, but their experience increased over time. Therefore, educators who implement the Common Knowledge Construction Model in their lessons should emphasize the content of the topic as much as possible during argumentation practices and create classroom environments that encourage students to collaborate. Additionally, since a significant amount of time is allocated to argumentation-based learning in the CKCM, careful planning is required to utilize this time effectively. Therefore, when planning, the selection of stories and scenarios should be tailored to the educational levels of the students, as this will also affect the course of the discussions.

Moreover, the findings of the study indicate that students found the Common Knowledge Construction Model interesting, engaging, and enjoyable. Considering the contributions of the CKCM to students, it can be observed that the model actively engages students throughout the process. Therefore, activities included in lessons according to the CKCM should be appropriate, practical, and applicable to the students' level. To achieve this, it is crucial to prepare the PECED papers used during the process meticulously, incorporate more visual elements into these papers, and include real-life examples. However, since some students may not enjoy writing or drawing, oral responses can also be considered instead of written materials. Additionally, preparing and distributing all materials and learning resources by the teacher before the implementation will help overcome any time constraints during the activities.

It is a well-known fact that using instructional materials in science education enhances students' interest in the subject. Therefore, researchers who will implement the CKCM in their lessons are advised to use rich materials in their instructional environments. Moreover, teachers should inform students about the use of technological tools such as tablets and smart boards effectively before the process. In this context, informative videos about challenging and hazardous experiments should be shown to students before the activities. This will prevent any potential negative incidents. The importance of group work should also be emphasized to students during CKCM practices. Students feel more comfortable when they are in an environment where they respect each other's ideas and can freely express their own thoughts. In this regard, educators should create a democratic atmosphere in their classrooms, value all students' opinions related to the topic, and provide guidance throughout the process. Therefore, educators should create more time and opportunities for students to collaborate in their classrooms.

In this study, it was determined that students' academic achievements continued to be retained even after a certain period of time based on the results obtained from the retention tests. The findings from the interviews also revealed that students established strong connections between the concepts covered in the lessons and everyday life. Therefore, educators who will utilize the CKCM should incorporate more expressions and examples from daily life in their lessons. This will help students overcome thoughts like 'What difference does it make if I learn this?'

This research was conducted in the 6th-grade science class during the "Matter and Heat" unit. The same study can be implemented in different units of the 6th-grade science class, allowing for comparisons between class levels. Furthermore, it is recommended to use the CKCM in other subjects as well, as it has positive effects on students' cognitive, affective, and psychomotor learning. The research was carried out in a school located in the district center. To diversify the data obtained, similar studies can be conducted in rural schools and in schools where scientific studies are less common. Additionally, researchers are advised to conduct thorough preliminary research when determining the sample group. Choosing schools that support scientific studies could be another recommendation.

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Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

The research proposal titled "Investigation of common information structure model applications towards matter and heat unit of secondary school 6th grade in terms of various variables" was discussed and unanimously accepted at the meeting of Manisa governorship national education directorate ethics committee commission dated 27.11.2018 and numbered 6792. The approval code of the study is 46949512-605.01-e.22713582.

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Appendix 1

TINY RAINDROP

There was a Tiny Raindrop who was curious about everything. Everyone loved this cute Raindrop. Because there was no one cuter or smarter than him in the sky.

One day, while Raindrop was wandering in the sky, he saw the angry Sun. The sun said to him: "Hey tiny Raindrop, don't come any closer to me, it wouldn't be good for you."

Not knowing what to do, Raindrop did what the Sun said and continued on his way.

While he was on the road, he encountered "Cold Weather" this time. Cold Weather said the same thing: "Hey tiny Raindrop, don't hang around here too much, it won't be good for you."

PREDICT

Why do you think the sun and the cold weather might have warned Raindrop?

……
……
……

EXPLAIN

Explain the reasons for your predictions.

……
……
……

COLLECT DATA

Let's do a fun experiment with you.

Required materials: Butter, Pot, Tube, Fork, Lighter, Container, Jar Lid and Some water.

Experimental Procedure: Heat some butter in a pot. Then wait for it to cool down and observe.

Then put some water into the container and light the bottom of the tube. Cover the water container with the jar lid. Wait for a while. Close the bottom of the tube and after a while, take the jar lid off the container and observe the situation.

EXPLAIN

Explain the information you obtained from the experiment in your own words.

……
……
……

DRAW

If you wanted to draw with the information you learned in this lesson, what would you draw?

……
……
……

Arguments You Created

……
……
……