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A Descriptive Review of Common Knowledge Construction Model Studies in Science Education: The Case of Türkiye

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Abstract: This study aimed to examine Common Knowledge Construction Model (CKCM) studies published in Türkiye within the scope of science education by using descriptive content analysis. Articles and postgraduate theses published on CKCM between 2011-2022 were analyzed based on different parameters. Publication types, educational needs for publication, aims and focuses, studied science topics, contents, methods, data collection tools, samples/study groups, teaching techniques applied in the model, and the results of the studies were analyzed separately for these articles and theses. The delimitations in identifying the studies to be analyzed were as follows: I) the studies were published during the period to 2011-2022, II) the context was relevant to Türkiye, and III) the focus was CKCM in science education. As a result, 21 research articles and 16 postgraduate theses (8 master's and 8 doctoral theses) were obtained. The fact that very few studies have been conducted on CKCM was cited as the most common educational need among the reviewed studies. Intervention studies have been widely conducted, and most studies have been carried out using experimental methods. Questionnaires and scales, as well as achievement tests, were most frequently used in the data collection processes. Predict-(Explain)-Observe-Explain (P(E)OE) and Conceptual Change Text (CCT) were the most frequently used teaching techniques within the scope of the CKCM. While the science subjects taught varied socio-scientific issues (SSIs), such as water pollution, greenhouse effects, and human-environment relations were found to be the most frequently taught science content. The obtained results were discussed by considering the similarities and differences between CKCM and other teaching models. Specific suggestions were provided based on the analyzed parameters.

Keywords: Common knowledge construction model, descriptive content analysis, science education.

Fen Bilimleri Eğitiminde Ortak Bilgi İnşa Modeli Çalışmalarının Betimsel Analizi: Türkiye Örneği

Öz: Bu çalışmanın amacı, fen bilimleri eğitimi kapsamında Türkiye'de yayınlanan Ortak Bilgi İnşa Modeli (OBİM) çalışmalarının betimsel içerik analizidir. Bu kapsamda 2011-2022 yılları arasında OBİM'e yönelik yayınlanan makale ve lisansüstü tezler farklı parametreler açısından analiz edilmiştir. Araştırmaların yıllara göre yayın türleri, yayınlanma gerekçeleri, amaçları ve odakları, çalışılan fen konuları, yöntemleri, veri toplama araçları, örneklemleri-çalışma grupları, modelde uygulanan öğretim teknikleri ve çalışmaların sonuçları analiz edilmiştir. Çalışmaların tespitinde belirlenen sınırlar, I) 2011-2022 yılları arasında yayınlanması, II) bağlamının Türkiye olması ve III) odağının fen eğitiminde OBİM olmasıdır. Taramalar sonucunda toplam 21 araştırma makalesi ve 16 (8 yüksek lisans ve 8 doktora) lisansüstü teze ulaşılmıştır.

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Araştırmalarda en sık karşılaşılan gerekçe, OBİM ile ilgili az sayıda çalışma yapılmış olmasıdır. En sık sayıda gelişimsel amaçlı çalışmalar göze çarpmış bu çalışmaların çoğunluğu deneysel yöntemlerle gerçekleştirilmiştir. Veri toplama süreçlerinde en sık anketler-ölçekler ve başarı testleri kullanılmıştır. En sık kullanılan öğretim teknikleri Tahmin-Açıkla-Gözle-Açıkla ve Kavramsal Değişim Metinleri olmuştur. Öğretimi gerçekleştirilen fen konuları çeşitlilik gösterirken özellikle çevre sorunlarına yönelik sosyobilimsel konular (su kirliliği, sera etkisi, insan-çevre ilişkileri vb.) sıklıkla öğretilen konular olmuştur. Elde edilen sonuçlar, OBİM'in diğer öğretim modelleriyle benzerlik ve farklılıkları dikkate alınarak tartışmaya açılmış ve analiz edilen parametrelere göre spesifik önerilere yer verilmiştir.

Anahtar Kelimeler: Ortak bilgi inşa modeli, betimsel içerik analizi, fen bilimleri eğitimi

Introduction

In recent years, various new and contemporary approaches have been used in the science learning and teaching processes. The effectiveness of these inquiry-based teaching practices has been the subject of many current science education studies (Tsai, 2018; Seage and Türegün, 2020). These approaches, employed for effective science teaching, aim to develop students' conceptual understanding levels, academic achievements, skills, affective learning, and so on.

The Common Knowledge Construction Model (CKCM) is one approach that makes students active in the learning environment and enables them to discover and construct knowledge on their own. CKCM, which has been used to teach many specific science subjects, is becoming increasingly widespread at different levels of education, especially in recent years (Çalık & Cobern, 2017; Uke et al., 2024). This model, which makes students active in the learning environment and enables them to discover and construct knowledge on their own, is fundamentally based on Marton's theory of variation in learning and Piaget's conceptual change study (Ebenezer et al., 2004).

According to this combination, the world is open to multifaceted interpretative variations, and thus, individuals can interpret a natural phenomenon in qualitatively different ways. Considering these differences, it is necessary to focus on the possible conceptual variations and diversity that students experience for a given phenomenon in learning environments. In particular, students' prior knowledge and prior learning are very important and an essential factors that shape the learning process.

CKCM identifies possible misconceptions and prior knowledge by emphasizing the significance of students' prior learning, and supports conceptual understanding in a way that forms the basis of new learning. In this context, many teaching materials have been developed to apply the model effectively, and different teaching methods have been used together to ensure conceptual change.

In CKCM, there is a particular focus on the different perceptions and conflicts between children's perspectives and scientists' expertise. In this process, the students' ideas should be explored. However, this process should not involve only probing prior knowledge, as in other inquiry-based approaches. Students should also be aware that these ideas and beliefs may contradict scientific explanations. The aim is to confront students with inconsistencies and contradictions between these ideas and belief systems, which are mostly formed through daily experiences and the information contained in scientific texts (Ebenezer & Connor, 1998). Therefore, the model requires structured experiences that confront students with discrepancies between their own ideas and beliefs, and the information presented in scientific texts.

Ebenezer et al. (2010) defined learning as an attempt to understand phenomena using various methods and recommended employing these methods throughout each phase of the model. Accordingly, the first phase of the 4-phase model, exploration and categorization, aims to assess students' readiness and their current level of knowledge on the subject, and to encourage them to question their existing knowledge. Students are expected to freely express multiple ideas on a relevant topic. To facilitate this, opinions on a scientific phenomenon or event are elicited, and explanatory categories are developed using simple tasks, such as diagrams, visualizations, and videos (Çalık & Cobern, 2017; Ebenezer & Fraser, 2001). Teachers should establish a positive and supportive learning environment to enable students to articulate their views clearly.

The second phase, construction and negotiation, involved diversifying teaching activities and creating multiple communication, negotiation, and discussion settings. Guided by the teacher, interactions between peers and between teachers and students are encouraged to facilitate objective construction of new information (Biernacka, 2006). The primary aim of this multifaceted communication process is to demonstrate that science is not solely based on observations and experiments, but also possesses a negotiable and socially constructive nature. Moreover, students develop social skills such as active listening, understanding opposing viewpoints, respect, and empathy.

During the translation and extension phase, socioscientific issues (SSI) related to the subjects were considered. Open-ended and contentious aspects of subject matter are explored within various disciplines, and solutions are sought by linking them to social and environmental problems, particularly at the local or national level (Ebenezer et al., 2004). By the end of this phase, students are expected to transfer their understanding to other contexts such as science, technology, society, and the environment (STSE). Alternative assessment techniques are recommended to evaluate the diverse learning outcomes that students develop throughout the process in the reflection and assessment phases. This involves conducting comprehensive evaluations of students' scientific research skills, attitudes, and social skills in the assessment process (Ebenezer et al., 2010). Teachers can focus on how students explore, articulate, and revise their concepts based on the evidence and explanations they provide. Students may be prompted to apply their scientific concepts to societal contexts and provide explanations within a socioscientific framework (Çalık & Cobern, 2017). Additionally, from the outset to the conclusion of the process, students' conceptual shifts were identified and areas requiring further examination were determined.

The literature contains numerous studies on CKCM practices across various science subjects and skills. These studies typically aim to develop various educational outcomes in accordance with the nature of the model. Ebenezer et al. (2010) examined the effect of CKCM regarding alternative concepts on the excretory system; Wood (2012) studied conceptual change on acid-bases; Kıryak (2013) explored the level of conceptual understanding about water pollution; Bakırcı (2014) focused on opinions on academic achievement and the nature of science regarding the topics of light and sound; Benli Özdemir (2014) investigated academic achievement and attitudes towards science in various science subjects; and Vural (2016) delved into conceptual understanding and daily life associations about acids and bases. An examination of the common points in these studies shows that they aimed to develop an educational output that was compatible with the phases of the model. The diversity of teaching activities in CKCM was reflected in the phases of each study. The aims, samples, content of the science subjects taught, grade levels, and teaching techniques used in the model varied considerably in these studies, which generally used the experimental research method. This study aims to present a holistic perspective on CKCM studies by systematically analyzing studies that reflect this variable structure.

Purpose and Significance of the Study

Content analysis studies focusing on different themes have been found based on a literature review in the field of science education. In this context, review studies have been conducted on curriculum development in science education (Ünal et al., 2004), socio-scientific issues (Topçu et al., 2014), qualitative studies (Ültay & Aydın, 2017), and STEM education studies (Li et al., 2019). The theme reviewed and analyzed in this study was a teaching model. A limited number of review studies address a specific teaching model in the context of science education. Review studies on teaching models and approaches, such as context-based learning and argumentation, have generally been conducted in the form of meta-analysis and thematic content analysis (Batdı, 2014; Dikmen & Tuncer, 2018; Ültay & Çalık, 2012). CKCM studies conducted in science education were reviewed and analyzed within the scope of this research. Examination of the CKCM studies published in Türkiye showed that it is a new model with a tendency to be used at higher rates. Accordingly, it can be argued that this descriptive content analysis study on CKCM has a diagnostic and summative character for researchers who want to work in this field. It is believed that this study will guide science education researchers, especially those at the graduate level. According to Çalık (2019), this type of research can increase foresight in the future. In particular, it can be determined which specific science subjects are more suitable for teaching SSI and NOS, which are the most important claims of the model, and suggestions can be made for similar specific science subjects. From an opposing point of view, it can also be determined which science subjects are not suitable for teaching by considering the negative results of the reviewed studies. Additionally, the studies reviewed in this study will be compared with international CKCM studies and will provide guidance for future studies in Türkiye. Considering these rationales and the results in the relevant literature, this study aimed to examine the trends of CKCM studies conducted in the field of science education in Türkiye during the period to 2011-2022. For this purpose, the following research questions were sought.

1) What is the distribution of CKCM studies in Türkiye according to year and publication type?
2) What are the educational needs of the CKCM studies published in Türkiye?
3) What are the aims, focuses, and specific science topics of CKCM studies published in Türkiye?
4) What are the methodologies and samples used in CKCM studies published in Türkiye?
5) What are the data collection tools used in CKCM studies published in Türkiye?
6) What are the specific teaching techniques applied in the CKCM studies published in Türkiye?
7) What are the results of CKCM studies published in Türkiye?

Method

Research Design

In this study, Common Knowledge Construction Model (CKCM) studies in the field of science education in Türkiye were examined using the descriptive content analysis method within a qualitative research approach. This method, commonly utilized in educational science research, involves a thorough qualitative and quantitative review and analysis of research focused on a specific topic, aiming to provide insights for future studies (Neuendorf, 2002; Ültay et al., 2021). Research conducted using this method offers a consolidated resource for researchers working in a specific field but lacks direct access to studies in that area (Çalık and Sözbilir, 2014). Given the objectives of this study, CKCM studies in Turkish science education were evaluated based on specific criteria, and the research method was determined to be a descriptive content analysis.

Data Collection Process

To assess studies related to the Common Knowledge Construction Model (CKCM) in the field of science education published in Türkiye, we explored studies from the national literature between 2011 and 2022. We searched the ULAKBİM (Turkish Academic Network and Information Center) Social Sciences Database, Turkish Education Index (TEI), Google Scholar databases, and the YÖK (Council of Higher Education) National Thesis Center using the following relevant keywords: "Common Knowledge Construction Model," "Common Knowledge Construction Model in Science Education," and "Common Knowledge Construction Model and Science Education." At the end of the search, we accessed the full texts of 21 articles and 16 graduate theses (8 Master's Theses, 8 Doctoral Theses). During the review process, we encountered abstracts presented at national congresses along with published full texts. However, these were not included in the analysis because of their presentation at national congresses and the unavailability of their full texts. Additionally, we identified four authors who produced articles based on their graduate theses. These authors were included in the analysis as they provided more comprehensive data. Thus, 37 theses and articles were analyzed during the process.

Data Analysis

Qualitative data analysis, as described by Patton (2014), can be approached either inductively to uncover codes, categories, and themes, or deductively to examine data within existing frameworks. In this study, a deductive approach was adopted, as the data collected from the reviewed studies adhered to established frameworks such as educational needs assessment, data collection tools, methods, and outcomes. The criteria considered in this review included publication type, publication necessity, study objectives, science topics covered, methodologies, data collection instruments, sample demographics, instructional strategies within the model, and study findings. These parameters were selected based on previous literature reviews (Bağ & Çalık, 2018; Çalık et al., 2005) and analytical methods outlined in Ültay et al.'s (2021) study of descriptive content analysis. Additionally, to encompass the variety of instructional techniques characteristic of the Common Knowledge Construction Model (CKCM), teaching activities at each stage were used as analytical criteria. Data from the studies were coded according to these parameters, with higher-level coding being used to generate themes for certain aspects. For instance, while identifying the science topics studied (content), basic coding sufficed, whereas themes related to the educational needs were derived through more comprehensive coding. Table 1 outlines the parameters considered in the analysis process along with illustrative examples.

Table 1.

Parameters and Examples of Reviewed Studies

1.	Distribution of the publication (year-type)	2014-Doctorate, 2022 Articles
2.	Educational needs for publication	-It provides the basis and materials for future work.
3.	Aim and focus of the studies	-Intervention-Teaching SSI with CKCM
4.	Studied science topic (contents)	Water pollution, Heat transfer
5.	Method of the study	Experimental method, Mixed Method
6.	Data collections tools	Conceptual understanding test, Interviews
7.	Sample (Study Groups)	Middle school 7^{th} graders, Science teachers
8.	Teaching techniques applied in the model	-Predict-(Explain)-Observe-Explain (P(E)OE)
9.	Result of the study	-CKCM is effective in improving scientific literacy

Based on the defined delimitations and parameters, the earliest publication of CKCM in Türkiye dates back to 2011. The most recent review was conducted in December 2022, with an ongoing publication process for 2023 in several journals. Consequently, the analyzed publications encompass CKCM studies from 2011 to 2022, accessible through the university's database affiliated with researchers.

Validity, Reliability and Limitations

The studies accessed through the database review were meticulously categorized based on their publication year and coded according to each parameter under examination. In this process, both researchers independently analyzed all studies and coordinated their efforts. Each study is coded separately for each parameter. If no new higher-level coding was deemed necessary after the initial coding, tables were prepared for inclusion in the Findings section. To ensure coding reliability, both researchers developed their own codes for all parameters, and common or similar codes were organized into tables. In cases with differing codes, a consensus was reached based on the study content. The formula [Agreement/(Agreement+Disagreement)] developed by Miles and Huberman (1994) was employed for coding reliability, resulting in a compatibility ratio of 0.92. This consensus-driven approach guided coding for subsequent studies, ensuring validity and reliability.

Some criteria were determined to ensure transparency in the study and make the findings open to the scrutiny of other researchers. According to these criteria, the studies included in the review and those excluded were stated along with their justifications, and the processes of collecting and analyzing the data were explained in detail. Databases from which the analyzed studies were obtained are presented. The analyzed studies are marked with the symbol '*' in the references. Thus, another measure of transparency was considered by making the reviewed studies open to the scrutiny of other researchers (Braun & Clarke, 2006).

In this study, articles and theses were analyzed. The main reasons for this are that the articles have gone through the peer-review process, and the theses have undergone jury evaluation.

Thus, publications with a high level of scientific rigor were analyzed. According to Day (1996), as cited in Özdeş et al. (2020), it is important to increase the objectivity and scientific rigor of publications that undergo editorial and peer-review processes. Therefore, it can be said that the analysis processes carried out in this study also contributed to its scientific rigor. CKCM studies presented at congresses, conferences, symposiums, etc. and abstracts or full texts published were not analyzed in this study. The main reason for this is that these publications are not subjected to detailed peer review and editorial review as articles and theses are, and it is impossible to access all papers published or presented because of the large number of congresses, symposiums, conferences, etc. This is one of the limitations of this study. However, there may be a risk of repetition in the analysis process because of the possibility of converting these papers into articles in the future. Considering these situations, we aimed to increase the reliability of the research by excluding these studies from the analysis.

Findings

This section presents the findings of the studies analyzed in the order of the research problems. The studies are presented in tables according to the structure of the codes and themes, with explanations provided for each table.

Table 2.

Distribution of Publications in CKCM Studies (1st Research Question)

Year of Publication	Publication Type		
	Articles	Master's Theses	Doctoral Theses
2011	1	-	-
2013	1	1	-
2014	1	-	2
2015	1	1	1
2016	2	-	1
2017	2	1	-
2018	3	1	2
2019	2	3	1
2020	2	1	-
2021	4		1
2022	2	1	
Total	21	8	8

According to Table 2, 21 articles, eight master's theses, and eight doctoral theses were accessed as a result of the review conducted in the relevant databases. The highest number of studies for all publication types was published in 2018 and 2019, and generally, the highest level of accumulation belonged to these years. When the theses (master's and doctoral) were examined together, it was observed that the highest number of theses were written in 2019. It was concluded that the first doctoral studies were published in 2014; the first master's - level study was published in 2015, with a fluctuating distribution in years in this publication type. More than half of the total number of theses were written, especially in 2017, 2018, and 2019. The first study was published in 2013, and it was found that most of the research was conducted in 2021. Publications of the article type have shown a balanced, increasing distribution over the years.

Table 3.

Educational Needs of CKCM Studies (2nd Research Question)

Needs	Studies	f
Need for adequate research on CKCM	R1; R2; R3; R4; R5; R6; R7; R8; R9, R10; R11; R13; R14; R16; R17; R19; R20; R21; R23; R24; R25; R26; R30; R33; R34; R35; R37	27
The need to examine the overlap between the Science Curriculum and CKCM	R2; R3; R4; R5; R6; R7; R8; R9; R10; R13; R14; R16; R17; R20; R24; R26; R29; R32; R33; R34; R31;	22
The need for more studies to examine the effect of CKCM on cognitive learning outcomes such as abstract concepts, alternative concepts, conceptual understanding, etc.	R1; R2; R4; R6; R8; R10; R11; R13; R14; R19; R20; R21; R25; R27; R29; R30; R31; R35; R36	19
To what extent CKCM improve different components of scientific literacy (NOS, SSI, etc.).	R3; R5; R7; R13; R14; R16 R20; R21; R24; R26; R27; R30; R31; R32; R34; R35	16
It provides the basis and materials for future work.	R2; R10; R13; R14; R17; R20; R28; R29; R33; R34	10
More detailed stakeholder views on the phase of CKCM, implementation results and potential problems (students, student teachers, teacher candidates, etc.)	R1; R3; R5; R6; R17; R18; R32	7

As shown in Table 3, the most frequently emphasized issue in CKCM studies was the need for adequate research. Kıryak (2013) reported that there were no prior studies on water pollution among the limited number of studies on CKCM. Another educational need for CKCM research is related to the overlap and balance between the Science Curriculum (SC), SSI, and CKCM. Ertuğrul (2015) stated that the nature of SC and CKCM overlapped to a large extent in the STSE learning area. The effect of CKCM in teaching difficult, abstract concepts and eliminating alternative concepts was another educational need put forward by researchers. Vural (2016), who included this justification in his research, stated that the effectiveness of CKCM should be explored in addressing students' lack of information and correcting their misconceptions in teaching acid and base concepts. Emphasizing the necessity of a teaching model based on the teaching of the nature of science, Bakırcı and Çiçek (2017) explained that this is one of the most important characteristics of CKCM. Sütlüoğlu Dursun (2019) reflected that as a new research topic, CKCM can be a basis for future research and can provide effective materials and added that teaching SSI with CKCM can especially provide this material diversity. Bakırcı and Çepni (2014), who reported knowing the phases of CKCM and the opinions of teachers about CKCM as the basic justification, emphasized the importance of examining the compatibility of CKCM features with SC features. Citing SSI, one of the most important learning outcomes of CKCM, as the main reason, Yıldırım (2018) emphasized the educational need for a teaching model based on teaching SSI, reporting that SSI was included in the third phase of the model.

Table 4.

Aims, Focuses and Specific Science Topics in CKCM Studies (3rd research question)

Studies in the Chronological Order	The Aim of Study			Focus of Studies	Specific Topic of Studies
	Descriptive	Intervention	Theoretical		
İyibil, (2011)		X		Energy teaching with CKCM	Energy
Kıryak, (2013)		X		The effect of CKCM on conceptual understanding	Water Pollution
Bakırcı and Çepni, (2014)			X	The place and applicability of CKCM in science curriculum	-
Benli Özdemir, (2014)		X		The effect of CKCM on cognitive-affective learning	Atom, Matter, Heat, Light, Human and Environ ment
Bakırcı, (2014)		X		Designing and applying suitable material for CKCM	Light and Sound
Bakırcı et al., (2015)	X			Opinions about CKCM	-
Ertuğrul, (2015)		X		The effect of CKCM on some learning outcomes	Light and Sound
Çavuş Güngören, (2015)		X		Learning and teaching the nature of science with CKCM	Nature of Science
Bakırcı et al., (2016)		X		The effect of CKCM on conceptual understanding	Celestial Bodies
Akgün et al., (2016)	X			Students' opinions about CKCM	-
Vural, (2016)		X		The effect of CKCM on conceptual understanding	Acid and Base
Bakırcı and Yıldırım, (2017)		X		The effect of CKCM on conceptual understanding	Greenhou se Effect
Bakırcı and Çiçek, (2017)		X		The effect of CKCM on the nature of science	Living Things
Yıldızbaş, (2017)		X		The effect of CKCM on academic achievement	Reflectio n of Light
Bakırcı and Ensari, (2018)		X		The effect of CKCM on conceptual understanding	Heat and Temperat ure

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Bakırcı et al., (2018)	X		Teaching SSI with CKCM	Human and Environment
Karabal, (2018)		X	The effect of CKCM on decision making and problem solving skills	SSI (Genetics, Global Warming, Nuclear Energy, Hydroelectric Power Plants)
Caymaz, (2018)		X	Teaching of electrical energy unit with CKCM	Electrical Energy
Yıldırım, (2018)		X	The effect of CKCM on the nature of science and entrepreneurial skills	Structure and Properties of Matter
Güzel and Uzunkaya, (2019)		X	The effect of CKCM on the nature of science	Sound
Çelik et al., (2018)	X		CKCM in science education laboratory applications	Laboratory Activities for Different Science Subjects
Bayar, (2019)		X	The effect of CKCM on academic achievement	Solar System and Eclipses
Sütlüoğlu Dursun, (2019)		X	Developing and evaluating teaching materials in accordance with CKCM	Sun, Earth and Moon
Atayeter, (2019)		X	The effect of CKCM on academic achievement and attitude towards science	Structure and Properties of Matter
Özden, (2019)		X	The effect of CKCM on multiple learning	Force and Energy
Uzunkaya, (2019)		X	The effect of CKCM on multiple learning	Sound
Çavuş-Güngören and Hamzaoğlu, (2020)	X		Pre-services teachers' opinions about CKCM	Nature of Science
Bakırcı et al., (2020)		X	The effect of CKCM on the scientific process skills	Biodiversity
Türk (2020)		X	Effect of CKCM on conceptual change	Systems in the Body

Duruk et al., (2021)	X	Impact of CKCM on students' understanding of heat transfer	Heat Transfer
Haydari, (2021)	X	CKCM supported by out-door education	Human and Environ ment
Haydari and Coştu, (2021)	X	The effect of CKCM on problem solving skills	Biodivers ity
Yurtbakan et al., (2021)	X	Conceptual growth of fourth grade students'	Organic and Non-organic Food
Balaban and Özdemir, (2021)	X	The effect of CKCM on conceptual understanding	Water Pollution
Palta, (2022)	X	The effect of CKCM on understanding of radioactivity	Radioacti vity
Balaban et al., (2022)	X	The effect of CKCM students' understanding	Chemical Reactions and Enthalpy
Sungur Alhan, (2022)	X	The effect of CKCM based instruction on lesson planning	Prepearin g Lesson Plan for Different Science Subjects

CKCM studies published in Türkiye were categorized according to their general purpose as Descriptive, Intervention, and Theoretical.

Descriptive Studies:

Table 4 shows that four of the studies examined were descriptive. Bakırcı et al. (2015) identified the views of science teachers about CKCM, Akgün et al. (2016) determined the views of sixth-grade students, and Çavuş Güngören and Hamzaoğlu (2020) studied the views of teacher candidates. Bakırcı et al. (2018) examined the views of seventh-grade students at the end of a process in which SSIs were taught through CKCM. Çelik et al. (2018), in a comparative study of different inquiry-based teaching models, revealed the critical views of pre-service science teachers about CKCM.

Intervention Studies:

The majority of CKCM studies were designed as intervention studies, owing to the characteristics of the model. While some of these studies were designed to teach a specific science subject or unit (Ertuğrul, 2015; İyibil, 2011; Kıryak, 2013), others were designed for teaching units covering more than one subject and outcome (Benli Özdemir, 2014; Çelik et al., 2018). In addition to studies aiming to improve subject content knowledge, some CKCM studies aimed at improving different learning outcomes (NOS, SSI, etc.) are also included in the literature (Çavuş Güngören, 2015; Karabal, 2018). Some of these studies also aimed to develop skills (critical thinking, logical thinking, scientific process skills, etc.) with different educational outcomes (Bakırcı and Çepni, 2016; Bakırcı et al., 2020; Yıldızbaş, 2017).

Theoretical Studies:

Bakırcı and Çepni (2014) analyzed the structural features, similarities, and commonalities of CKCM and SC in their study, focusing on introducing the characteristics and phases of the model rather than collecting data on CKCM.

Table. 5

Methods and Sampling of the CKCM Studies (4th Research Question)

Studies in the Chronological Order	Methods of the Studies							Sample / Research Group
	Case Studies	Phenomelogical	Document	Mixed Method	Experimental	Action Research	Unspecified	
İyibil, (2011)					X			7th Grade Students (42)
Kıryak, (2013)				X				7th Grade Students (25)
Bakırcı and Çepni, (2014)			X					Science Curriculum
Benli Özdemir, (2014)				X				7th and 8th Grade Students (87)
Bakırcı, (2014)					X			6th Grade Students (76)
Bakırcı et al., (2015)							X	Science Teachers (15)
Ertuğrul, (2015)				X				6th Grade Students (121)
Çavuş Güngören, (2015)	X							Pre-Service Science Teachers (41)
Bakırcı et al., (2016)					X			7th Grade Students (40)
Akgün et al., (2016)		X						Middle School Students (5)
Vural, (2016)						X		Gifted Students (79)
Bakırcı and Yıldırım, (2017)					X			7th Grade Students (25)
Bakırcı and Çiçek, (2017)					X			5th Grade Students (32)
Yıldızbaş, (2017)				X				6th Grade Students (64)
Bakırcı and Ensari, (2018)					X			9th Grade Students (60)
Bakırcı et al., (2018)	X							7th Grade Students (25)
Karabal, (2018)					X			Pre-Service Science Teachers (67)
Caymaz, (2018)					X			7th Grade Students (62)
Yıldırım, (2018)				X				8th Grade Students (50)

Çelik et al., (2018)	X			X	Pre-Service Science Teachers (40)
Güzel and Uzunkaya, (2019)			X		6th Grade Students (57)
Bayar, (2019)			X		6th Grade Students (83)
Sütlüoğlu Dursun, (2019)					5th Grade Students (27)
Atayeter, (2019)			X		4th Grade Students (39)
Özden, (2019)		X			7th Grade Students (29)
Uzunkaya, (2019)		X			6th Grade Students (57)
Çavuş-Güngören and Hamzaoğlu, (2020)	X				Pre-Service Science Teachers (25)
Bakırcı et al., (2020)			X		5th Grade Students (36)
Türk (2020)			X		6th Grade Students (60)
Duruk et al., (2021)			X		6th Grade Students (30)
Haydari (2021)		X			5th Grade Students (27)
Haydari and Coştu, (2021)			X		5th Grade Students (74)
Yurtbakan et al., (2021)			X		4th Grade students (20)
Balaban and Özdemir, (2021)			X		Pre-Service Science Teachers (18)
Palta, (2022)			X		Pre-Service Science Teachers (48)
Balaban et al., (2022)			X		11th Grade Students (54)
Sungur Alhan, (2022)			X		Pre-Service Science Teachers (29)

According to Table 5, experimental research is the most frequently used method in CKCM studies. The experimental method was adopted in one study at the primary school level, 12 studies at the secondary school level, two studies at the high school level, and four studies at the university level (for pre-service teachers). Mixed studies in which qualitative and quantitative data collection tools were used together were included eight times. All these studies were conducted at the secondary school level.

It was concluded that few methods, other than experimental and mixed research methods, have been adopted in CKCM research. Three studies were conducted with a case study, one with a phenomenological study, one with action research, and one with document analysis.

Table. 6

Data Collection Tools of the CKCM Studies (5th Research Question)

	Inter	Obse	Docu	Paper-Pencil Test	Skill Tests/ Inventories	Alternative Techniques

Studies in the Chronological Order				Scales and Questionnaires	Achievement Test	Conceptual Understanding Test	Open-Ended Questions	Critical Thinking	Scientific Process Skill	Problem Solving	Others Skills Test	WAT	Rubrics	Others
İyibil, (2011)					X							X		X
Kıryak, (2013)	X					X						X		
Bakırcı and Çepni, (2014)			X											
Benli Özdemir, (2014)	X	X		X	X	X			X			X		X
Bakırcı, (2014)	X			X	X	X		X	X			X		
Bakırcı et al., (2015)	X													
Ertuğrul, (2015)				X	X						X			
Çavuş Güngören (2015)	X	X	X	X			X							X
Bakırcı et al., (2016)					X	X						X		
Akgün et al., (2016)	X													
Vural, (2016)		X		X		X	X						X	
Bakırcı and Yıldırım, (2017)					X	X								
Bakırcı and Çiçek, (2017)	X			X										
Yıldızbaş, (2017)				X	X	X		X						
Bakırcı and Ensari, (2018)					X	X								
Bakırcı et al., (2018)	X						X							
Karabal, (2018)	X									X	X			
Caymaz, (2018)	X			X	X	X								
Yıldırım, (2018)	X			X							X			
Çelik et al., (2018)							X							
Bayar, (2019)					X				X					
Sütlüoğlu Dursun, (2019)	X				X									
Atayeter, (2019)				X	X									
Özden, (2019)	X		X	X		X					X		X	
Uzunkaya, (2019)		X		X	X	X		X						
Çavuş-Güngören and Hamzaoğlu, (2020)	X						X							
Bakırcı et al., (2020)								X	X					
Türk, (2020)				X		X								
Duruk et al., (2021)						X								
Haydari, (2021)	X			X		X				X				
Haydari and Coştu, (2021)										X				

Yurtbakan et al., (2021)			X	
Balaban and Özdemir, (2021)			X	
Palta, (2022)		X		
Balaban et al., (2022)	X	X		
Sungur Alhan, (2022)				X

Interviews

Interviews (Semi-structured) were used as data collection tools in 15 CKCM studies. These studies revealed in-class applications of CKCM (Bakırcı & Çiçek, 2017) and opinions on learning outcomes, such as NOS and SSI (Bakırcı, 2014; Çavuş Güngören, 2015). Additionally, situations such as students' decision-making tendencies (Karabal, 2018); their views on the sun, earth, and moon (Sütlüoğlu Dursun, 2019); and their perspectives on lesson plans prepared with CKCM (Çavuş Güngören & Hamzaoğlu, 2020) were uncovered through semi-structured interviews.

Observation

Observations were used as a data collection tool in five CKCM studies. In two different studies (Benli Özdemir, 2014; Uzunkaya, 2019), students' behaviors, feelings, and thoughts during the lessons were observed. Additionally, Çavuş Güngören (2015) used observations to evaluate pre-service teachers' teaching skills related to CKCM and Vural (2016) used observations to evaluate students' performance.

Documents

Documents were used as data collection tools in the three CKCM studies. Specifically, Bakırcı and Çepni (2014) analyzed SC content for its alignment with CKCM. Çavuş Güngören (2015) examined lesson plans created by pre-service teachers for CKCM implementation. Özden (2019) included lesson plans that demonstrated the utilization of student materials and the coverage of subjects aligned with CKCM phases.

Paper-Pencil Test

Scales and Questionnaires: Questionnaires and scales were used as data collection tools in 15 studies on CKCM. In this context, questionnaires and scales revealing views on NOS are most frequently used (Bakırcı, 2014; Benli Özdemir, 2014; Caymaz, 2018; Çavuş Güngören, 2015; Türk, 2020; Uzunkaya, 2019; Yıldızbaş, 2017). Additionally, various scales have been employed to reveal students' environmentally responsible behaviors, affective tendencies (Haydari, 2021), and attitudes (Atayeter, 2019; Balaban et al., 2022; Özden, 2019; Vural, 2016).

Achievement Test: Achievement tests were used as a data collection tool in 13 studies on CKCM. An academic achievement test was used for the subject of Light and Sound in three studies (Bakırcı, 2014; Ertuğrul, 2015; Yıldızbaş, 2017). Özdemir (2014) used an academic achievement test that covered more than one science subject in the data collection process. İyibil (2011) used an academic achievement test as a data collection tool on Energy, Bakırcı et al. (2016) on Celestial Bodies, Bakırcı and Yıldırım (2017) on the Greenhouse Effect, Caymaz (2018) on Electric Energy, Bakırcı and Ensari (2018) on Heat and Temperature, Sütlüoğlu Dursun (2019) on the Sun, the

Earth, and the Moon, Atayeter (2019) on the Structure and Properties of Matter, and Bayar (2019) on the Solar System and Eclipses.

Conceptual Understanding Test: Conceptual understanding tests were used as a data collection tool in 14 studies on CKCM. A two-tier conceptual understanding test was used as a data collection tool in two of these studies (Bakırcı, 2014; Benli Özdemir, 2014). Kıryak (2013) used conceptual understanding tests for Water Pollution as a data collection tool, Bakırcı et al. (2016) for Celestial Bodies, Vural (2016) for Acids and Bases, Yıldızbaş (2017) for Reflection of Light, Bakırcı and Yıldırım (2017) for the Greenhouse Effect, Caymaz (2018) for Electric Energy, Bakırcı and Ensari (2018) for Heat and Temperature, Uzunkaya (2019) for the Sound Unit, Özden (2019) for Force and Energy Unit, Türk (2020) for Systems in the Body, Haydari (2021) for Human and Environment, and Balaban et al. (2022) for Chemical Reactions and Enthalpy Unit.

Open-Ended Questions: Open-ended questions were used as data collection tools in five studies on CKCM. Çavuş Güngören (2015) also collected data with open-ended questions in parallel with the interview process conducted on the nature of science. Vural (2016) used 6 open-ended questions to examine students' prior knowledge at the beginning of CKCM. Bakırcı et al., (2018) collected data with 11 open-ended questions based on SSIs encountered by students in daily life. Çavuş Güngören and Hamzaoğlu (2020) asked open-ended questions to pre-service science teachers to collect data on the characteristics and limitations of the lesson plans prepared with CKCM.

Skill Tests/Inventories

It was concluded that seven different skill tests (inventories) were used as data collection tools 12 times in studies on CKCM. Critical thinking skills tests were used in four studies conducted with 6th graders (Bakırcı, 2014; Bakırcı et al., 2020; Uzunkaya, 2019; Yıldızbaş, 2017). The science process skill tests are among the most frequently used skill tests. Scientific process skill tests for different grade levels were used in four studies (Bakırcı, 2014; Bakırcı et al., 2020; Bayar, 2019; Benli Özdemir, 2014). However, problem-solving skills tests have been used in three different studies (Haydari, 2021; Haydari & Coştu, 2021; Karabal, 2018). As data collection tools, Ertuğrul (2015) used a logical thinking group test, Karabal (2018) used a decision-making inventory, Yıldırım (2018) used an entrepreneurship scale, and Özden (2019) used a scientific inquiry skill test.

Alternative Techniques

It was concluded that alternative assessment and evaluation techniques were used as data collection tools, seven times in six different studies on CKCM. The Conceptual Change WAT (CC-WAT) was used as a data collection tool to observe conceptual changes in five studies (Bakırcı, 2014; Bakırcı et al., 2016; Balaban and Özdemir, 2021; Benli Özdemir, 2014; İyibil, 2011; Kıryak, 2013; Yurtbakan et al., 2021). Vural (2016) used rubrics to evaluate student performance within the scope of the CKCM, while Özden (2019) used rubrics to evaluate students' psychomotor learning. Sungur Alhan (2022), also used rubrics to evaluate the lesson plans of pre-service science teachers. İyibil (2011) used concept maps to reveal the knowledge structure in students' minds, while Benli Özdemir (2014) used drawings. Çavuş Güngören (2015) collected data with diaries reflecting pre-service teachers' experiences and opinions.

Table 7.

Specific Teaching Techniques Used in CKCM Studies (6th Research Question)

Studies in the Chronological Order	Phases of the CKCM				
	Exploring and Categorizing	Constructing and Negotiating	Extending and Translating	Reflecting and Assessing	Phase Not Specified
İyibil, (2011)	Unspecified	Unspecified	Unspecified	Unspecified	-
Kıryak, (2013)	Visualizations (poster, board etc.),	P(E)OE, Experiment	Group Discussion	Visualizations, Project	
Benli Özdemir, (2014)	Unspecified	Unspecified	Unspecified	Unspecified	Unspecified
Bakırcı, (2014)	WAT, Group Discussion	P(E)OE	CCT, Worksheets (for NOS)	SG, DBT, WAT	Worksheets
Ertuğrul, (2015)	Unspecified	Unspecified	Unspecified	Unspecified	Worksheets
Bakırcı et al. (2016)	Worksheets, OEQ	P(E)OE	CCT, Worksheets (for SSI)	SG, DBT	
Akgün et al. (2016)	Unspecified	Unspecified	Unspecified	Unspecified	Worksheets
Vural (2016)	Visualizations (Clipboard Cards, Pictures etc.),	Station Technique, P(E)OE	Group Discussion, Games	Worksheets	
Bakırcı and Yıldırım, (2017)	Brainstorming, WAT	Worksheets, Analogies	Videos, CCT	DBT, SG, CM	
Bakırcı and Çiçek, (2017)	Brainstorming, WAT	Worksheets, Analogies	Videos, Animation, Brainstorming	CM, DBT, SG	
Yıldızbaş, (2017)	WAT, Brainstorming	P(E)OE, Resim.	CCT, Worksheets (for SSI and NOS)	WAT, SG, DBT	
Bakırcı and Ensari, (2018)	Brainstorming, WAT	P(E)OE, Analoji, Worksheets	CCT, Group Discussion, NOS Teaching	WAT, SG, DBT	
Bakırcı et al. (2018)	Visualizations, WAT	Visualizations (Pictures)	Worksheets, Group Discussion	WAT, SG, DBT	
Karabal, (2018)	Unspecified	Unspecified	Unspecified	Unspecified	Worksheets
Caymaz, (2018)	Drawing, Worksheets	P(E)OE, CC, CCT	Case Study, CC, NOS Teaching	SG, CC	
Yıldırım, (2018)	WAT, Worksheets (for NOS)	P(E)OE, Worksheet	Discussion, Analogy, CC	WAT, SG, DBT	
Çelik et al. (2018)	Unspecified	Unspecified	Unspecified	Unspecified	
Bayar, (2019)	Unspecified	Unspecified	Unspecified	Unspecified	Worksheets
Sütlüoğlu Dursun, (2019)	OEQ, Worksheet	Augmented Reality	Modelling, Discussion	Poster	
Atayeter, (2019)	WAT, Worksheets	P(E)OE	Case Study, Discussion	DBT	
Özden, (2019)	WAT	P(E)OE, Animation	Video, CC, CCT	DBT, OEQ, WAT	
Uzunkaya (2019)	WAT, CC	P(E)OE, CC	Analogy, CC, CCT, SG, DBT	DBT	

Çavuş-Güngören and Hamzaoğlu, (2020)	Group Discussion, Question-Answer	Problem solving	Case Study	Group Discussion
Bakırcı et al. (2020)	Question-Answer, Brainstorming	Discussion, Videos	Discussion	CM, SG, DBT
Türk, (2020)	Question-Answer	Poster, banner etc.	Not employed	Not employed
Haydari, (2021)	Brainstorming, WAT, Videos, Question-Answer	P(E)OE, Worksheets	Worksheets (for SSI and NOS), Games	DBT, SG, WAT
Duruk et al. (2021)	Brainstorming. Discussion,	P(E)OE, Worksheets	Not employed	Not employed
Haydari and Coştu, (2021)	Brainstorming, Videos, WAT	P(E)OE, Videos. Games	Worksheets (for SSI), Out-of-School Activities	WAT, DBT
Yurtbakan et al. (2021)	WAT, Mind Maps	P(E)OE, News, videos	News, Videos etc.	WAT
Balaban and Özdemir, (2021)	Brainstorming, WAT	Group Discussion	Group Discussion, Videos	WAT
Palta, (2022)	Visualizations (Poster, photos etc)	P(E)OE, Virtual Experiments	Virtual Experiments	Online match tests,
Balaban et al. (2022)	Question-Answer	P(E)OE	Graphics	Multiple choice
Sungur Alhan, (2022)	Unspecified	Unspecified	Unspecified	Unspecified

Concept Map (CM), Concept Cartoon (CC), Conceptual Change Text (CCT), Predict-(Explain)-Observe-Explain (P(E)OE), Word Association Test (WAT), Structural Grid (SG), Diagnostic Branched Tree (DBT), Open-Ended Questions (OEQ)

The First Phase of the CKCM, Exploring and Categorizing

The most frequently used techniques in exploring and categorizing, the first phase of CKCM, were the Word Association Test (WAT) (Bakırcı, 2014; Haydari and Coştu, 2021; Yıldızbaş, 2017) to identify students' prior knowledge and cognitive structures, and Brainstorming (Balaban and Özdemir, 2021; Haydari, 2021) to attract students' interest and attention to the lesson. There are also a few studies that include question-answer, visualization, and group discussion activities (Kıryak, 2013; Palta, 2022; Türk, 2020).

The Second Phase of the CKCM, Constructing and Negotiating

Predict-(Explain)-Observe-Explain (P(E)OE) was the most frequently used technique for Constructing and Negotiating the second phase of the CKCM. In most studies, processes such as the exchange of ideas and discussions between students and teachers have been conducted through P(E)OE (Atayeter, 2019; Balaban and Özdemir, 2021; Caymaz, 2018; Duruk et al., 2021; Haydari and Coştu, 2021; Uzunkaya, 2019; Vural, 2016; Yıldırım, 2018). The techniques used were approximately equally distributed. Vural (2016) used stations; Bakırcı and Yıldırım (2017) used analogy through worksheets; Yıldızbaş (2017) used discussions through the pictures they presented; Caymaz (2018) used concept cartoons and conceptual change text; Sütlüoğlu Dursun

(2019) used augmented reality applications; and Özden (2019) used question-answer and discussion activities.

The Third Phase of the CKCM, Translating and Extending

The third phase of CKCM, Translating and Extending, includes frequently used concept teaching techniques in the literature. Conceptual change texts and concept cartoons are the most frequently used techniques (Bakırcı & Ensari, 2018; Caymaz, 2018; Özden, 2019; Uzunkaya, 2019). However, it was observed that the use of various teaching activities, which is one of the most important features of CKCM, emerged during this phase. Different techniques, such as analogies, visualization tools (videos, graphics, modeling, etc.), discussions on the nature of science and SSIs, and games, were applied during this phase.

The Fourth Phase of the CKCM, Reflecting and Assessing

Alternative measurement and evaluation techniques are included in Reflecting and Assessing, the fourth phase of CKCM. The intended use of these techniques within the scope of CKCM is shown in table below.

Table 7.1.

Purposes of use of assessment and evaluation tools used within the scope of CKCM

Purpose of Using the Techniques	*DBT*	*SG*	*CM*	*WAT*	*Others*
Identifying and removing misconception	R8; R10; R14; R21	R8; R14; R22	R14		R29
Measuring meaningful learning	R7	R10; R7	R7		
Evaluating learning at the end of the teaching process	R2; R3; R9; R26; R34	R3; R9; R26; R34,	R9; R26		R26; R29
Identifying how concepts are structured in the mind	R22; R31; R35	R22; R31; R35		R9	
Ideation, discussion and evaluation of emerging products					R25; R33, R28; R36
Observing conceptual change				R2; R8; R9; R10; R13; R21; R22; R26; R31; R34; R35; R37	

Diagnostic Branched Tree (DBT), Structural Grid (SG), Word Association Test (WAT), Concept Map (CM), Others (Poster, Project, Group Discussion etc.)

Table 8.

Results of the CKCM Studies (7th Research Question)

	Results	Studies	f
Positive Results	CKCM is effective in increasing academic achievement and permanent learning.	R1; R2; R5; R8; R10; R11; R12; R13; R14; R16; R17; R20; R22; R26; R27; R29; R30; R31; R33; R34; R35	22

	CKCM is effective in improving scientific literacy.	R3; R7; R10; R13; R14; R16; R17; R20; R22; R25; R26; R30; R31; R33; R34; R35, R36	17
	CKCM is effective in eliminating alternative concepts, conceptual change and conceptual understanding.	R1, R3; R4; R5; R6; R8; R10; R11; R12, R13; R14; R19; R20; R22; R23; R25; R26; R27; R29; R30; R33; R35; R36, R37	14
	CKCM is effective in skill development. (Critical thinking, logical thinking, decision making, problem solving, entrepreneurship, scientific inquiry, scientific process)	R8; R9; R10; R18; R20; R21; R22; R24; R26; R31; R34; R35	11
	CKCM is effective in affective learning.	R1; R2; R12; R13; R16; R21; R26, R33	8
	CKCM is a usable model for different learning environments and contents.	R6; R10; R17; R21; R25; R26; R28; R30	8
	CKCM is effective in interdisciplinary science teaching.	R3; R6; R17; R24; R28; R34	6
	Science curriculum compatible with CKCM	R5; R6; R17; R21; R26	5
Negative Results	Partial or insufficient learning	R7; R19; R21; R24; R26; R28; R29	7
	CKCM stages are time-consuming and detailed	R6; R10; R16; R17; R18; R23	6
	Not suitable for teaching some SSIs	R6; R10; R14; R16; R17; R28	6
	Difficulties in implementation	R16; R17; R18; R28	4

Positive Results for CKCM

Studies on the CKCM have mostly yielded positive results. The most frequently cited positive outcome was the effect of CKCM on increasing academic achievement and providing permanent learning. Another positive result is the effectiveness of CKCM in improving scientific literacy. According to these results, which point to the development of various subdimensions of scientific literacy through CKCM, it was concluded that students had more scientific views and replaced their daily language with scientific language at the end of the courses conducted with CKCM (Kıryak, 2013). Özden (2019) found that CKCM contributed significantly to the development of students' views on scientific knowledge. Additionally, many studies have revealed that the understanding of the nature of science, one of the most important sub-dimensions of scientific literacy, was developed with the help of CKCM (Bakırcı, 2014; Yıldızbaş, 2017; Caymaz, 2018; Uzunkaya, 2019; Türk, 2020; Haydari, 2021).

One of the important results for CKCM in this study was related to its effectiveness in developing different skills. The reviewed studies have demonstrated the effectiveness of CKCM on scientific process skills (Bakırcı, 2014; Bakırcı et al., 2020; Bayar, 2019; Benli Özdemir, 2014). Similarly, many studies have emphasized the effectiveness of CKCM in improving critical thinking skills (Uzunkaya, 2019; Yıldızbaş, 2017). Karabal (2018) revealed the effectiveness of CKCM on problem-solving and decision-making skills, Ertuğrul (2015) on logical thinking skills, Yıldırım (2018) on entrepreneurship skills, and Özden (2019) on scientific inquiry skills.

Some studies have revealed the effectiveness of CKCM in eliminating alternative conceptions, promoting conceptual change, and enhancing conceptual understanding of science subjects. Kıryak (2013) reported that CKCM provided an effective learning environment for eliminating alternative concepts. Based on teachers' opinions, Bakırcı et al. (2015) concluded that CKCM ensured conceptual change, while Vural (2016) stated that activities and materials developed in accordance with CKCM increased students' conceptual understanding.

Another positive finding of CKCM is its applicability to different learning environments. According to Bakırcı et al. (2015), this model has multidisciplinary features. Based on students' opinions, Akgün et al. (2016) reported that CKCM can be used in other courses. Hamzaoğlu and Çavuş Güngören (2020) also stated that CKCM can be used for topics such as science and engineering applications, the environment, and so on.

Some studies have demonstrated the effectiveness of CKCM in different learning domains, focusing on affective learning. Accordingly, Akgün et al. (2016) stated that lessons became more enjoyable in discussion (negotiation) environments created with CKCM. Atayeter (2019) mentioned that the implementation of teaching activities prepared with CKCM increased students' interest in and attitudes towards science lessons. Özden (2019) concluded that CKCM provided positive contributions in affective areas, such as fostering positive feelings towards science, stimulating curiosity about science, and promoting the desire to learn science.

One of the important characteristics of CKCM is its ability to address various science-related disciplines from a holistic (interdisciplinary) perspective, as reflected in the research results. Bakırcı et al. (2018) revealed that CKCM, when applied to SSIs such as organic foods, environmental problems, technology addiction, and nuclear power plants, was effective in developing students' abilities to solve daily life problems. Çavuş Güngören and Hamzaoğlu (2020) reported that pre-service teachers stated that CKCM allowed for associations with Science-Technology-Society-Environment.

Emphasizing the research results that reveal the compatibility between Sience Curriculum (SC) and CKCM, Bakırcı and Çepni (2014) reported that the approaches used in vision, purpose, measurement, evaluation, etc., in science education were largely similar to the theoretical foundations of CKCM. Özden (2019) emphasized that the nature of science education and the features of CKCM largely overlap.

Negative Results for CKCM

The research presented negative results in addition to the positive results revealed in studies conducted on CKCM. One of the most frequently highlighted negative results was the lack of suitability of CKCM for teaching about all SSIs. In Bakırcı's (2014) study, teachers stated that associating every subject with SSI was difficult, while in Hamzaoğlu and Çavuş Güngören's (2020) study, pre-service teachers stated that CKCM cannot be applied to all subjects. The literature also includes research results showing that some learning may be insufficient because of CKCM practices. Bakırcı and Çiçek (2017) found that the development of some aspects of the nature of science remained at a low level for a small number of students at the end of CKCM education.

Karabal (2018) reported that education with CKCM could not provide sufficient development for some subdimensions of the decision-making tendencies of pre-service teachers, and Sütlüoğlu Dursun (2019) concluded that some misconceptions or alternative conceptions still persisted at the end of teaching with CKCM. One of the frequently emphasized negative results for CKCM is related to the time-consuming and detailed nature of some of the phases. İyibil (2011) stated that the duration of science courses is insufficient to use this model. Two different studies have emphasized that exploring and categorizing phases is too time-consuming (Bakırcı, 2014). Çavuş Güngören (2015) reported that teachers should have more information to apply the model, while Çavuş Güngören and Hamzaoğlu (2020) concluded that CKCM implementation may be difficult in classes that are overcrowded or have students with many individual differences.

Conclusion and Discussion

It was concluded that, regarding publication type, articles were published most frequently in the CKCM studies carried out in Türkiye within the scope of science education. Although the number of articles published in all years was found to be similar, there has been a partial increase, especially since 2014. The compatibility of the Science Curriculum (SC) updated in 2013 with the CKCM may be an important reason for this increase. This compatibility has been presented as the need for CKCM research in many studies (Balaban and Özdemir, 2021; Benli Özdemir, 2014; Ertuğrul, 2015; Karabal, 2018; Vural, 2016). It can be argued that the changing objective structures in the SC are suitable for teaching with CKCM (for example, emphasizing the SSI and the nature of science) and may guide further research. In addition, theses may have been published later (as of 2014) than articles because of the narrow scope of the articles compared to the theses. Küçüközer (2016), who reached similar conclusions supporting this finding, stated that the number of postgraduate theses conducted in the field of science education increased immensely in 2014. The increase and diversity of theses may parallel the increasing number of faculty members in science education departments in Türkiye (Aybek, 2023).

The most frequently cited educational need in the analyzed CKCM studies was the small number of studies. This issue has also been included in different review studies (Ültay & Ültay, 2014). Another frequently emphasized need was the overlap and harmony of SC and CKCM, especially concerning the nature of science, SSI, and the strong emphasis on alternative techniques in assessment and evaluation (Çavuş Güngören & Hamzaoğlu, 2020; Özden, 2019). Another educational need for CKCM studies is related to its effect on teaching abstract concepts, eliminating alternative concepts, and improving conceptual understanding. This impact, which is one of the main reasons for the many different teaching models and approaches used in the literature, was proposed by researchers in CKCM. Specifically, researchers have highlighted the similarity between CKCM and different models, such as the 5E Learning Cycle and Context-Based Learning, along with similar needs presented for all these models (Çavuş Güngören, 2015; Uzunkaya, 2019). Additionally, this need may have been cited frequently because of the frequent use of concept teaching techniques (POE, CC, CCT, etc.) in the second and third phases of CKCM.

The nature of science and SSI is an important requirement in CKCM studies. These needs may have been presented because these two learning outcomes, which have been an active research topic in Türkiye over the last 20 years, were handled together in CKCM (Bakırcı et al., 2017). In particular, both the nature of science and the increasing tendency towards intervention (developmental) research on SSI may provide another rationale for CKCM studies (Han Tosunoğlu & İrez., 2019; Özcan, 2013).

Among the reviewed studies, 29 were designed as interventions (experimental, mixed, and action research methods), in accordance with the nature of CKCM. Most of these studies have aimed to develop students' academic achievement, conceptual understanding levels, and various skills (scientific process skills, problem-solving skills, etc.). In addition to covering basic scientific content such as Light, Sound, Solar System, and Celestial Bodies, there was an aim to develop knowledge and skills related to SSI-based environmental issues (Water Pollution, Greenhouse Effect, Global Warming, Human and Environment Relationship).

While the views of teachers and students were included in five descriptive studies that were reviewed, the compatibility of CKCM with SC was introduced in one theoretical study. Experimental research is generally used to teach science subjects in science education literature. In this context, the reason why the majority of CKCM studies were designed experimentally may be related to their impact on teaching various science subjects. Similarly, the quantitative dimension in mixed studies has been designed experimentally in many cases. Since these mixed studies were mostly comprehensive master's and doctoral theses, they were also supported by qualitative data-collection processes.

The most frequently used data collection tools in CKCM studies are achievement tests, conceptual understanding tests, questionnaires, and interviews. This situation is also encountered in studies outside the Turkish sample (Candaş and Çalık, 2023). While achievement tests and conceptual understanding tests were used for the science subject content, questionnaires and scales were used to assess different skills. Questionnaires, scales, achievement tests, and conceptual understanding tests are data collection tools used in educational research, usually in experimental research with a pre-test-post-test control design. Considering that the most frequently used method for CKCM is experimental research, it can be argued that these data collection tools are suitable for CKCM. Interviews were mostly used for qualitative data collection processes in mixed studies and case studies, in which the opinions of participant groups were obtained. The frequent use of alternative assessment and evaluation techniques is a striking finding of the data collection tools used in CKCM studies. Many studies have used WAT, which is used to reveal conceptual change (Kıryak & Çalık, 2018), as a pre-test and post-test in CKCM research.

In the first phase, lessons were introduced using different techniques. Alongside techniques such as WAT, discussion, brainstorming, and visualization techniques such as drawings and posters are frequently used. It can be said that this diversity in the studies examined within the scope of this research is in line with the aim of revealing students' multiple ideas, which is one of the features of the first stage of the CKCM.

The striking finding in the second stage was the frequency of use of the P(E)OE technique (17 times). In the third stage of CKCM, the frequency of use of concept teaching techniques, such as CCT, CCs, analogies, and case studies, draws attention. In the last phase of CKCM, alternative measurement evaluation techniques are included. While DBT, SG, WAT, and CMs were most frequently included in this phase, performance tasks, such as projects and posters, were used less frequently.

In general, positive results were obtained in CKCM studies. The most common positive outcome was increased academic achievement. Similar results have also been reported in review studies conducted on different teaching models (Bağ & Çalık, 2017; Ültay & Çalık, 2012). The development of many sub-dimensions of scientific literacy (such as the nature of science and scientific inquiry) was another positive result of the reviewed research. Additionally, the positive effects of CKCM on various educational skills (including critical thinking skills, problem-solving skills, scientific process skills, etc.) and affective factors (such as attitude, curiosity, interest, etc.) were reported in the reviewed studies.

There were also negative results in the reviewed CKCM studies, although these were few. In particular, studies emphasizing that not all science content is suitable for SSI teaching are noteworthy (Bakırcı & Çepni, 2014; Caymaz, 2018). The reason for this negative finding may be related to the fact that some subject/outcome content in the SC is directly related to SSI, whereas the SSI association is left to teachers in other subject/outcome content. Other negative results highlighted in these studies were related to the fact that some CKCM phases were too time-consuming and there were implementation difficulties due to teacher competencies. Bağ and Çalık (2017) reached similar negative results in their review study conducted on argumentation studies.

Suggestions for New CKCM Research/Researchers

The experimental research method was the most frequently used in the reviewed CKCM studies. Although this was compatible with the nature of CKCM research, the number of mixed and action research studies, which use similar developmental methods, could be increased. In action research, where the roles of researchers and teachers are the same, CKCM can be used to solve problems that teachers (including teachers, academics, and experts) identify in their own science learning environments.

One of the most frequently cited negative findings in the conclusion sections of CKCM studies was the lack of SSIs directly related to science subject content. Examples of CKCM can be used to teach SSIs associated with specific science topics in textbooks, current science teaching resources, academic articles, theses, etc.

It is recommended to use alternative assessment and evaluation techniques to reflect and assess CKCM phases. On the other hand, questionnaires, scales, achievement tests, etc., which have been used many times in the literature, are also included as data collection tools in the reviewed CKCM studies. It is thought that using the alternative assessment and evaluation techniques recommended for use in the reflecting and assessing phases as a data collection tool would be more appropriate for the nature of CKCM.

The study groups/samples of the studies reviewed here mostly consisted of students at the secondary school level (grades 5th, 6th, 7th, and 8th grades). Science teaching practices of CKCM at the basic education level (in the 3rd and 4th grades) can also be included. In addition, studies can be conducted on physics, chemistry, and biology teaching practices at the high school level (in the 9th, 10th, 11th, and 12th grades).

The CKCM studies reviewed within the scope of this research were mostly carried out before the COVID-19 pandemic. CKCM studies can be conducted in accordance with hybrid teaching processes, which are predicted to be an important part of general education in the future.

Tools, applications, and visualization materials that are compatible with these hybrid processes can be developed for CKCM research.

Suggestions for Science Teacher Education/Educators

Another negative finding in the reviewed studies was related to the lack of teacher competencies in CKCM. It is suggested that various applications of this model, which can be considered new in the national literature, should be emphasized in undergraduate science teacher training programs and professional training courses for current teachers. One of the most important features of CKCM is that different teaching techniques and materials can be used within the model's scope. Accordingly, different and enriched teaching activities specific to each phase of the model can be included in educational resources, such as textbooks and articles.

Suggestions for New Descriptive Content Analysis Studies

The phases of CKCM are partially similar to other instructional models (such as the 5E learning cycle and context-based learning, etc.). Comparative descriptive and thematic analyses can be conducted to reveal how these models are used in science education research. Thus, the advantages and disadvantages of each instructional model can be revealed in light of research data, and suggestions can be made about which instructional model is effective for which science subjects.

Some of the parameters identified for CKCM in this study can be examined in greater depth. For example, the data analysis methods used in the studies, statistical analyses, researchers' recommendations/suggestions, etc., can be presented in detail. Additionally, some parameters that were not addressed in this study (such as the analysis of studies and grade levels) can be included in the research delimitations in new CKCM descriptive and thematic analysis studies.

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Geniş Özet

Problem Durumu

Etkili fen öğretimi için öğrencileri öğrenme ortamlarında aktif kılan, bilgiyi kendilerinin keşfedip yapılandırmalarını sağlayan yaklaşımlardan bir tanesi Ortak Bilgi İnşa Modeli'dir (OBİM). Özellikle son yıllarda birçok spesifik fen konu içeriğinin öğretimi için kullanılan OBİM, farklı düzeylerdeki eğitim kademeleri için gittikçe yaygınlaşmakta ve popülerlik kazanmaktadır. OBİM'in farklı fen konuları, öğrenme alanları ve becerileri için uygulamalarını ortaya koyan birçok çalışmaya alan yazında yer verilmiştir. Ebenezer ve diğ. (2010), boşaltım sistemi konusundaki alternatif kavramlar için, Kıryak (2013), su kirliliği konusuyla ilgili kavramsal anlama düzeyi için, Bakırcı (2014), ışık ve ses konusuna yönelik akademik başarı ve bilimin doğasına yönelik görüşler için OBİM'in etkisini incelemişlerdir. Bu çalışmaların ortak noktaları incelendiğinde, modelin aşamalarıyla uyumlu olduğu düşünülen bir eğitsel çıktının geliştirilmesi amaçlanmıştır. Genellikle deneysel araştırma yöntemiyle gerçekleştirilen bu çalışmaların amaçları, örneklemleri, öğretilen fen konu içerikleri, sınıf düzeyleri, modelde kullanılan öğretim teknikleri vb. oldukça değişkenlik göstermektedir. İlgili değişken yapıyı yansıtan çalışmaların sistematik olarak analiz edilmesiyle OBİM çalışmalarına yönelik bütüncül bir bakış açısının bu araştırmayla ortaya konması hedeflenmektedir. Buna göre, OBİM için gerçekleştirilen betimsel içerik analizinin, bu alanda çalışmak isteyen araştırmacılar için özetleyici ve tanılayıcı bir özelliğe sahip olduğu söylenebilir. Bu kapsamda, Türkiye'de fen bilimleri eğitimi alanında gerçekleştirilen OBİM çalışmalarının 2011-2022 yılları arasındaki yönelimlerinin incelenmesi araştırmanın temel amacı olarak belirlenmiştir.

Yöntem

Bu araştırmada, Türkiye'de fen eğitimi alanında yapılan OBİM çalışmaları nitel araştırma yaklaşımı içerisinde betimsel içerik analiz yöntemi ile belirli parametrelere göre incelenmiştir. Özellikle eğitim bilimleri alanında sıklıkla kullanılan bir araştırma türü olan bu yöntemde, belirli bir konuya odaklanan araştırmalar gözden geçirilir ve gelecekte yapılacak çalışmalara ışık tutması amacıyla nitel ve nicel olarak analiz edilir (Neuendorf, 2002; Ültay vd., 2021).

OBİM çalışmalarına ulaşmak için ulusal alan yazında 2011-2022 yılları arasında yayınlanan çalışmalara ulaşılmıştır. Bunun için, ULAKBİM Sosyal Bilimler Veri Tabanı, Türk Eğitim İndeksi (TEİ), Google Scholar veri tabanları ve YÖK Ulusal Tez Merkezi ilgili anahtar kelimelerle taranmıştır. Taranan bu anahtar kelimeler 'Ortak Bilgi Yapılandırma Modeli' ve 'Fen Eğitiminde Ortak Bilgi Yapılandırma Modeli' 'Ortak Bilgi İnşa Modeli' ve 'Fen Eğitiminde Ortak Bilgi İnşa Modeli' olarak belirlenmiştir. Tarama sonunda 21 makale ve 16 lisansüstü tezin tam metinlerine ulaşılmıştır.

Analize dahil edilen 37 çalışma betimsel içerik analizine uygun şekilde incelenmiştir. Bu inceleme sürecinde dikkate alınan parametreler sırasıyla çalışmaların yıllara göre yayın türleri, yayınlanma gerekçeleri, amaç ve odakları, çalışılan fen konuları (içerikleri), yöntemleri, veri toplama araçları, örneklemleri/çalışma grupları, modelde uygulanan öğretim teknikleri ve çalışmaların sonuçları olarak belirlenmiştir. Her bir parametreye göre incelenen çalışmaların verileri kodlamalarla ortaya konarken bazıları için ise bir üst kodlamalarla temalar oluşturulmuştur. Örneğin çalışılan konular(içerik) tespit edilirken birinci seviye kodlamalar yeterli olurken çalışmaların gerekçeleri analiz edilirken bir üst kodlama yoluyla bazı temalar belirlenmiştir.

Bulgular

OBİM araştırmalarında en sık vurgulanan gerekçe bu alanda az sayıda çalışma yapılmış olmasıdır. Ortaya konan diğer bir gerekçe Fen Bilgisi Dersi Öğretim Programı) ile OBİM'in örtüşmesi ve uyumuna yöneliktir. Zor, soyut kavramların öğretilmesinde ve alternatif kavramların giderilmesinde OBİM'in etkisi, araştırmacılar tarafından ortaya konan bir diğer gerekçe olmuştur. Henüz yeni araştırma konusu olarak OBİM'in gelecekte yapılacak araştırmalar için temel olabileceğini ve etkili materyaller sunabileceği birçok araştırmada öne sürülmüştür.

Türkiye'de yayınlamış olan OBİM araştırmaları genel amaçlarına göre betimleyici, gelişimel ve kuramsal olarak kategorilendirilmiştir. Bu çalışmalardan 5 tanesi betimsel, 31 tanesi modelin doğasına uygun olarak gelişimsel, 1 tanesi ise kuramsal çalışmalardır.

OBİM araştırmalarında en sık sayıda kullanılan yöntemin deneysel araştırmalar olduğu görülmektedir. Nitel ve nicel veri toplama araçlarının birlikte kullanıldığı karma OBİM araştırmalarına 8 kez yer verilmiştir. Bunların dışında az sayıda durum çalışması, doküman analizi ve eylem araştırmasına yer verildiği tespit edilmiştir.

Veri toplama süreçlerinde en sık olarak anketler-ölçekler ve başarı testleri kullanılmıştır. Bununla birlikte 14 çalışmada veri toplama aracı olarak (yarı yapılandırılmış) görüşmeler, 4 çalışmada gözlemler, 3 çalışmada dokümanlar, 13 çalışmada başarı testleri, 11 çalışmada kavramsal anlama testleri, 4 çalışmada açık uçlu sorular kullanılmıştır. Ayrıca 7 farklı beceri testinin (envanterinin) toplamda 12 kez veri toplama aracı olarak kullanıldığı ve 6 farklı çalışmada toplamda 7 kez alternatif ölçme değerlendirme tekniklerinin kullanıldığı tespit edilmiştir.

OBİM kapsamında en sık kullanılan öğretim teknikleri Tahmin-Açıkla-Gözle-Açıkla ve Kavramsal Değişim Metinleri olmuştur. Öğretimi gerçekleştirilen fen konuları çeşitlilik gösterirken özellikle çevre sorunlarına yönelik sosyobilimsel konular (su kirliliği, sera etkisi, küresel ısınma, insan-çevre ilişkileri vb.) sıklıkla öğretilen fen konu içerikleri olmuştur.

OBİM araştırmalarında en sık olarak belirtilen olumlu sonuç, akademik başarıyı arttırmada ve kalıcı öğrenmeyi sağlamadaki etkisi, en sık belirtilen olumsuz sonuç ise, OBİM'in tüm SBK'ların öğretimi için uygun olmadığıdır.

Sonuç ve Öneriler

Taranan OBİM araştırmalarında en sık olarak deneysel araştırma yöntemi kullanılmıştır. CKCM araştırmalarının doğasıyla uyumlu benzer nitelikte gelişimci karma ve eylem araştırmalarının sayısı arttırılabilir.

Taranan araştırmaların çalışma grupları ve örneklemleri büyük oranda ortaokul düzeyindeki öğrencilerden oluşmaktadır. OBİM için temel eğitim düzeyindeki fen bilimleri öğretimi uygulamalarına ve lise düzeyindeki fizik, kimya, biyoloji öğretimi uygulamalarına yönelikte çalışmalar gerçekleştirilebilir.

OBİM'e fen bilimleri öğretmen yetiştirme lisans programlarında ve halihazırdaki görev yapan öğretmenler için profesyonel eğitim kurslarında daha fazla yer ve