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# Impact of common knowledge construction model on the academic achievement and attitude towards science in science education

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**Abstract**

The main purpose of this study is to explore the effect of the Common Knowledge Construction Model (CKCM) on the academic achievement and attitude towards science of primary education students in science topics. The group in this study consists of 87 students from four different classrooms of 7 $^{th}$ and 8$^{th}$ grades. This study in which the integrated design of the mixed method. Science and Technology class was taught based on the CKCM in the experimental group and 5E learning cycle was applied in the control group. Data of the study were obtained as a result of conducting the academic achievement tests, attitude towards science test, views on phenomenographic categories, classroom observation notes, video records. As a result, the students of the 7$^{th}$ grade were effective on improving the students' developing their academic achievement. On the other hand, the students of the 8$^{th}$ grade were led to a medium level improvement in developing the viewpoints of the students on academic achievement. 7$^{th}$ and 8$^{th}$ grade Science and Technology lessons taught based on CKCM were not effective on improving the students' developing their attitude towards scıence. It was observed that concepts taught based on phenomena are considered more meaningful and perceived more easily by the students.

Keywords: Academic achievement and attitude towards science, common knowledge construction model, 5E learning cycle model.

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## 1. Introduction

As long as depending on changing circumstances, the needs of individuals is also changing. It is possible to train highly qualified individuals; in order to to respond to the needs of the times and not to lag behind developing and changing world. The community who want to educate qualified individuals were directed to rapid changes in the teaching process. The curriculum is the beginning of these changes. Changing needs and developments in science and technology have also provided quickly program development activities. One of these programs is also for Science Education Program. Program development activities have begun at proclamation of the Turkish Republic and it continues even today. In particular, together with technological and scientific developments comprehensive studies on Science Education Program were made in 1992, 2000, 2004 and finally in 2013.

Ministry of Education has gone through fundamental changes in some laws with primary education and education law in the 2013-2014 academic year with 30.03.2012 date and 28261 decree. One of the decisions taken was replaced as 7$^{th}$ item of the article number 222. It is below:

ITEM 7$^{th}$ - *"Primary education is the Ministry of Education and Training Institutions which established to achieve the purpose specified in item 1$^{th}$ and "has four-year term and primary compulsory school and four-year term and secondary compulsory school.*

The name of the course "Science and Technology" was held in "Science" with 4+4+4 education system. In this context, it was changes in the curriculum. Learning areas have been identified as Live and Life, Matter and Change, Physical Events, World and Universe of subject areas and Skill, Perception, Science-Technology-Society-Environment (STSE) of learning areas in order to achieve the vision of Science Curriculum. These learning areas and recoveries associated with areas of scientific process skills, life skills, feeling and science-technology-society-environment and these skills are outlined in the table below (MEB, 2013):

Table 1. Learning Outcomes (Areas) in Science Lesson Curriculum

| Knowledge | Skill | Feeling | Science-Technology-Society-Environment |
|---|---|---|---|
| a. Live and Life<br>b. Matter and Change<br>c. Physical Events<br>c. World and Universe | a. Scientific Process Skills<br>b. Life Skills<br>-Analytical Thinking<br>-Decide<br>-Creative Thinking<br>-Entrepreneurship<br>-Contact<br>-Team work | a. Attitude<br>b. Motivation<br>c. Values<br>c. Responsibility | a. Socio-Scientific Issues<br>b. Nature of Science<br>c. Science and Technology Relationship<br>c. Contribution of Social Sciences<br>d. Sustainable Development Awareness<br>e. Science and Career Awareness |

When Table 1 is examined, sciencetific literacy individuals who have not only basic knowledge in the learning areas outcomes; who have skills, feeling and science-technology-society-environment in the learning areas outcomes and take an active role in the learning process and construct information in the mind. In order to to respond to the needs of the times and not to lag behind developing and changing world, science educators tend to develop alternative models.

As a result, "Common Knowledge Construction Model (CKCM) " has emerged as an alternative model which emphasize that establishing a connection to real life in the information science, nature of science, phenomenography and conceptual change (Ebenezer & Haggerty, 1999). CKCM takes place in the 2013 Science Curriculum and it has been proposed to develop skills of knowledge, skills, feeling and science-technology-society-environment in the learning areas.

### *1.1. State of the literature*

- When examining related literature, the researches about effectiveness of the CKCM's practice is limited. In this context, this study will acquaint with CKCM.
- CKCM is popular and authentic learning model. This model will improve students' metacognitive skills which are essential for lifelong learning. It is contemplation about one's education and learning; past, present, and future.
- CKCM is a multidirectional learning model. It allow working as a scientist, transferring the experience, reflecting on categorized information, thinking, discussioning and sharing, using their knowledges in daily life and solving in socio-scientific issues for students.

### *1.2. Contribution of this paper to the literature*

- CKCM is conform with greatly the nature of the 2013 Science curriculum and it is one of the proposed learning curriculum model. Lessons plans, which are prepared with CKCM, are complementary in terms of the nature of science and socio-scientific issues. It is provided that Science course can teach effectively with this model will be prepared lesson plans, activities, assessment tools and applications.
- Each phase of the CKCM can provide multiple benefits to the students. The students can be protagonist of each step and they will achieve both cognitive and affective learning in the learning process.
- CKCM can offer the opportunity to transfer knowledge to daily life in the mind of students, creating awareness and sensitivity in socio-scientific issues, responsibility, sharing, expressing yourself. In this context, this study will provide a major contribution to the science education.

## 2. Purpose of the Study and Research Questions

The main purpose of this study is to explore the effect of the Common Knowledge Construction Model (CKCM) on the conceptual change of primary education students in science topics. In this context the research is to answer the following questions:

**1.** Experimental and control groups students'

**1.1.** Is there any significant difference between academic achievement pre-test and post-test levels?

**1.2.** Is there any significant difference between attitude towards science pre-test and post-test levels?

**2.** Control groups students'

**2.1.** Is there any significant difference between academic achievement pre-test and post-test levels?

**2.2.** Is there any significant difference between attitude towards science pre-test and post-test levels?

**3.** Experimental groups students'

**3.1.** Is there any significant difference between academic achievement pre-test and post-test levels?

**3.2.** Is there any significant difference between attitude towards science pre-test and post-test levels?

**4.** What are the views of the experimental group students' for CKCM?

## 3. Method

The main purpose of this study is to explore the effect of the Common Knowledge Construction Model (CKCM) on the conceptual change of primary education students in science topics. For this purpose, it was used mixed method which is used both quantitative and qualitative data collection methods. This type of research provide that more reliable, rich and comprehensive of the results collected quantitative and qualitative data were combined, obtained by blending with each other (Creswell, 2012). It was provide that more reliable, rich and comprehensive of the results using a combination of quantitative and qualitative data. Quantitative data of the study were conceptual tests and word association tests; the qualitative data of the study that the semi-structured interviews and video recorded during the application. Quantitative data were collected at the start of the study, qualitative data were collected during the application and both quantitative and qualitative data were collected again at the end of the study. Quantitative and qualitative data were analyzed separately. Quantitative and qualitative data were linked by bringing together in the findings and comments section. According to this; it was used integrated design of the mixed methods research designs.

The experimental method with pre-test/post-test control group was used in the study. Experimental design is used to test correlation cause and result between variables. The experimental method with pre-test/post-test control group is referred as two-factor showing an experimental design; one repeated measurements (pretest-posttest), and the other subjects in different categories (experimental and control groups). In this design, one participant is located in the experimental and control groups is just one of them (Buyukozturk, 2007).

### *3.1. Data collection tools*

The data of the research was collected by the academic achievement tests, attitude towards science tests, phenomenographic categories and semi-structured questionnaire in this study.

- **Academic achievement tests**

The academic achievement tests developed by the researcher and it was used to determine students' prior achievement before teaching process relevant and to evaluate students' academic achievement change at the end of the process.

***Validity and Reliability Study of the Academic Achievement Tests***

**Item Analysis for the "*Structure of the atom*" Achievement Test**

7th and 8th question has been removed from the "***Structure of the atom"*** achievement test. Content validity of the achievement test has not changed because of the questions which are written for each alternative. The average item difficulty value of the selected items and at the end of the achievement test; it is 0.54. According to the average item difficulty value (0.54), the test is medium difficulty. There are 8 easy questions, 2 difficult questions, 8 medium difficulty questions.

**It was found**

**Cronbach's α reliability factor; 0.80 (n = 101)**

**r = .54**

**Item Analysis for the "Sound" Achievement Test**

2th, 3th, 11th, 14th, and 30th question has been removed from the **"Sound"** achievement test. Content validity of the achievement test has not changed because of the questions which are written for each alternative. The average item difficulty value of the selected items and at the end of the achievement test; it is 0.54. According to the average item difficulty value (0.54), the test is medium difficulty. There are 17 easy questions, 1 difficult questions, 7 medium difficulty questions.

**It was found**

**Cronbach's α reliability factor; 0.85 (n = 100)**

**r = .64**

- **Attitude towards science test**

The attitude towards science test developed by the researcher (Benli, 2010) and it was used to determine students' prior attitude towards science before teaching process relevant and to evaluate students' attitude towards science change at the end of the process.

**Item Analysis for the Attitude towards science test**

The attitude towards science test consists of 30 items in likert-type questionnaire with 17 negative statements and 13 positive statements.

**It was found**

**Cronbach's α reliability factor; 0.88 (n = 298)**

- **Phenomenography**

Marton (1986) has been identified phenomenography, "Experience related to phenomena in the world around the individual, conceptualization, perception and perception from different perspectives, structure allowing them to create a structure with several qualitative way". It has been requested that express the concepts that exist in the minds of students on the subject at the beginning of the application process. The students had the opportunity to realize their pre-knowledge by starting a concrete concept that know better. Students and teachers have shaped the science course according to the concepts based on the existing situation in mind.

## 4. Results and Discussions

Research findings were interpreted by analyzing sub-problems and were presented in tables with various statistical methods in this part of the research.

**Findings of the 7th grade experimental and control groups:**

Table 2. "Structure of the atom" Phenomenographic Categories of the 7th Grade Experimental Group Students'

| Phenomenographic Categories (Description Category) | EXAMPLE STUDENTS EXPRESSIONS | n |
|---|---|---|
| Description Category 1 *"Atom; The smallest building block of matter. "* | *"Atom is the smallest building material is the cornerstone."* *"Atom is the smallest piece of matter unseen."* | 18 |
| Description Category 2 *"Atom; the cornerstone of the inanimate. "* | *"Lackluster in atoms located in living cells."* *"The table, row, is the cornerstone of the pen."* | 15 |
| Description Category 3 *"Atom is bomb."* | *"There's the atomic bomb."* *"Atom is used in making bombs. I heard in Hiroshima."* | 5 |

n= The repetition frequency of the determined description category

According to Table 2, at the beginning of the application process, it is seen that students have preliminary information about "structure of the atom" concept in the mind. It is seen that students try to explain "structure of the atom" concept with former knowledge and they have superficial knowledge.

- Is there any significant difference between "structure of the atom" academic achievement pre-test and post-test levels of the experimental groups students'?

Table 3. "Structure of the atom" academic achievement pre-test and post-test average of experimental groups students' results of t-test for dependent groups'

| Experimental | n | $\overline{X}$ | SD | df | t | p | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Pre-test | 24 | 7.17 | 3.29 | 23 | -10.62 | .00 | .83 |
| Post-test | 24 | 13.75 | 3.13 | | | | |

According to Table 3, there is a significant difference between experimental group students "structure of the atom" conceptual success pre-test and post-test in favor of the post-test ($t_{23}$ = -10.62, p = .00 < 0.05).

- Is there any significant difference between "structure of the atom" academic achievement pre-test and post-test levels of the control groups students'?

Table 4. "Structure of the atom" academic achievement pre-test and post-test average of control groups students' results of t-test for dependent groups'

| Control | n | $\overline{X}$ | SD | df | t | p | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Pre-test | 23 | 6.70 | 2.16 | 22 | -5.04 | .00 | .53 |
| Post-test | 23 | 10.70 | 4.03 | | | | |

According to Table 4, there is a significant difference between control group students "structure of the atom" academic achievement pre-test and post-test in favor of the post-test ($t_{22}$ = -5.04, p = .00 < 0.05).

- *Is there any significant difference between experimental and control groups'* "structure of the atom" *academic achievement pre-test levels?*

Table 5. "Structure of the atom" academic achievement pre-test levels of the experimental and control groups students' results of t-test for independent groups'

| Group | n | $\overline{X}$ | SD | df | t | p |
|---|---|---|---|---|---|---|
| Experimental | 24 | 7.17 | 3.29 | 45 | .57 | .56 |
| Control | 23 | 6.70 | 2.16 | | | |

According to Table 5, there isn't any significant difference between experimental and control groups students conceptual success pre-test levels ($t_{45}$ = .57 p = .56 > 0.05).

- *Is there any significant difference between experimental and control groups'* "structure of the atom" *academic achievement post-test levels?*

Table 6. "Structure of the atom" academic achievement post-test levels of the experimental and control groups students' results of t-test for independent groups'

| Group | n | $\overline{X}$ | SD | df | t | p | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Experimental | 24 | 13.75 | 3.19 | 45 | 2.88 | .00 | .16 |
| Control | 23 | 10.70 | 4.03 | | | | |

According to Table 6, there is a significant difference between experimental and control groups students' academic achievement post-test levels in favor of the experimental group ($t_{45}$ = 2.88, p = .00 < 0.05).

Table 7. Attitude towards science post-test levels of the experimental and control groups students' results of t-test for independent groups'

| Group | n | $\overline{X}$ | SD | df | t | p | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Experimental | 24 | 140.46 | 4.31 | 45 | 4.93 | .00 | .35 |
| Control | 23 | 129.39 | 10.07 | | | | |

According to Table 6, there is a significant difference between experimental and control groups students attitude towards science post-test levels in favor of the experimental group ($t_{45}$ = 4.93, p = .00 < 0.05).

**Findings of the 8th grade experimental and control groups:**

Tablo 8. "Sound" unit phenomenographic categories of the 8th grade experimental group students'

| Phenomenographic Categories (Description Category) | EXAMPLE STUDENTS EXPRESSIONS | n |
|---|---|---|
| Description Category 1 "Sound; natural and artificial sound source. " | "Music is the sound of the human voice has the sound of birds." "Radio, the voice of television." | 9 |
| Description Category 2 "Sound; it is a tool for communicating. " | "Sound, allows us to communicate with each other." "Through sound, we communicate, we solve our problems by talking." | 13 |
| Description Category 3 "Sound; sounds fine, deep voice ... " | "The sound of the girl thin, thick sound of men." "This year, my voice started to thicken." | 7 |
| Description Category 4 "Sound;It is noise. " | "The class we make a lot of noise, it's the noise." "Over the sound it is noise." | 6 |

n= The repetition frequency of the determined description category

According to Table 8, at the beginning of the application process, it is seen that students have preliminary information about "sound" concept in the mind. It is seen that students try to explain "sound" concept with former knowledge in daily life and they have superficial knowledge.

- Is there any significant difference between "sound" academic achievement pre-test and post-test levels of the experimental groups students'?

Table 9. "Sound" academic achievement pre-test and post-test average of experimental groups students' results of t-test for dependent groups'

| Experimental | n | $\overline{X}$ | SD | df | t | p | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Pre-test | 20 | 11.75 | 4.71 | 19 | -7.34 | .00 | .74 |
| Post-test | 20 | 18.45 | 4.92 | | | | |

According to Table 9, there is a significant difference between experimental group students "sound" academic achievement pre-test and post-test in favor of the post-test ($t_{19}$ = -7.34, p = .00 < 0.05).

- Is there any significant difference between "sound" academic achievement pre-test and post-test levels of the control groups students'?

Table 10. "Sound" academic achievement pre-test and post-test average of control groups students' results of t-test for dependent groups'

| Control | n | $\overline{X}$ | SD | df | t | p | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Pre-test | 20 | 8.55 | 3.37 | 19 | -12.45 | .00 | .89 |
| Post-test | 20 | 17.05 | 3.28 | | | | |

According to Table 10, there is a significant difference between control group students "sound" academic achievement pre-test and post-test in favor of the post-test ($t_{19}$ = -12.45, p = .00 < 0.05).

- *Is there any significant difference between experimental and control groups'* "sound" *academic achievement pre-test levels?*

Table 11. "Sound" academic achievement pre-test levels of the experimental and control groups students' results of t-test for independent groups'

| Group | n | $\overline{X}$ | SD | df | t | p |
|---|---|---|---|---|---|---|
| Experimental | 20 | 11.75 | 4.71 | 38 | 2.46 | .01 |
| Control | 20 | 8.55 | 3.37 | | | |

According to Table 11, there isn't any significant difference between experimental and control groups students conceptual success pre-test levels ($t_{38}$ = 2.46, p = .01 < 0.05).

- *Is there any significant difference between experimental and control groups'* "sound" *academic achievement post-test levels?*

Table 12. Descriptive Statistics "Sound" academic achievement post-test levels of the experimental and control groups students'

| Group | n | $\overline{X}$ | $\overline{X}_{ud}$ |
|---|---|---|---|
| Experimental | 20 | 18.45 | 17.43 |
| Control | 20 | 17.05 | 18.06 |

Table 13. "Sound" academic achievement pre-test levels of the experimental and control groups students' results of t-test for independent groups'

| Group | SS | df | MS | F | p |
|---|---|---|---|---|---|
| Pre-test | 257.699 | 1 | 257.699 | 23.358 | .00 |
| Group | 3.449 | 1 | 3.449 | .313 | .57 |
| Error | 408.201 | 37 | 11.032 | | |
| Total | 685.500 | 39 | | | |

According to Table 13, there isn't any significant difference between experimental and control groups students' academic achievement post-test [$F_{(1\text{-}37)}$ = 0.57 p > .05].

Table 14. Attitude towards science post-test levels of the experimental and control groups students' results of t-test for independent groups'

| Group | n | $\overline{X}$ | SD | df | t | p | $\eta^2$ |
|---|---|---|---|---|---|---|---|
| Experimental | 20 | 98.25 | 14.63 | 38 | .36 | .72 | .00 |
| Control | 20 | 96.95 | 6.81 | | | | |

According to Table 14, there isn't any significant difference between experimental and control groups students attitude towards science post-test levels ($t_{38}$ = .36, p = .72 > 0.05).

## 5. Discussion and Conclusion

It was concluded in the study that, as compared to the 5E learning cycle model, 7th grade Science and Technology lessons taught based on Common Knowledge Construction Model (CKCM) were effective on improving the students' developing their academıc achıevement. On the other hand, it was noted that, as compared to the 5E learning cycle model, 8th Grade Science and Technology lessons taught based on Common Knowledge Construction Model (CKCM) were led to a medium level improvement in developing the viewpoints of the students on academıc achıevement. 7th grade and 8th grade Science and Technology lessons taught based on Common Knowledge Construction Model (CKCM) were not effective on improving the students' developing their and attıtude towards scıence. It was observed that concepts taught based on phenomena are considered more meaningful and perceived more easily by the students. The experimental group students said that "CKCM is free, different, educational, fun and useful and providing permanent information".

Ebenezer, Chacko, Kaya, Koya, Ebenezer (2010) found that the experimental group students who used CKCM in their lessons passed a conceptual change process on *"excretory system"*. In another study, İyibil (2012) showed that conceptual changes of the experimental group students developed positively with CKCM. Kaya, Zorlu and Aydemir (2012) stated that Science and Technology teacher candidates said that "CKCM contributed positively for conceptual change process to elementary school students". Kiryak (2013) showed her master's thesis that CKCM improve conceptual understanding of the 7$^{th}$ grade students about the *"water pollution".* After the application, alternative concepts has been resolved that students have related to *"water pollution".* Vural and et al (2012) made learning activities based on CKCM about *"acids and bases".* They showed that conceptual change of the gifted students developed positively with these activities. Wood (2012) showed her doctoral thesis that CKCM improve conceptual understanding about *"acids and bases"* of the high school students.

It was noted that as compared to the 5E learning cycle model, 8$^{th}$ Grade Science and Technology lessons taught based on Common Knowledge Construction Model (CKCM) were led to a medium level improvement in developing the viewpoints of the students on conceptual change. A significant increase in the number of answers to the key words of the experimental group students has been observed. But answers to students' keywords were more quantitatively not far from scientific but superficial answers about *"Energy resources and recycling".* The experimental group students said that "CKCM is different, educational, fun and useful and providing permanent information". But when expressions of the students were examined, they could not understand the nature of the process. Students of the 8th grade failed to ensure enough participation of means since year-end exams, age of puberty, the search for identity etc.

Iyibil (2011), Vural and et al (2012), Kiryak (2013) found that CKCM is effective in scientific aspects and removing misconceptions. **Taskin and Yildiz (2011) showed that science lesson with CKCM is effective,** entertaining and instructive for 6$^{th}$ grade.

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