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The Effect of Common Knowledge Construction Model-Based Instruction on 7th Grade Students' Academic Achievement and Their Views about the Nature of Science in the Electrical Energy Unit at Schools of Different Socio-economic Levels

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Abstract

The aim of this study is to investigate the effectiveness of the common knowledge construction model (CKCM)-based instruction on academic achievement and 7th grade students' views about the nature of science (NOS) presented in electrical energy unit at schools of different socio-economic levels. In accordance with this purpose, three secondary schools at different socio-economic levels (lower, middle and upper) in Kastamonu Province, Turkey, were selected. One experimental group and one control group were randomly selected from schools at each socio-economic level. The teaching interventions in all groups lasted for 6 weeks (24 class-hours). While the lessons of the experimental group were taught with the activities developed in accordance with the CKCM, the lessons of the control group were taught in compliance with the 2013 Science Curriculum. As a result of this study, it was observed that the CKCM-based instruction increased students' level of academic achievement and ensured the permanence of the knowledge learned. In terms of academic achievement, no significant difference was observed between the schools at the lower and middle socio-economic levels and the schools at middle and upper socio-economic levels. However, a significant difference between the schools at the lower and upper socio-economic levels was observed in favor of the upper socio-economic level school. Moreover, the CKCM-based instruction had a positive effect on the students' views on the nature of science.

Keywords Academic achievement · Common knowledge construction model · Electrical energy · Nature of science · Socio-economic level

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Introduction

With developments in the field of science and technology from past to present, the amount of information that people can access has increased considerably, which has caused both the social structure and the educational understanding of that society to change. Therefore, the quality of science education has been questioned by educators. In some studies on the method of teaching science courses, it is observed that traditional teaching interventions render the students inactive, do not motivate them towards the lesson and reduce academic achievement (Akkuş, Günel & Hand, 2007; Briscoe & Peters, 1997; McCarthy & Anderson, 2000). For a better quality science education, it is important to educate active individuals who conduct research and both question and produce knowledge themselves, rather than passive individuals who simply memorize knowledge. Among the most important aims of science education are that students learn basic concepts related to science, assimilate these concepts and use them in daily life. One of these basic concepts is "electricity", and there are many studies in the field of electrical energy. These studies are generally related to 5E learning model, STEM, argumentation, mind mapping, laboratory-based and computer-assisted instruction (Batır, 2018; Bawaneh, 2019; Çoban, 2019; Şen, 2019). No studies have been found on the CKCM with electrical energy. The 7th grade electrical energy unit includes abstract concepts such as "current, resistance, voltage". Information about these concepts that students acquire in preschool or through informal ways is often incompatible with the scientific equivalents of the concepts, making it difficult for students to learn (Arnold & Millar, 1993; Farrokhnia & Esmailpour, 2010; Zacharia, 2007). This incompatibility also makes it difficult for teachers to teach the subject (Gunstone, Mulhall & McKittrick, 2009; Mulhall, McKittrick & Gunstone, 2001). Although many methods or techniques are used in the teaching of electrical energy, misconceptions persist in different teaching levels (Chiu & Lin, 2005; İpek & Çalık, 2008; Yürümezoğlu & Çökelez, 2010). Therefore, it is considered important to use the CKCM, which is a new teaching model that contributes to the development of students' conceptual understanding and is effective in the teaching of abstract and complex subjects such as electrical energy (Bakırcı & Yıldırım, 2017; Benli-Özdemir, 2014; Ebenezer, Chacko, Kaya, Koya & Ebenezer, 2010).

One of the superior aspects of the CKCM is that it does not depend on a single method or technique but of the synthesis many learning theories, and it allows the use of methods or techniques that are appropriate to the structure of the subject and the level of the student (Bakırcı, Çepni & Ayvacı, 2015; Biernacka, 2006; Ebenezer & Connor, 1998; Ebenezer et al., 2010). When the studies on the CKCM are examined, it can be said that the common points of their results are that it increases students' academic achievement, provides conceptual changes, improves positive attitudes towards lessons and increases conceptual understanding. Bakırcı, Çalık and Çepni (2017), Bakırcı and Ensari (2018) and Kıryak and Çalik (2018) also emphasize that the CKCM is an effective teaching model for academic achievement and the nature of science (NOS). Also, it is understood from the studies that the CKCM are effective on science education. In this context, the CKCM is applied in schools at all socio-economic levels. These approaches raise the question, "What are the effects of teaching at schools of different socio-economic levels?" For this reason, the effects of the CKCM-based instruction at schools of different socio-economic levels were investigated in this study.

Common Knowledge Construction Model

Based on the constructivist approach, the common knowledge construction model (CKCM), which is both a learning and a teaching method, was developed by Ebenezer and Connor in 1998. When the theoretical bases of the model are examined, it is seen that it was founded on Marton's "relational learning theory", Bruner's "cultural symbolic theory", Vygotsky's "zone of proximal development" and Doll's "postmodern thought on scientific discourse and program development". These learning theories provide frameworks for students to better understand the phenomenon related to science or socio-scientific phenomena, to reconfigure the process of learning and teaching and to develop common knowledge between teachers and students (Biernacka, 2006; Ebenezer & Connor, 1998; Ebenezer & Puvirajah, 2005).

The CKCM argues that students construct world views as a result of their personal interactions with the natural environment and their social interactions with others (Biernacka, 2006; Ebenezer, Chacko & Immanuel, 2004). Therefore, for students to interpret scientific ideas and rules that contain common knowledge, (i) their views on the world must first be determined and (ii) a connection must then be established between scientific ideas and their personal views (Ebenezer & Fraser, 2001). The CKCM argues that schools should provide students with social skills along with basic skills. Therefore, learning environments should be created in which students can grow up as individuals who think critically and who are willing to assume responsibility and are aware of global problems. The teacher should offer opportunities for his/her students in this direction. If the teacher shows empathy, understanding and sensitivity towards his/her students and interacts positively with them, both the students' learning experiences and the ability to deal with the problems they face effectively increases (Noddings, 2005; Wood, 2012). The model constitutes four phases that interact with each other. These phases are exploring and categorizing, constructing and negotiating, translating and extending and reflecting and assessing (Ebenezer & Connor, 1998).

Nature of Science

One of the main components of science literacy is the NOS. With the change in the understanding of education, the role of the NOS in science education, especially its effect on developing science literacy, has become more prominent (Khishfe & Lederman, 2006; Lederman, 2007) and this has increased the importance given to the NOS. How science should be taught is a subject that has been debated for many years and that the NOS is a part of education.

The NOS has become an integral part of science education, given the contribution of nature to science to both individual and science education. This situation has made it important to identify and develop individuals' understanding of the NOS (Çavuş, 2010). In this context, students', pre-service teachers' or teachers' understanding of the NOS (Demirtel, 2010) or elimination of misconceptions (Köksal & Ertekin, 2015); some researchers divide into as implicit and explicit-reflective approach (Abd- El-Khalick & Lederman, 2000), others divide into three as historical, implicit and explicit reflective approach (Khishfe & Abd- El-Khalick, 2002). What these approaches are: (1) *Historical Approach:* the historical approach used in the teaching of the NOS is an approach that assumes that students can comprehend how scientific knowledge progresses in historical process through case studies (Ayvacı, 2007). The study of historical events seems to be beneficial for individuals to have more consistent views about the NOS (Lee, 2008). (2) *Implicit Approach*: the implicit approach, another approach used in the teaching of the NOS, is based on the idea that students' engagement with science will understand the NOS. According to this approach, a teaching process that takes into account research-based activities and scientific process skills is considered to be sufficient in teaching the NOS (Kaya, 2011).

The main assumption of this approach is that individuals will learn the NOS through teaching environment based on scientific process skills or inquiry-based research activities without any emphasis on the NOS (Yücel-Dağ, 2015). (3) *Explicit Reflective Approach*: in this approach, the teaching of the NOS is planned according to the content of the science and discussed clearly (Khishfe & Lederman, 2006). The above-mentioned approaches are mainly used in the teaching of the NOS (Et, 2019). Studies reveal that the implicit approach is not effective in the teaching of the NOS, and that the NOS must be explicitly emphasized by considering it as other science concepts, principles, theories and laws; in other words, it should be taught with the explicit reflective approach (Çil, 2010). In the literature, different approaches, methods and techniques have been used (CKCM, argumentation, conceptual change pedagogy, etc.) to increase the impact of the explicit reflective approach (Karaman, 2019). As a result of the explicit reflective approach, it was found that most of the students learned one or more of the elements of the NOS and their academic achievement increased (Benli-Özdemir, 2014; Boran, 2014; Çil, 2010). Therefore, this approach is more appropriate for the CKCM and was used in the research.

When the literature is examined, no study has been conducted regarding NOS within the scope of the electrical energy unit. Moreover, there are no studies investigating students' views on NOS at schools of different socio-economic levels. Therefore, in this study, the effect of the CKCM-based instruction on students' views on NOS was investigated to attempt to fill the gap in the literature. Simultaneously, the activities regarding NOS prepared in accordance with the electrical energy unit within the scope of the CKCM will guide teachers who are implementers of the curriculum.

The Aim of the Study

In this study, different teaching materials on electrical energy were developed and used within the context of the CKCM. Therefore, the aim of this study is to investigate the impact of the CKCM on academic achievements and views about the NOS of 7th grade students at schools of different socio-economic levels. Within the scope of this study, the following research questions were tried to be responded:

1. What are the effects of the CKCM-based instruction on 7th grade students' academic achievement and the permanence of the learned knowledge at schools of different socio-economic levels?
2. What is the effect of the CKCM-based instruction on 7th grade students' views on the NOS at schools of different socio-economic levels?

Methods

Model of the Study

In the study, the effects of the CKCM-based instruction at schools of different socio-economic levels were examined. Within this scope, a "quasi-experimental design with a pre-test post-test control group" was preferred among experimental research methods. Initially, three middle schools of different socio-economic levels (lower, middle and upper) in Kastamonu Province in Turkey were selected using the Student Status Determination Survey (SSDS).

The SSDS (see Appendix 1) developed by Bacanlı (1997) was used to decide on the lower, middle and upper socio-economic schools where the application will be conducted. The information pertaining to the average monthly income of the family was updated considering the intervals in the study of Kut and Salgür (2015). The lowest score a student can obtain from the scale is 10 (assuming there is at least one item in the last question), and the highest score is more than 41 (the total points of the first nine questions is 41 at most, the number of items was included in this score in the last question). After the questionnaire was applied, the total score that each student received from the questionnaire was calculated. Subsequently, one-way analysis of variance was conducted to determine whether there was a significant difference in terms of socio-economic level between the schools' mean scores. The results of the analysis of variance are provided in Table 1.

According to Table 1, there was a statistically significant difference between the mean scores of schools [$F_{(4–254)} = 45{,}54$, $p = <.05$]. The results of Scheffe's test, one of the multiple comparison (post hoc) techniques carried out to identify differences among schools, are presented in Table 2.

The student status determination survey was applied in five schools in total. As seen in Table 2, there was no significant difference between only school 2 and school 3, school 3 and school 4; thus, the socio-economic levels of these schools were similar.

According to Table 3, there were four different levels of school in terms of socio-economic level. The study would be conducted at schools of three different socio-economic levels. Therefore, school 4 was determined as "Lower SEL", school 2 as "Middle SEL" and school 5 as "Upper SEL" (SEL: socio-economic level). Then, one

Table 1 Results of one-way analysis of variance of schools' mean scores according to SSDS

Source of variance	Total of squares	SD	Squares average	*F*	*p*	Significant difference
Inter group	7338.98	4	1834.74	45.54	.000	1–2, 1–3, 1–4, 1–5, 2–4, 2–5, 3–5, 4–5
In group	10,233.06	254	40.28			
Total	17,572.04	258				

School 1: 1; school 2: 2; school 3: 3; school 4: 4; school 5: 5

Table 2 Scheffe's test results of the schools' point average

Schools		*p*
School 1	School 2	.000
	School 3	.000
	School 4	.000
	School 5	.016
School 2	School 1	.000
	School 3	.724
	School 4	.012
	School 5	.007
School 3	School 1	.000
	School 2	.724
	School 4	.270
	School 5	.000
School 4	School 1	.000
	School 2	.012
	School 3	.270
	School 5	.000
School 5	School 1	.016
	School 2	.007
	School 3	.000
	School 4	.000

experimental and one control group were selected randomly from each school. These groups should be as similar as possible. Therefore, the opinions of the teachers teaching the courses were consulted, and the classes with an approximate level of academic achievement were determined via pre-tests during the identification process of the experimental and control groups to be studied. Before the teaching interventions, achievement test and views of the NOS questionnaire were applied as pre-tests in each group; after the teaching interventions, the same tests were applied again as post-tests. Moreover, the achievement test was applied again to all groups as a delayed post-test after 5 weeks. The experimental design used in this study is shown in Appendix 2, Table 14.

Table 3 Homogeneous subgroups according to the mean scores of schools

Schools	*N*	Group 1	Group 2	Group 3	Group 4
School 4	45	28.88			
School 3	49	31.87	31.87		
School 2	44		33.77		
School 5	47			38.82	
School 1	74				43.01
p		.240	.695	1.000	1.000

$p > .05$

Study Group

A convenience sampling method that endows the study with speed and practicality was used in the selection process of the study group (Yıldırım & Şimşek, 2006). The study was conducted at three different schools in Kastamonu Province in Turkey in the 2017–2018 academic year. These schools differ in terms of socio-economic level (lower, middle and upper). One experimental and one control group were selected from each school within the scope of the study. In the school with a lower socio-economic level, class 7-A ($n = 18$) was chosen as the experimental group and class 7-C ($n = 18$) as the control group. In the school with a middle socio-economic level, class 7-A ($n = 21$) was chosen as the experimental group and class 7-B ($n = 24$) as the control group. In the school with an upper socio-economic level, class 7-B ($n = 28$) was chosen as the experimental group and 7-C ($n = 29$) as the control group. In the identification of the experimental and control groups in the schools, the proximity of the achievement levels of the classes was determinant. Appendix 3, Table 15 shows the information belonging to the working groups.

Data Collection Tools

In this research, a mixed method including quantitative and qualitative research designs was used. The Electrical Energy Achievement Test (EEAT) was used as a quantitative data collection tool, and the Views of Nature of Science Questionnaire (VNOS) was used as a qualitative data collection tool.

Electrical Energy Achievement Test

In this study, EEAT was developed by the researchers with the aim of determining the effect of the use of the CKCM in teaching the electrical energy unit on the academic achievement of the students. Multiple-choice achievement tests have been used to determine the effect of the CKCM on students' academic achievement in several studies (Bakırcı & Ensari, 2018; Benli-Özdemir, 2014; Vural, 2016), Since emphasis was placed on complementary measurement and evaluation techniques in the evaluation phase of the CKCM, the relevant techniques were included in the preparation of the achievement test. This test is designed to include complementary measurement and evaluation techniques such as concept map, diagnostic branched tree, structural grid, concept cartoon. As the scoring is easy and objective, the questions were prepared as multiple-choice according to these techniques. The reasons for choosing this test are: it is easier to achieve scoring reliability in crowded groups with multiple-choice tests (Klufa, 2015), it can include many items, covers the acquisitions in the subject area and thus provides high scope validity (Güler, 2017). The validity and reliability of this test, consisting of 20 questions, was conducted. The reliability of the test was 0.89, which showed that the test is reliable. Two example questions of the achievement test are provided in Appendix 4.

Views of Nature of Science Questionnaire

In this study, VNOS developed by Çil (2010) was used. The questionnaire comprising five questions was developed by Khishfe and Lederman (2006), and it was adapted into

Turkish by Çil (2010) both by editing the existing questions and by adding new ones. The validity and reliability of the study conducted by Çil (2010) contains a total of nine questions. In this study, the first two questions were excluded from the questionnaire and the questionnaire applied with seven questions based on consultation with expert opinions (the questions removed from the questionnaire are "what is science and what distinguishes science from other fields of science (philosophy, history, etc.").

The possibility that students may have difficulty in explaining these questions and that these two questions reflect "the general view about science" aspect, which is not included in NOS aspects planned to be investigated in this study, are provided as reasons. In the seven-question VNOS applied as a pre-test and post-test in the pilot implementation stage of the model, two problems were not sufficiently understood by the students, and some of the expressions were corrected in these questions. The number of questions included in the questionnaire, which aspects of NOS are included in each problem and who prepared these questions, are presented in Appendix 5, Table 16.

Developing Activities Based on the CKCM

According to the 2013 Science Curriculum, the 7th grade electrical energy unit includes two topics: "connecting light bulbs" and "transformation of electrical energy". In the unit, there are a total of 12 acquisitions, seven in the first subject and five in the second one. The research was planned by dividing it into three subjects, not according to the two subjects mentioned in the unit. It was apparent from the subject and acquisition ranking in the curriculum that the students were expected first to discover the circuits consisting of bulbs connected in series and parallel, and then to observe and interpret the luminosity differences in the cases in which the bulbs were connected in series and parallel (Ministry of National Education [MoNE], 2013). The subjects included in the unit and the number of acquisitions per subject are shown in Table 4.

Teaching Intervention

The implementation lasted 6 weeks both for experimental and control groups. While lessons were based on present 2013 Science Curriculum in the control groups, they

Table 4 Number of acquisitions in the 7th grade electrical energy unit

	2013 Science Curriculum		Study conducted	
Electrical energy unit	Subjects	Number of acquisitions	Subjects	Number of acquisitions
	Connecting light bulbs	7	*Current and voltage*	4
			Connecting in series and parallel	3
	Transformation of electrical energy	5	*Transformation of electrical energy*	5
	Number of acquisitions	12	Number of acquisitions	12

were based on the CKCM in the experimental groups. The three subjects in the unit (current and voltage, connecting in series and parallel, transformation of electrical energy) were taught to all groups in the same weeks, in the same order. The same timetable was observed in all groups. In addition, pre-tests and post-tests were performed on the same day, the same week.

Teaching in the Control Groups

The 7th grade regular teacher taught the control groups with 2013 Science Curriculum involving lectures. The principle of teaching adopted in these classes was that knowledge resides with the teacher and that it is the teacher's responsibility to transfer that knowledge as facts to students. The teacher explained the knowledge structures in following the prescribed textbook. At the end of each class, the teacher asked direct questions on important concepts. The teacher dictated notes while the students copied. The experiments were carried out on the subjects of the unit and homework assignments were given. A course plan for control groups is shown in Appendix 6.

Teaching in the Experimental Groups

Under this heading, the details regarding in which phase of the model and why the activities developed within the scope of the CKCM will be used are explained in detail in the experimental groups. Since similar procedures were carried out in the same phase of the model for each topic, the activities developed in relation to the subject "Connecting in Series and Parallel" are introduced to serve as examples.

Exploring and Categorizing Phase

In this phase, the teacher revealed the students' prior knowledge about the subject with the help of a few simple activities and created categories according to the common points of the students' statements. The teacher should not consider the students' views as true or false. He should focus on what and how students think and not how much they know and create a supportive environment for students to freely reveal their views. The teacher can thus become aware of the alternative concepts present in the students' minds and make them aware of each other's opinions. For this purpose, "Tom and Jerry are installing a circuit" activity was applied at this stage (some examples are illustrated in the Appendix 7). In the activity, the students were first asked to explain how to install a simple single-wire and two-wire electrical circuit using circuit materials, pictures of which were given to them, and then they were asked to show it via a drawing. The aim of the activity is to discover and categorize students' prior knowledge of the installation of a simple single-wire and two-wire electrical circuit.

After the activity was conducted, students with alternative concepts were highlighted in the literature. After the students' opinions on the installation of a simple electrical circuit were revealed, the "how to connect light bulbs?" activity was conducted. Here, the students' knowledge on how to install a circuit with more than one bulb and what they knew about the ways to connect the light bulbs were revealed. In addition, their preliminary information about whether the brightness will change was also examined in the event that the bulbs were connected in different ways.

One of the features that distinguishes the CKCM from other models and makes it superior to them is that it informs students about NOS. The aim of the last activity called “the invention of the traffic light” conducted at this phase was to inform students about the aspects of NOS, such as “empirical, imagination and creativity”. For this purpose, NOS activity was first distributed to students, and then, they were asked to write their views about the questions on paper. The teacher then made the volunteer students read the text in the speech bubbles, and each question was discussed in class. At this phase, the teacher guided the class and encouraged the students to provide different examples.

Constructing and Negotiating Phase

This phase comprises the construction of scientific knowledge and negotiation of the meaning of concepts. First, the activity consists of “did the electricity go out?” during the constructing and negotiating phase. The aim of the activity is to enable students to realize that bulbs can be connected in different ways in daily life. Afterwards, the “let’s connect the light bulbs in series and parallel” activity based on the predict-explain-observe-explain method was conducted. In this activity, each group is intended to construct circuits connected in series and parallel and to construct their knowledge of the subject by discussing the predictions and results of their observations first among their group members and later as a class. Then, to solve alternative concepts among the students, “who are you right?” and “what are you thinking about?” activities were conducted. In both activities, group and class discussions were conducted.

Translating and Extending Phase

In this phase, students are given many opportunities to associate their learning with daily life. In the phase of translating and extending, the “why are all the lights out?” activity was first conducted. The aim of this activity is to determine whether students learn how other bulbs are affected when one of the bulbs connected in series is burned out, and whether they can transfer this information to similar problems that they encounter in their daily life. For this purpose, three cases from daily life were provided as an example and they were asked to interpret the common problem experienced in these cases. Then, with “let’s make a traffic light” activity, the students were asked to draw the series and parallel circuits described in the speech bubbles, and to find out which statement in the speech bubble was correct. The last activity conducted in this phase was “how did Edison invent the light bulb?”. Based on the nature of the model, activities should also be carried out to inform students about the NOS during this phase. Reflecting and Assessing Phase Process-oriented evaluations were performed in all phases of the CKCM. The activity “what have we learned?” was conducted to reinforce what they learned in this phase. Two questions were prepared in accordance with the alternative measurement and evaluation techniques in the activity. The first of these questions was prepared in accordance with the structured grid technique. In the question, the students were given nine circuits consisting of light bulbs connected only in series, only in parallel, and both in series and in parallel, and they were asked to group them. With respect to the second question, it was suitable for the concept cartoon technique. In this question, the characters of a comic strip, especially the ones they liked, were used to attract students' interest. They were asked to explain which of the views in the speech bubbles were correct and why.

Analysis of the Data

Analysis of the Data Obtained from EEAT

The EEAT consists of 20 multiple-choice questions. Students received 1 point for each correct answer in the test and 0 for each wrong or unanswered question. Therefore, the maximum score that could be obtained from the test was 20, and the minimum score was 0. The EEAT was applied as a pre-test, post-test and delayed post-test in all groups. The data obtained from the achievement test were analysed using SPSS program in the experimental and control groups of the lower, middle and upper SEL types.

Analysis of the Data Obtained from VNOS

Students' views in the questionnaire are divided into three categories as "weak, variable and adequate" in terms of each aspect. If the student stressed that scientific knowledge was unchangeable in all questions, he was considered to have a "weak" view. If he stressed that scientific knowledge was changeable in one question and unchangeable in the other, he was considered to have a "variable" view. If he presented explanations stressing that scientific knowledge was changeable in all three questions, he was considered to have an "adequate" view. The questionnaire was applied as a pre-test and post-test in all experimental and control groups. Each NOS aspect was analysed sequentially, and the kind of views all the experimental and control groups had regarding this aspect is presented as frequencies and percentages. Thus, each participating group's pre- and post-application ratio of having weak, variable and adequate views was compared. In addition, the views of different groups regarding the same aspect were also compared. The responses of the students to the questionnaire were evaluated both by the researcher and one science specialist independently. The results of the assessment were compared, consensus and disagreement were calculated and the percentage of reliability was found via the formula proposed by Miles and Huberman (1994):

$$Percentage\ of\ Consistency\ (P) = \frac{Na\ (Consensus)}{Na\ (Consensus) + Nd\ (Dissensus)} \times 100$$

Finding .80 or more as a result of the formula indicates that the evaluation is reliable (Miles, Huberman & Saldana, 2014; Patton, 2002). The reliability percentage obtained from the pre-test was 86.2, while the reliability percentage obtained from the post-test was 90.1. These results indicate that it is reliable to evaluate the questionnaire using different coders.

Results

In this section, the quantitative and qualitative data obtained from experimental and control groups were analysed.

Results Related to the Quantitative Data

Findings Concerning the First Sub-problem of the Study

A total of six groups, one experimental and one control group from each of the three schools of lower, middle and upper SEL, participated in the study. Descriptive statistics for the mean scores of the groups' academic achievement pre-tests before the application are provided in Table 5.

One of the conditions that the ANOVA can be applied to unrelated samples ensures the conditions regarding the variance equality of the groups. Levene's test was conducted to fulfill this requirement and because $p = .822 > .05$; thus, the variance of the groups was homogenous. An ANOVA was carried out for the samples to determine whether there was a significant difference between the mean scores of pre-test academic achievement among the groups (see Table 6).

According to Table 6, there was no statistically significant difference between the mean scores for the pre-test experimental and control groups [$F_{(5-132)} = .338$; $p > .05$]. These results indicate that the experimental and control group students' preliminary knowledge about electrical energy unit was similar and that there were no significant differences between the groups in accordance with the socio-economic level. Table 7 shows the comparison of the academic achievement pre-test and post-test as well as post-test and delayed post-test mean scores for the lower, middle and upper SEL experimental group students with the paired-samples *t* test.

According to Table 7, there was a significant difference between the academic achievement pre-test and post-test mean scores for the lower, middle and upper SEL experimental groups in favor of the post-test scores. Additionally, there were no significant differences between the academic achievement post-test mean scores and delayed post-test mean scores for all experimental groups. According to these findings, the CKCM-based instruction increased the academic achievement of lower, middle and upper SEL experimental groups and provided the permanence of academic achievement among all experimental groups. Moreover, the CKCM-based instruction had a very large effect on increasing the academic achievement of the lower SEL ($\eta^2 = 1.06$), middle SEL ($\eta^2 = 1.59$) and upper SEL ($\eta^2 = 2.11$) experimental groups. Table 8 shows the academic achievement post-test mean scores for the experimental and control groups in comparison with the independent samples *t* tests.

Table 5 Descriptive statistics concerning the groups' academic achievement pre-test mean scores before the application

	Groups	*N*	$\overline{X}$	*SS*
Lower SEL	Experimental	18	6.94	3.18
	Control	18	6.72	2.44
Middle SEL	Experimental	21	7.42	2.82
	Control	24	6.54	2.82
Upper SEL	Experimental	28	7.10	2.60
	Control	29	7.24	2.40

SEL socio-economic level

Table 6 Results of ANOVA for the mean pre-test academic achievement scores in the experimental and control groups

Source of variance	Squares sum	SD	Squares average	*F*	*p*
Inter group	12.32	5	2.46	.338	.889
In group	961.64	132	7.28		
Total	973.97	137			

$p > .05$

According to Table 8, there was a significant ($p < .05$) difference between students' academic achievement post-test mean scores in the experimental and control groups in favor of the experimental groups. The descriptive statistics for the academic achievement post-test mean scores of the both groups at different socio-economic levels are presented in Table 9.

As seen from the information in Table 9, there were differences between the academic achievement post-test mean scores of the lower, middle and upper SEL experimental and control groups. ANOVA was performed for unpaired samples to ascertain whether this difference was significant, and the results of the analysis are provided in Table 10.

According to Table 10, there was no statistically significant difference [$F_{(2\text{–}68)} = 1.192$, $p > .05$] between the academic achievement post-test mean scores of the control groups at different socio-economic levels. Again, as seen in Table 10, there was a statistically significant difference between the academic achievement post-test mean scores of experimental groups at different socio-economic levels [$F_{(2\text{–}64)} = 3.667$, $p < .05$]. According to this finding, academic achievement changed significantly according to the experimental groups at different socio-economic levels. The results of Scheffe's test, one of the multiple comparison (post-hoc) techniques used to identify differences in experimental groups, are provided in Table 11.

Table 7 Results of the *t* test for the lower, middle and upper sel experimental group students' academic achievement pre-, post-and delayed post-test mean scores

	Tests	*N*	$\overline{X}$	*SS*	*SD*	*t*	*p*	η^2
Lower SEL	Pre-test	18	6.94	3.18	17	− 4.48	.000	1.06
	Post-test	18	12.33	3.49				
	Post-test	18	12.33	3.49	17	.25	.805	
	Delayed post-test	18	12.05	4.92				
Middle SEL	Pre-test	21	7.42	2.82	20	− 7.29	.000	1.59
	Post-test	21	13.47	3.61				
	Post-test	21	13.47	3.61	20	− 0.13	.895	
	Delayed post-test	21	13.61	4.18				
Upper SEL	Pre-test	28	7.10	2.60	27	− 11.17	.000	2.11
	Post-test	28	14.96	2.84				
	Post-test	28	14.96	2.84	27	0.88	.387	
	Delayed post-test	28	14.21	2.94				

Table 8 Results of the independent samples t test for the experimental and control groups students' academic achievement post-test mean scores

	Groups	*N*	$\overline{X}$	*SS*	*SD*	*t*	*p*	η^2
Lower SEL	Experimental	18	12.33	3.49	34	2.38	.023	.79
	Control	18	9.55	3.50				
Middle SEL	Experimental	21	13.47	3.61	43	2.47	.017	.74
	Control	24	11.08	2.85				
Upper SEL	Experimental	28	14.96	2.84	55	4.78	.000	1.27
	Control	29	10.82	3.61				

According to Table 11, there was no significant difference between the post-test mean scores for academic achievement in the lower SEL and middle SEL experimental groups. Additionally, there was no significant difference between post-test mean scores for the middle SEL and upper SEL experimental groups. However, there was a significant difference between the post-test mean scores for academic achievement in the lower SEL and upper SEL experimental groups favoring the upper SEL experimental group. According to these findings, the effect of the CKCM-based instruction on the academic achievement of upper SEL students was greater than that of lower SEL students.

Results Related to the Qualitative Data

Findings Concerning the Second Sub-Problem of the Study

The answers given to the questions in the questionnaire were divided into three categories as "weak", "variable" and "adequate" in terms of each aspect. The results are presented as the frequency and percentage. In addition, through descriptive analysis, sample statements reflecting students' views on NOS were also included. The students at different socio-economic levels were taught for 6 weeks via the instruction based on the CKCM. Within the scope of the CKCM, activities including NOS aspects were also conducted. The students' views in both groups concerning NOS before the application are provided in Table 12.

Table 9 Descriptive statistics regarding the academic achievement post-test mean scores for the experimental and control groups at different socio-economic levels

Group	SEL type	*N*	$\overline{X}$	*SS*
Experimental	Lower	18	12.33	3.49
	Middle	21	13.47	3.61
	Upper	28	14.96	2.84
Control	Lower	18	9.55	3.50
	Middle	24	11.08	2.85
	Upper	29	10.82	3.61

Table 10 ANOVA results for the academic achievement post-test mean scores of experimental and control groups at different socio-economic levels

Groups	Source of variance	Squares sum	SD	Squares aaverage	*F*	*p*
Experimental	Inter group	78.87	2	39.43	3.667	.031
	In group	688.20	64	10.75		
Control	Inter group	26.73	2	13.37	1.192	.310
	In group	762.41	68	11.21		

According to Table 12, none of the students in the lower and middle SEL experimental groups had an adequate view on the observation and inference aspects of NOS, while a small percentage (7%) of students had an adequate view in the upper SEL experimental group. Additionally, none of the students in the middle and upper SEL experimental groups had an adequate view of the subjectivity aspect, in contrast to 11% of the lower SEL experimental group. Before the application, the views of the lower, middle and upper SEL experimental groups regarding NOS were similar. Additionally, none of the students in the control groups had an adequate view on the observation and inference aspects as well as the imagination and creativity aspects of the NOS before the application. The lower, middle and upper SEL control groups' preliminary knowledge about the NOS was similar and quite weak. The change in views among the lower, middle and upper SEL experimental and control groups students after the application is provided in Table 13.

According to Table 13, there was a significant increase in the rate of adequate views in the experimental groups after the application. The views of the lower, middle and upper SEL experimental groups regarding the NOS were similar, that is, it did not differ according to the socio-economic level. The CKCM-based instruction positively affected students' views on the NOS in all the experimental groups. After the application, the rate of adequate view in the control groups was quite low. Moreover, none of the students in the control group had an adequate view of the observation and inference aspects of the NOS. The number of students who had a weak or variable view was quite high in the lower, middle and upper SEL control groups.

Table 11 Scheffe's test results pertaining to the academic achievement post-test mean scores of experimental groups at different socio-economic levels

SEL type		The difference between the mean scores	*p*
Lower	Middle	− 1.14	.558
	Upper	− 2.63	.035
Middle	Lower	1.14	.558
	Upper	− 1.48	.298
Upper	Lower	2.63	.035
	Middle	1.48	.298

Table 12 Experimental and control groups students' views on nos before application at schools of different socio-economic levels

			Empirical			Tentative			Observation and inference			Subjectivity			Imagination and creativity			Social and cultural factor		
			W	*V*	*A*	*W*	*V*	*A*	*W*	*V*	*A*	*W*	*V*	*A*	*W*	*V*	*A*	*W*	*V*	*A*
Experimental groups	*Lower SEL*	f	6	10	2	7	9	2	13	5	0	10	6	2	5	11	2	9	7	2
		%	33	56	11	39	50	11	72	28	0	56	33	11	28	61	11	50	39	11
	Middle SEL	f	10	10	1	5	12	4	15	6	0	12	9	0	9	10	2	14	7	0
		%	48	48	4	24	57	19	71	29	0	57	43	0	43	48	9	67	33	0
	Upper SEL	f	11	15	2	6	21	1	17	9	2	18	10	0	12	14	2	13	13	2
		%	39	54	7	21	75	4	61	32	7	64	36	0	43	50	7	46	46	8
Control groups	*Lower SEL*	f	11	7	0	6	12	0	13	5	0	14	4	0	7	11	0	7	10	1
		%	61	39	0	33	67	0	72	28	0	78	22	0	39	61	0	39	55	6
	Middle SEL	f	14	10	0	11	13	0	18	6	0	15	8	1	10	14	0	10	13	1
		%	59	41	0	46	54	0	75	25	0	63	33	4	42	58	0	42	54	4
	Upper SEL	f	13	15	1	7	20	2	20	9	0	16	12	1	10	19	0	13	15	1
		%	45	52	3	24	69	7	69	31	0	55	42	3	35	65	0	45	52	3

W weak, *V* variable, *A* adequate

Note: The percentages in the table are rounded to the nearest decimal

Table 13 Experimental and control groups students' views on the nos after application at schools of different socio-economic levels

			Empirical			Tentative			Observation and inference			Subjectivity			Imagination and creativity			Social and cultural factor		
			W	*V*	*A*	*W*	*V*	*A*	*W*	*V*	*A*	*W*	*V*	*A*	*W*	*V*	*A*	*W*	*V*	*A*
Experimental Groups	*Lower SEL*	f	2	7	9	0	8	10	1	10	7	2	6	10	1	7	10	3	5	10
		%	11	39	50	0	44	56	6	56	38	11	33	56	6	38	56	16	28	56
	Middle SEL	f	1	13	7	0	11	10	3	10	8	3	8	10	1	8	12	4	7	10
		%	5	62	33	0	52	48	14	48	38	14	38	48	5	38	57	19	33	48
	Upper SEL	f	1	15	12	1	12	15	4	13	11	1	14	13	2	11	15	2	8	18
		%	4	53	43	4	43	53	14	46	40	4	50	46	7	39	54	7	29	64
Control groups	*Lower SEL*	f	7	10	1	6	12	0	11	7	0	11	7	0	5	12	1	6	11	1
		%	39	55	6	33	67	0	61	39	0	61	39	0	27	67	6	33	61	6
	Middle SEL	f	12	12	0	11	12	1	15	9	0	11	12	1	11	13	0	11	12	1
		%	50	50	0	46	50	4	63	37	0	46	50	4	46	54	0	46	50	4
	Upper SEL	f	11	17	1	6	20	3	21	8	0	16	11	2	14	15	0	14	14	1
		%	38	59	3	21	69	10	72	28	0	55	38	7	48	52	0	48	48	4

W weak, *V* variable, *A adequate*

Note: The percentages in the table are rounded to the nearest decimal

Conclusion and Discussion

The CKCM has been found to have an effect on academic achievement and the 7th grade students' views on the NOS as well as on their knowledge about current, resistance, voltage, connecting in series and parallel, transformation of electrical energy subjects. The achievement of the experimental groups can be explained by the fact that the CKCM is evaluated at least at all stages and that the third step of the model is the effective establishment of knowledge in relation to daily life. In addition to this, it is considered that alternative concepts related to the subject are determined in the first stage of the CKCM, and the elimination of these alternative concepts is also thought to be effective at later stages (Bakırcı & Ensari, 2018).

There were no statistically significant differences between the mean scores of the academic achievement pre-tests of the experimental and control groups before the application. In each of the experimental groups (lower, middle and upper SEL), there was a significant difference between the academic achievement pre-test and post-test scores in favor of the post-test. Accordingly, the CKCM-based instruction in the experimental groups increased the academic achievement of the students. This can be interpreted to a great extent as the fact that the CKCM-based instruction enables students to gain active participation in the course, conduct group activities, make comments, discuss and produce projects and develop their conceptual understanding. In the literature, the results of some studies (Akgün, Duruk & Gülmez-Güngörmez, 2016; Bakırcı & Ensari, 2018; Bakırcı & Yıldırım, 2017; Benli-Özdemir, 2014; Ebenezer et al., 2010; Kıryak & Çalik, 2018; Wood, 2012) investigating the effects of the CKCM-based instruction on academic achievement support the results of this research. In each of the experimental groups, no statistically significant difference was observed between the academic achievement post-test and delayed post-test scores.

The CKCM-based instruction had a large effect on students' academic achievement and ensured the permanence of academic achievement in the experimental groups. This can be explained as it renders the students quite active in every phase of the model and encourages them to think, discuss and revise their current knowledge continuously. The characteristics of the model mentioned herein are also emphasized in studies conducted on the CKCM in the literature. In those studies, it is stated that the model is entertaining, encouraging and interactive (Ebenezer et al., 2004) and that it increases the argumentative quality (Ebenezer & Puvirajah, 2005), promotes interest in the lesson and boosts the will to learn (Benli-Özdemir, 2014; Biernacka, 2006; Demircioğlu & Vural, 2016; İyibil, 2011).

In each of the control groups (lower, middle and upper SEL), there was a significant difference between the academic achievement pre-test and post-test scores in favor of the post-test scores. Accordingly, instruction of the control groups increased the academic achievement of the students. There were no statistically significant differences between the lower, middle and upper SEL control groups in terms of the academic achievement post-test scores. Knowledge of the control group students at different socio-economic levels with respect to the electrical energy unit was similar. This may be due to the fact that the CKCM-based instruction is not used to explain the subjects in the control groups. Regarding the socio-economic level, there were no significant differences between the lower SEL and the middle SEL experimental groups as well as between the middle and upper SEL experimental groups in terms of academic achievement post-test scores. However, there was a statistically significant difference between the academic achievement post-test scores of the lower SEL experimental group and the upper SEL experimental groups, and this difference favored the upper SEL experimental group.

The CKCM-based instruction was more effective for academic achievement in the upper than in lower SEL experimental group. The CKCM is a method in which continuous activities are held and students participate in these activities. School facilities, student profile and time are important factors in conducting these activities. In particular, since the school facilities are better in the upper SEL experimental group, the students here may have been more successful than the other SELs.

Before the application, the control groups' views on the aspects of the NOS were mostly concentrated on "weak" and "variable" categories. After the application, the views of the control groups remained largely the same. There was no significant difference between the views of the control groups at different socio-economic levels regarding aspects of the NOS. The views of the control groups at different socio-economic levels were close to each other and quite weak. In the 2013 science curriculum, emphasis was placed on the NOS (MoNE, 2013). However, the aspects of the NOS were not sufficiently included in the textbooks. Integrating the NOS in the course provided support for students to develop an adequate view on the NOS (Çil, 2010). In this context, the limited number of activities concerning the NOS in the textbooks, the inadequacy of the NOS activities that have spread to and integrated all subjects may explain why poor results.

Before the application, the experimental groups' views on the aspects of the NOS were mostly concentrated on "weak" and "variable" categories. After the application, these views were concentrated on "variable" and "adequate" categories. In the experimental groups with whom the CKCM-based instruction was conducted, there was a notable increase in the adequate view on all aspects of the NOS. However, the rate of increase in observation and inference aspects was lower compared with the other aspects. This may have occurred as the students investigated issues that they were curious about by experimentation and observation within the scope of the science course and considered it the only way to obtain knowledge. There were no significant differences between the views of the experimental groups at different socio-economic levels regarding the aspects of the NOS. The views of the experimental groups at different socio-economic levels were similar to each other and mostly adequate.

At schools of different socio-economic levels, the post-views of the experimental groups on the NOS were more adequate than the control groups of the same socio-economic level. In contrast, the students in the experimental groups had more variable or adequate views, whereas the students in the control groups had a weaker or variable view. In the experimental groups, seven activities, including the aspects of the NOS, were applied. These activities were "the invention of battery", "the invention of the traffic light", "how did Edison invent the light bulb?", "Leiden jar", "travel in time", "great fire in Kastamonu" and "Nicola Tesla: a scientist thinking ahead of the age he lived in". Before these activities were applied to the experimental groups, the students had misconceptions that are considered common in the literature with respect to aspects of the NOS. Some of these misconceptions are as follows. (1) An experiment is carried out to reinforce a subject learned in a science course or to prove the accuracy of the knowledge (the empirical aspect of the NOS) (McComas, 1998). (2) The information contained in the textbooks will never change, and if scientists have found anything, it is absolutely true (the tentative aspect of the NOS) (Çil, 2010; Khishfe & Lederman, 2006). (3) The only source of scientific knowledge is experiment and observation, and the experimental and observational results cannot be commented on subjectively, and if so, one will move away from the scientific route (the observation and inference aspects of the NOS) (Çil, 2010; Lederman & O'Malley, 1990). (4) Scientists who study the same subject, who perform similar experiments and who have similar data, cannot obtain different results from one another. Because, according to them, science is universal and results cannot change from person to person (the subjective aspect of the NOS) (Çil, 2010; McComas, 1998; Meichtry, 1992). (5) Scientists can use their creativity during their studies, but they think that there is no place for imagination in science, and scientists do not live in the realm of imagination because, if they did, science would move away from its aim (the imagination and creativity aspects of the NOS) (Khishfe & Lederman, 2006). (6) Science is universal and cannot be influenced by society (the social and cultural aspects of the NOS) (Çil, 2010).

It can be stated that all activities carried out in the CKCM-based instruction process (especially the activities of the NOS) are effective in the development of adequate views of students. The results of studies investigating the effect of the CKCM-based instruction on students' views on the NOS (Bakırcı et al., 2017; Biernacka, 2006; Çavuş-Güngören, 2015) and the results of this research overlap.

As observed in this study, the CKCM-based instructions increased the academic achievement of students and the permanence of the learned knowledge and made a positive contribution to their views on the NOS. Therefore, it is important to use defensible models such as the CKCM that consists of exploration and categorization of learners' ideas and construction and negotiation of meanings that lead to better test results and conceptual understanding (Ebenezer et al., 2010). To help students learn science lessons better, teachers can consider using a teaching model such as the CKCM for science achievement and the NOS as pointed by this study.

Suggestions. In this study, the CKCM-based instruction was observed to have a positive effect on students' academic achievements and their views on the NOS in the electrical energy unit. As the amount of research increases, an idea can be formed concerning the common impact of the model. The effects of the CKCM-based instruction can be investigated at different grade levels, such as pre-school and primary school. The effects of the CKCM-based instruction on socio-scientific issues and students' ability to conduct socio-scientific discussions can be investigated.

There are many studies showing that the CKCM is effective in science teaching. In this context, science teachers should be encouraged with in-service teacher trainings to use the CKCM in-class. In this study, the effects of the CKCM-based instruction at schools of different socio-economic levels were investigated. More experimental studies like this one can be conducted, and teaching effects at schools of different socio-economic levels can be investigated.

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Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.
This study has been derived from the first author's doctoral dissertation and a part of the research was presented orally in the Vth International Eurasian Educational Research Congress (EJER-2018), 2–5 May 2018, Akdeniz University, Antalya, Turkey.

Appendix 1

Student Status Determination Survey (SSDS).

1. Your father's education.
() Not a school graduate.
() primary school graduate.
() Secondary/High school graduate.
() High school/University graduate.
() Master's/PhD.

2. Your mother's education.
() Not a school graduate.
() Primary school graduate.
() Secondary/High school graduate.
() High school/University graduate.
() Master's/PhD.

3. Number of people in your family.
() 8-more people.
() 6–7.
() 4–5.
() 3.

4. Whose house do you belong to?
() Rent.
() Ours.
() Lodging.

5. Number of rooms in your home (Kitchen excluded).
() Single room.
() Single room and living room.
() Two rooms and living room.
() Three rooms and living room.
() Four and more rooms and living room.

6. Heating system of the house in which you live.
() Stove.
() Heater.
() Floor heating or air conditioning () Naturel gas.

7. Average monthly income of your family.
() 2000 TL and below.
() 2001–3000 TL.
() 3001–5000 TL.
() 5001–8000 TL.
() 8000 TL and above.

8. Your father's profession.
() Worker.
() Farmer.
() Officer.
() Shopkeepers/Traders.
() Self-employment (Doctor, Lawyer and such)

9. Your mother's profession.
() Housewife.
() Farmer.
() Officer.
() Shopkeepers/Traders.
() Self-employment (Doctor, Lawyer and such)

10. Belongings of your family (You can select multiple options).
() Refrigerator.
() Washing machine.
() Dishwasher.
() Mobile phone.
() Laptop/tablet.
() Land.
() Apartment.
() Car.
() Computer.
() Summerhouse.
() TV.
() Air conditioning.

Appendix 2

Table 14 Experimental design of the study

		Pre-tests	Process	Post-tests	Delayed post-test
Experimental groups	Lower SEL Middle SEL Upper SEL	Achievement test Views of the NOS Questionnaire	Teaching the Subjects in Electrical Energy Unit in Accordance with the CKCM	Achievement test Views of the NOS Questionnaire	Achievement Test
Control groups	Lower SEL Middle SEL Upper SEL	Achievement test Views of the NOS Questionnaire	Teaching the Subjects in Electrical Energy Unit in Accordance with 2013 Science Curriculum[a]	Achievement test Views of the NOS Questionnaire	Achievement test

SEL socio-economic level

[a] In the 2017–2018 academic year, the 2013 Science Curriculum was applied at the schools

Appendix 3

Table 15 Demographic features of the study groups

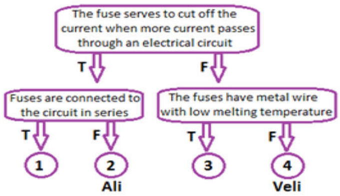
	Groups	Female		Male		Total
		f	%	*f*	%	*f*
Lower SEL	Experimental	10	55.6	8	44.4	18
	Control	8	44.4	10	55.6	18
Middle SEL	Experimental	11	52.4	10	47.6	21
	Control	10	41.7	14	58.3	24
Upper SEL	Experimental	13	46.4	15	53.6	28
	Control	12	41.4	17	58.6	29

Appendix 4

Ömer will prepare a poster about electrical devices that convert electrical energy into heat energy. On the other hand, Derya will prepare a poster about electrical devices that convert electrical energy into light energy.

Accordingly, which of the above pictures should be used in Ömer's poster and which of them should be used Derya's poster?

	Ömer's poster	Derya's poster
A.	1,4,5	2,3,6
B.	1,2,5	3,4,6
C.	3,4,6	1,2,5
D.	2,4,6	1,3,5



If the above information about the fuses is true, continue in direction **"T"**, if it is false, continue in direction **"F"**. **Ali** reaches the **2nd exit**, **Veli** reaches the **4th exit**. Accordingly, **which is true?**

A. Ali knows corrrectly both the intended use of the fuse and the way it is connected to the circuit.
B. Veli knows corrrectly the intended use of the fuse; but he knows wrong it's structure .
C. Ali knows wrong the intended use of the fuse; but he knows correctly the way it is connected to the circuit.
D. Veli knows wrong both the intended use of the fuse and it's structure.

Appendix 5

Table 16 Distribution of the questions in VNOS

Question number	NOS aspects	Source of the question
1	Empirical	Çil (2010)
2	Tentative	Khishfe and Lederman (2006)
3	Tentative Empirical Difference Between Observation and Inference Creative and Imaginative	Khishfe and Lederman (2006)
4	Empirical Difference Between Observation and Inference Creative and Imaginative Tentative	Khishfe and Lederman (2006)
5	Creative and Imaginative	VNOS-Form C
6	Social and Cultural Subjective	VNOS-Form C
7	Subjective Difference Between Observation and Inference Creative and Imaginative	Çil (2010)

Appendix 6

Course plan for control group

Course name	Science
Class:	7
Unit name:	Electrical energy
Subject:	How bulbs are connected, transformation of electrical energy
Recommended course hours:	24 h
Student acquisition/objectives and behaviors	1. Explains how serial and parallel connection is, draws a circuit diagram consisting of series and parallel connected bulbs. 2. Observes the brightness differences in cases where the bulbs are connected in series and in parallel and interprets the result. 3. Knows that electric energy sources provide electric current to electric circuits and electric current is a kind of energy transfer. 4. Connects the ammeter to the circuit in series and describes the value read as the current intensity and expresses the unit. 5. Measures the voltage (potential difference) between the terminals of the circuit by connecting the voltmeter in parallel to the circuit and expresses the unit. 6. Explores the relationship between the voltage between the ends of a circuit element and the current passing through it. 7. Associates the cause of the difference in brightness in cases where bulbs are connected in series and in parallel with electrical resistance.

	8. Makes experiments on the conversion of electrical energy into heat and light energy and observes the result. 9. Gives examples of technological applications based on the conversion of electrical energy to heat and light energy. 10. Comprehends that electrical energy is transformed into motion energy and motion energy is converted into electrical energy. 11. Investigates and presents how electricity is produced in power plants. 12. Discusses the importance of conscious and economical use of electrical energy in terms of family and country economy.
Methods and techniques to be applied	Lecture, Question-Answer, Role Playing, Group Work, Experiment.
Activities to be done	-Introduction of ammeter and voltmeter -Ohm's Law -How to Connect Light Bulbs? -Which Circuit Bulb Gives Light? -Examples of the conversion of electrical energy into many types of energy in daily life. -Test of conversion of part of energy into heat energy due to resistance of current passing wire. -An example of a robot developed as a result of the conversion of electrical energy into motion energy. -Interactive activities on electricity generation from hydroelectric, thermal, wind, geothermal and nuclear power plants -Importance of using conscious and economical electrical energy
Measurement and assessment	-Fill in the space -Mapping Projects for measurement and evaluation, concept maps, diagnostic branched tree, structured grid, six-hat technique, puzzle, multiple choice, open-ended, true-false, matching, gap filling, two-stage test suitable for the appropriate one of the different questions and techniques places.

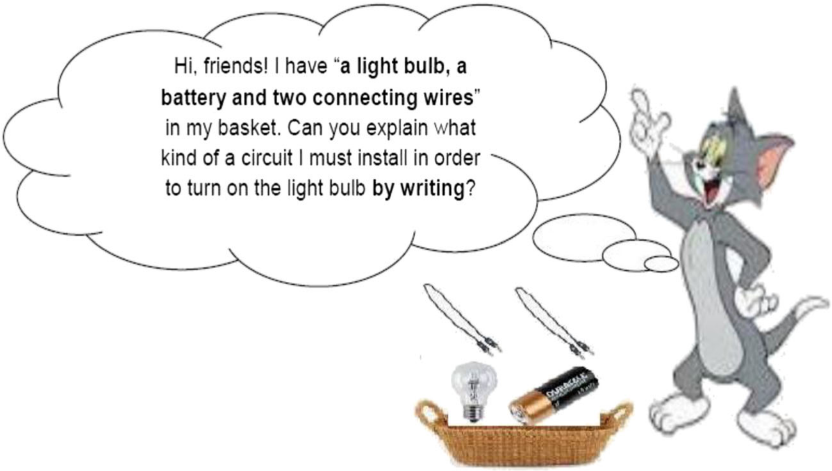
Appendix 7

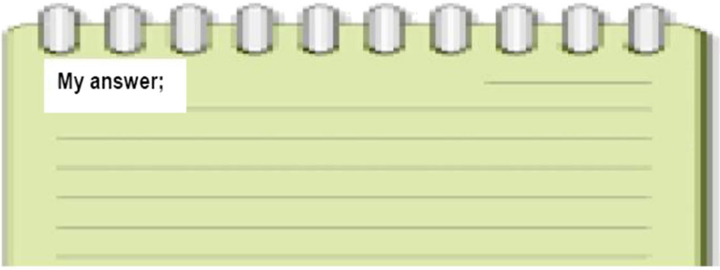
TOM AND JERRY ARE INSTALLING A CIRCUIT

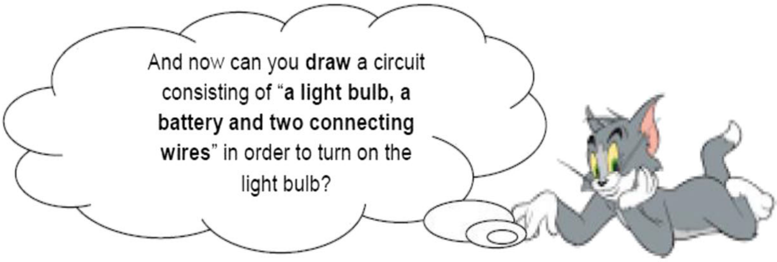
Hi, friends!
I have "**a light bulb, a battery and a connecting wire**" in my basket. Can you explain what kind of a circuit I must install in order to turn on the light bulb **by writing**?

My answer;

I think I need a circuit diagram in order for me to understand the subject better. And now can you **draw** a circuit consisting of "**a light bulb, a battery and a connecting wire**" in order to turn on the light bulb?

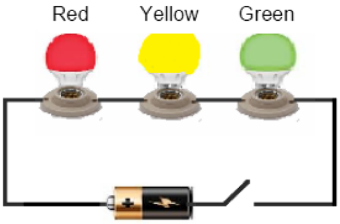

Hi, friends! I have "**a light bulb, a battery and two connecting wires**" in my basket. Can you explain what kind of a circuit I must install in order to turn on the light bulb **by writing**?

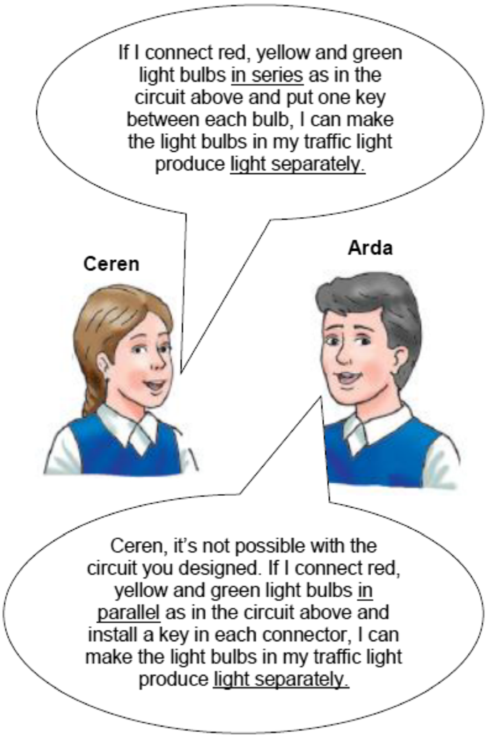

My answer;


And now can you **draw** a circuit consisting of "**a light bulb, a battery and two connecting wires**" in order to turn on the light bulb?

LET'S MAKE A TRAFFIC LIGHT

When the switch is turned off in the electrical circuit given in the adjacent picture, all the bulbs produce light. Ceren and Arda have developed two different designs to make a traffic light. Read the ideas of Ceren and Arda about their projects and draw the circuits they designed in the text boxes next to them.





Draw the circuit Ceren designed

Draw the circuit Arda designed

Who do you think is right, Ceren or Arda? Please, explain the reasons of your opinion.

....

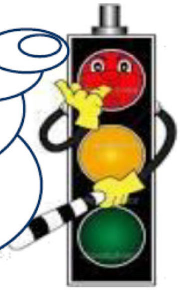
....

....

....

THE INVENTION OF THE TRAFFIC LIGHT

Did you know, friends? People started using me for the first time in London in 1868 and they used me a couple of years before the cars were discovered. Besides, they started using me long before the invention of automobiles. Traffic problem didn't start when cars showed up as you think; it was a problem for the big cities of the world even when there were just carriages around. When my red and green lamps they lit via gas burnt out a year later at that time, they removed me...



Garrett Morgan

I developed the first electric traffic light about 55 years after the test in London. But it wasn't so easy, friends. The first experiments started in 1914, and in 1923 I had the desired result. I had to do a lot of tests for 9 years...

- ***How many years did it take for Morgan to improve the traffic light?*** ....
- ***Why did Morgan have to do a lot of tests?*** ....
  ....
  ....
- ***Do you think that Morgan's many experiments and observations alone were enough to improve the traffic light?*** ....
  ....
  ....
- ***Is it sufficient to resort to experimental evidence when producing scientific knowledge?***
  ....
  ....
- ***Do you think Morgan used imagination and creativity while inventing the electric traffic light?*** ☐ ***Yes*** ☐ ***No***
  - ***If yes, at what <u>stage or stages</u> of research do you think he used imagination and creativity?***
    - ☐ *The selection of the research topic and planning the study*
    - ☐ *Experiment and Observation*
    - ☐ *Interpreting the data obtained and concluding*

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