CHAPTER 5

CONCEPT CARTOONS IN SCIENCE EDUCATION: DOES IT HAVE ANY EFFECT STUDENTS' ACHIEVEMENT, PERCEPTIONS OF INQUIRY LEARNIN SKILLS AND MOTIVATION TOWARDS SCIENCE LEARNING?

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ABSTRACT

Concept cartoons are among the visual aids recently used to promote students' classroom discussions, ensure their active participation and inquiry, and to encourage them towards research particularly in constructivist science teaching. The present study attempted to determine the effects of using concept cartoons in science teaching on elementary sixth-grade students' achievement, perceptions of inquiry learning skills, and their motivation towards learning science. Non-equivalent pretest-posttest control group semi-experimental design was used in the study. Throughout the applications about the unit on matter and heat, the experiment group was taught by using concept cartoons on the basis of the science and technology curriculum in Turkey, while the control group was simply taught on the basis of the curriculum. The results of the study revealed that concept cartoon applications in science classes created a significant difference in students' perceptions of inquiry learning skills, but it had no significant difference on motivation and achievement. As a result, the present study is believed to contribute to the literature on the use of concept cartoons in science teaching.

INTRODUCTION

Science teaching has a crucial place in raising individuals who produce knowledge and contribute to the development of their countries. Traditional science teaching, on the other hand, is argued to be largely inadequate in raising inquisitive, critical, reflectively – and creatively-thinking individuals who produce knowledge which they can apply to daily life situations. Therefore, the science teaching curriculum

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in Turkey was reorganized in the academic year 2005-2006 on the basis of the constructivist approach and was changed to Science and technology curriculum. The concept of "science literacy" forms the basis of the science and technology curriculum. The Turkish Ministry of National Education (2005) describes the aim of the new science and technology curriculum as follows: "To raise individuals who not only transmit accumulated knowledge to students but who also investigate, inquire, examine, can establish links between their daily lives and science subjects, can use the scientific method to solve any problem they face in all fields of life, and can see the world through the eyes of a scientist". To this end, the science and technology curriculum in Turkey involves activities appropriate for the constructivist approach which aims to help students acquire the general objectives in question.

The constructivist approach argues that every individual individually constructs their own meaning in the world around them through cognitive and social processes upon their experience and previous knowledge (Chee, 1997; Richardson, 1997; Winitzky and Kauchak, 1997; Aviram, 2000; Zion, Michalsky and Mevarech, 2005). This approach maintains that learning is a process whereby individuals make sense of their knowledge and experience as a result of their active participation and their social interaction with their environment. In this process, learners usually try to solve the events and situations they face in their daily lives through investigation and inquiry, and often by using the scientific method in formal or informal learning environments (Hatzitaskos and Karacapilidis, 2010). In this respect, according to the constructivist approach, concept cartoons constitute one of the instruments to be used in the science and technology curriculum. Various views has been put forward in the literature, arguing that concept cartoons have many benefits for students particularly in close relation to the constructivist approach such as revealing their conceptual understanding (Dabell, 2004), ensuring active participation, enhancing in-class motivation (Keogh et al., 2001; Long and Marson, 2003; Dalacosta et al., 2009), promoting discussions (Morris et al., 2007; Keogh and Naylor, 2000; Keogh, Naylor and Wilson, 1998; Naylor, Keogh and Downing, 2007), and encouraging towards inquiry and using the scientific method (Naylor, Keogh and Downing, 2001; Keogh, Naylor and Downing, 2003; Ozyilmaz Akamca, Ellez and Hamurcu, 2009). Although they were originally designed for the students in the age group of 9-13, concept cartoons are now being used in all stages of elementary – and secondary-level science teaching (Stephenson and Warwick, 2002). In view of these opinions, the present study attempted to obtain empirical findings about the impact of using concept cartoons in constructivist science and technology teaching upon motivation, perceptions of inquiry learning skills, and achievement.

CONCEPT CARTOONS

Dalacosta et al. (2009) define cartoons as "a form of art that has been promoted into an important visual language, which influences the human sentiments and transmits messages using symbols and pictures". As in many other areas, cartoons are used in education for various purposes (Keogh and Naylor, 1999; Sengul and Uner, 2010). The literature presents views regarding cartoons as effective instruments in learning and teaching (Ugurel and Morali, 2006) and can be used to encourage students (Roesky and Kennepohl, 2008; Tatalovic, 2009), and assessing students' learning, understanding and previous knowledge (Kempton, 2004; Song et al, 2008). Concept cartoons constitute one of the most important examples of the use of cartoons in educational environments. Unlike normal cartoons, these instruments do not usually involve elements like humor, exaggeration and criticism, but are designed about a scientific concept or phenomenon taken from daily life. Keogh and Naylor, (1999) and Webb, Williams and Meiring (2008) argue that in a broad sense, cartoons aim to make people laugh, with their funny aspects, while concept cartoons offer students opportunities to freely express their views, discuss and thus, inquire their knowledge in an environment in which they can feel safe by entertaining them. Concept cartoons help learners ask questions, reveal and improve learners' ideas, help implementing scientific ideas to daily situations, promote interest and motivation, and improves literacy and language (Long and Marson, 2003). According to Black and Harrison (2004), concept cartoons are excellent activities to promote peer discussions since they encourage students to reveal what they know, partially know and do not know about a concept or an idea. The characters to which students feel close in concept cartoons may eliminate possible cases of hesitation and embarrassment before their peers when expressing their opinions (Whitehead, 2007). Song et al. (2008), on the other hand, note that even the most silent students in the classroom may volunteer to talk when a familiar cartoon character shares their opinions. Thus, concept cartoons provide teachers with information about their students' conceptual understanding (Parkinson, 2004) and conceptual development throughout the process (Huang et al., 2006) so that they can reorganize existing activities and plan for further educational applications. Nevertheless, Hatzitaskos and Karacapilidis (2010) argue that concept cartoons have two limitations. First, the subjects under discussion have limited depth since concept cartoons do not contain much writing. Second, concept cartoons mainly aim to draw attention and promote thinking; they cannot be used to present information about the subject.

Keogh, Naylor and Wilson (1998) define concept cartoons as "caricature drawings involving the combined use of a visual stimulus and texts in dialogue form and reflecting everyday situations". Martinez (2004), on the other hand, defines them as "materials that help students gain access to concepts and knowledge in fun visual environments". In these instruments, three or more cartoon characters express their opinions about a situation or event from daily life in speech bubbles with concise and understandable words. In this respect, concept cartoons structurally resemble multiple-choice questions (De Lange, 2009; Cavagnetto, 2010). However, they are different from multiple choice questions in that they contain texts along with visual elements (Keogh and Naylor, 1999; Naylor and Keogh, 1999) and are designed about daily life situations (Keogh, Naylor and Wilson, 1998; Naylor and Keogh, 1999). Concept cartoons focus on daily life situations with which students are familiar through their own experience (Naylor and Keogh, 1999). In order to present scientific elements in their daily experience to students, these instruments are usually designed about possibly familiar daily life events (Keogh and Naylor, 1999). Furthermore, the opinions expressed by the characters in concept cartoons are often planned in relation to students' alternative conceptions or misconceptions about a subject. One or several of such opinions represent the scientifically correct opinion (Stephenson and Warwick, 2002). In some cases, concept cartoons may involve blanks to identify students' opinions or guesses about the situation represented in the cartoon (Chin, 2001). With all these aspects, concept cartoons are arguably a visual aid that can be used both in learning-teaching process and the assessment process. Chin and Teou (2009) and Kabapinar (2005) similarly note that concept cartoons can be used both as an assessment and learning-teaching instrument and have many uses in classroom environment.

How to use concept cartoons in classroom?

In classroom applications, concept cartoons may be used for various purposes and offered to students in the form of posters, projections and worksheets. After presenting the concept cartoons, students are invited to a discussion environment represented by the cartoon characters so that they can express and explain their opinions in group environment or individually (Dabell, 2004). Dabell (2008) argues that in classroom applications of concept cartoons, they are used as a stepping stone to create cognitive conflict in students' minds and to ensure full understanding, regardless of whether all student responses are correct or incorrect. By creating cognitive conflict in students' minds using concept cartoons, students arguably feel the need to attain the truth and think more clearly (Naylor, Keogh and Downing, 2001) and it would also be very important in creating a learning environment in which they would be eager to participate. In the last stage, students are guided by the teacher to test their arguments in a scientific environment or to investigate it using relevant resources so that they can put an end to the process of mental imbalance or to attain a state of mental balance. Parkinson (2002) maintains that students will be forced to think whether they need more information to arrive at a general conclusion as all viewpoints presented in concept cartoons is not correct. Thus, students will come to see that not everything is certain in science and what is most important is to examine all available evidence. When students realize their requirements to resolve the discussion, they are invited to participate in further investigations so that discussion as an aspect of scientific inquiry should be integrated with the process (Keogh, Naylor and Downing, 2003; Naylor, Keogh and Downing, 2007). Throughout this process, the teacher should act as a guide, providing students with clues, not the correct answers, and encouraging them to think (Kabapinar, 2005). This also offers students opportunities and an environment to resolve the cognitive conflict arising in their minds. In ensuring the retention of learning, it is believed to be very important for students to find themselves in a environment of cognitive conflict and to resolve this process of conflict on their own by doing, experiencing, and experimenting.

Literature review about concept cartoons

Since they were introduced in the literature by Keogh and Naylor in 1992, several studies have been conducted about concept cartoons (Keogh and Naylor, 1999), offering information about these instruments in different respects. A review of the literature on concept cartoons reveals researches containing examples of activities about concept cartoons (Evrekli, Inel and Cite, 2006; Balim, Inel and Evrekli, 2007; Balim et al., 2008; Birisci and Metin, 2010; Sahin and Cepni, 2011). Opinions about concept cartoons were investigated by Inel, Balim and Evrekli (2009) among students and by Birisci, Metin and Karakas (2010) among pre-service teachers. Furthermore, the literature also includes studies on the benefits and limitations of classroom applications and various uses of concept cartoons (Keogh and Naylor, 1996; Keogh and Naylor, 1999; Naylor, Downing and Keogh, 2001; De Lange, 2009; Kabapinar, 2009), their use as an assessment instrument (Keogh et al., 1999; 2001; Huang et al., 2006; Chin and Teou, 2009; Ingec, 2008; Ormanci and Sasmaz Oren, 2010), their use to identify and eliminate misconceptions and to reveal conceptual understanding (Chin, 2001; Stephenson and Warwick, 2002; Kabapinar, 2005; Ekici, Ekici and Aydin, 2007; Atasoy and Akdeniz, 2009; Sexton, Gervesoni and Brandenburg, 2009; Sasmaz Oren et al., 2010; Chin and Teou, 2010), and their use in identifying the approaches to mathematics teaching preferred by students and their beliefs about their preferences as students (Kinchin, 2004; Sexton, 2010).

There is research in the relevant literature that offers some findings about the subject of the present study. In one of such studies, Keogh and Naylor (1999) reported the results of their research on the use of concept cartoons in learning environments for science education. The researchers collected their data from in-service and pre-service teachers and elementary students. They employed case study, a qualitative research method, data triangulation and used interviews, questionnaires, and classroom observation. The data obtained from the study demonstrate that the teachers and students had highly positive opinions about concept cartoons and believe in their effectiveness. Moreover, the researchers also found that concept cartoons have effects on motivation and participation in classroom discussions. In another study, Naylor, Downing and Keogh (2001) dealt with the use of concept cartoons as a stimulus for discussion and argument in science education. Action research was used as a method in the study and the data collection instruments consisted of structured and non-structured observations, observations, interviews, and focus group interviews. The study was carried out in two elementary schools. The students were interested in focus discussions offering alternative viewpoints and stated positive opinions about concept cartoons. At the end of the study, the researchers concluded that concept cartoons were seen as an effective stimulus for a form of discussion in elementary science education; it ensured cognitive conflict among students; the students had positive views about concept cartoons, participated in discussions, and presented and defended alternative views; and classroom discussions encouraged students to scientific research and inquiry as a way to resolve debates.

In their study, Webb, Williams and Meiring (2008) used concept cartoons and writing frames to develop argumentation in science classrooms. They conducted their study with a total of 96 ninth-grade students in two classrooms. Students in both classrooms were divided into six groups of eight; three groups among these were selected and video recordings were done with one, audio recordings were done with another, and observations were made and field notes were taken for the third group. The study provided examples of the students' opinions presented during the discussions about concept cartoons and it was found that the combined use of concept cartoons and writing frames enhanced the levels of classroom discussions among students. Chen, Ku and Ho (2009) carried out another study on creating classroom discussion environments using concept cartoons. In this study, the researchers attempted to identify the effects of discussion-based teaching with concept cartoons upon students' discussions. The study employed a single-group pretest-posttest design and the applications lasted for six weeks with 21 students studying in an elementary school. The results of the study showed that the use of concept cartoons may enhance students' discussion skills. Furthermore, in the study, 21 students were grouped in three according to their achievement levels and discussion skills were examined in these groups classified as high, moderate, and low. As a result of the examinations, the scores of the moderate – and high-level groups were higher than those of the low-level group and there was a significant inter-group difference.

There are some other experimental studies in the literature dealing with the effectiveness of concept cartoons on variables such as attitudes, achievement, and inquiry learning in science classes (Durmaz, 2007; Balim, Inel and Evrekli, 2008; Ozyilmaz-Akamca and Hamurcu, 2009; Ozyilmaz-Akamca, Ellez and Hamurcu, 2009; Evrekli and Balim, 2010). Among these studies, Durmaz (2007) used a pretest-posttest model to examine the effect of using concept cartoons about 'mitotic and meiotic cell division' upon students' achievement in eight-grade science courses. The control group in the study was treated by the traditional approach, while applications based on the constructivist approach were made in the experiment group with concept cartoons. The study's results demonstrated the effectiveness of concept cartoons on achievement. In their study, Dogru and Keles (2010) found that the use of concept cartoons within 5E learning model to teach the sixth-grade science and technology unit of electricity in our lives did not have any impact on retention of learning. In another study with elementary fourth-grade students, Ozyilmaz-Akamca, Ellez and Hamurcu (2009) investigated the effect of computer-assisted concept cartoon applications on achievement. As a result of their study, they found that using concept cartoons positively influenced students' academic achievement. Balim, Inel and Evrekli (2008), on the other hand, investigated the effects of using concept cartoons in the 'Pressure' unit in science teaching upon seventh-grade students' academic achievement and inquiry learning skills. Pretest-posttest control group semi-experimental design was used and two groups, an experiment and a control group, were selected in the study. The experiment group was taught by using concept cartoons within 7E learning model, while the control group received teaching with only 7E learning model. At the end of the study, the students in the experiment group had higher perception scores of their inquiry learning skills when compared to those in the control group. No significant difference was found between the academic achievements of the two groups.

The relevant literature also contains research on the use of concept cartoons supported by different techniques and instruments. As an example of such research, Ozyilmaz-Akamca ve Hamurcu (2009) investigated the effects of science and technology education supported by analogies, concept cartoons, and predict-observe-explain techniques upon fifth-grade students' achievement in the science and technology course, their attitudes toward science and technology, and retention of learning. As a result of the study, the researchers found that these activities led to a significant difference in achievement, retention, and attitudes. As a different subject, Evrekli and Balim (2010) investigated the effectiveness of the combined use of mind maps and concept cartoons. They used a pretest-posttest control group model and the applications continued for four weeks. As a result, they found that these activities performed in the unit on matter and heat in the sixth-grade science and technology course led to a significant difference in students' achievement and enhanced their perceptions of their inquiry learning skills.

The study purpose and problem

The present study mainly aims to investigate the use of concept cartoons in science courses upon students' academic achievement, motivation towards learning science, and perceptions of their inquiry learning skills. In this context, the following research questions were addressed in the study:

1. Does the use of concept cartoons in science and technology courses significantly influence students' academic achievement?
2. Does the use of concept cartoons in science and technology courses significantly influence students' motivation towards learning science?
3. Does the use of concept cartoons in science and technology courses significantly influence students' perceptions of inquiry learning skills?

Method

Study design

The study employed non-equivalent pretest-posttest control group semi-experimental design (2 (group) x 2 (time) factorial design) (Cohen, Manion and Morrison, 2005). So, a control group and an experiment group were selected. The applications in the experiment group involve activities based on concept cartoons along with the Turkish science and technology curriculum; while the applications in the control group were simply based on the activities included in the curriculum (Table 1). Both groups were administered the scales of academic achievement, motivation towards learning science, and perceptions of inquiry learning skills as pretest and posttest.

Table 1. Group applications		
Group	Teaching Process	*n*
Concept cartoon group	Science and technology curriculum (5E learning model) and concept cartoon applications	24
Control group	Science and technology curriculum (5E learning model)	24

The dependent variables of the study include the students' academic achievement, perceptions of inquiry learning skills, and motivation towards learning science, while the independent variable consists of concept cartoon applications.

Participants

The study's participants consist of 48 (female = 20, male = 28) sixty-grade students studying in two classrooms in an elementary school in Turkey. Of these two classrooms, one was randomly selected as the experiment group and the other as the control group. Each of the experiment and control groups includes 24 students (female =10, male = 14 in each). The ages of the students in the experiment and control groups range between 11 and 13.

Data Collection Instruments

Academic Achievement Test on the Unit of Matter and Heat

The Academic Achievement Test on the Unit of Matter and Heat was developed by Evrekli (2010). During the development process for the test, the first step was to identify the acquisitions in the Turkish science and technology curriculum (17 acquisitions). Next, multiple choice questions were formulated in accordance with the unit's acquisitions and Bloom's cognitive domains. The preliminary version of the test was referred to expert opinion (n=5) in order to determine whether the questions in the test were appropriate for the units' acquisitions, suitable to predetermined cognitive level, and involved any scientific errors. Using the agreement percentage suggested by Miles and Huberman (1994), the agreement value according to expert opinion was .83 for scientific appropriateness, .89 for appropriateness for acquisitions and .81 for appropriateness for the cognitive domain. The preliminary application form was finalized by making the necessary editing on some of the items in the test in accordance with the experts' opinions.

The preliminary application form of the test was administered to 160 seventh-grade students with similar characteristics as the study group. Following the application, item and reliability analyses were made and thus, KR-20 reliability was found to be .86; the average difficulty as .64, average item discrimination as .56 and average item-total correlation as .53. The final version of the test contains 20 multiple choice questions. According to Bloom's taxonomy, three of these questions are in the application category, twelve in the comprehension category and five in the knowledge category.

The Scale for Motivation toward Science Learning

The Scale for Motivation toward Science Learning (MTSL) was developed by Dede and Yaman (2008) with Turkish students. The scale consists of 23 Likert-type items. The researchers performed the preliminary applications of the scale on 421 elementary students and obtained evidence about the scale's five-factor structure. Three exemplary items from the scale are as follows:

> *'I would like to investigate more than the information that the teachers present in the classroom.'*
>
> *'I like investigating the answers to science problems.'*
>
> *'I study hard to win the favor of my teacher in science courses.'*

These dimensions were identified as motivation toward investigation (α= ,75, six items), motivation toward performance (α=,68, five items), motivation toward communication (α=,56, five items), motivation toward participation (α= ,55, four items) and motivation toward cooperation (α=,59, three items). The Cronbach's alpha value for the entire scale was found to be .80. The scale consists of two negative and twenty-one positive items.

Inquiry Learning Skills Perceptions Scale

Inquiry learning skills perceptions scale was developed by Balim and Taskoyan (2007). The scale consists of 22 perception items. The researchers identified the scale's factors as 'negative perception' (seven items), 'positive perception' (nine items) and 'perceptions of correctness inquiry' (seven items). Some items from the scale are given below as examples:

> *'I verify the correctness of an experiment I make.'*
> *'I try to establish cause-and-effect relationships between the phenomena I face.'*
> *'When I read something, I think whether what I read is correct.'*

The scale was first administered to 501 elementary students studying in Turkey. The sub-factors in the scale have reliability values of 0.73, 0.67 and 0.71, respectively. The researchers calculated the Cronbach's alpha reliability for the entire scale as 0.84; and Spearman-Brown test split-half internal consistency coefficient as 0.82. The highest possible score on the scale is 110; and the lowest is 0. The scale consists of 7 negative and 16 positive items.

Treatment

The science curriculum in Turkey was reorganized on the basis of the constructivist approach in the academic year 2005-2006. The science and technology curriculum involves different teaching methods and techniques based on the constructivist approach. The current curriculum particularly focuses on the concept of science literacy and includes acquisitions concerning scientific process skills, science-technology-society-environment and attitude-value (MNE, 2005). The present study attempted to investigate the effects of concept cartoon applications used in the unit of "matter and heat" in the sixth-grade science and technology course upon students' academic achievement, perceptions of inquiry learning skills and motivation toward science learning. The applications in the study lasted for a total of six weeks. During four weeks, the experimental applications continued, and students were administered the pretest and posttest in the remaining two weeks. All of the applications were carried out by a course teacher, who is also one of the authors of this article. The teacher had been previously informed about concept cartoons. Furthermore, the researchers provided the teacher with necessary information about the activities. The applications in the control group were carried out by only using the activities included in the science and technology curriculum, while the applications in the experiment group were based on concept cartoons used in the science and technology curriculum.

Experiment Group Applications

Prior to the experiment group applications, the students were administered the data collection instruments as the pretest. Throughout the experimental applications, the activities included in the sixth-grade elementary textbook and student's workbook organized according to the science and technology curriculum were supported by concept cartoons. Concept cartoons were usually used to reveal the students' existing beliefs and opinions before the experimental activities in the unit and to encourage them to experimentally seeking for answers to questions. Figure 1 presents an example of the concept cartoons developed by Evrekli (2010) and used in the study.

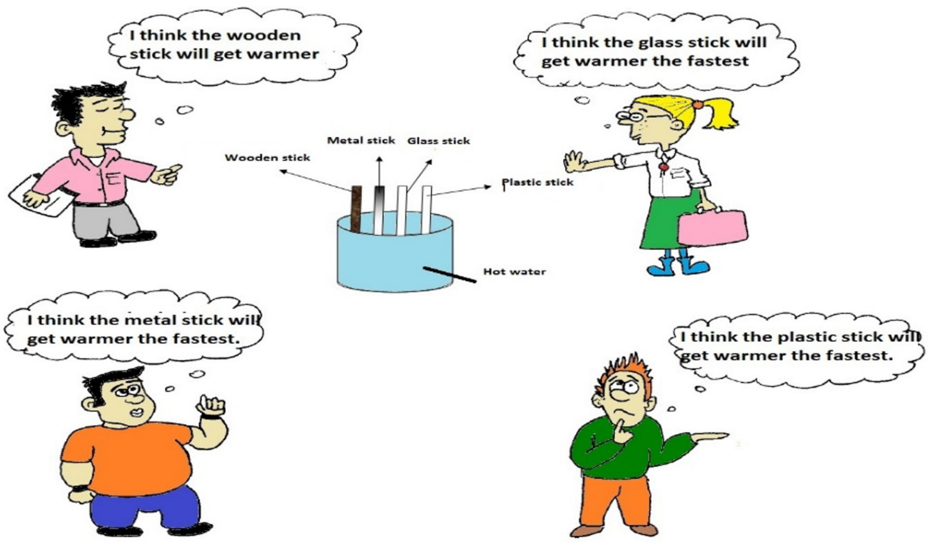

Figure 1. An exemplary concept cartoon used in the study (to take students' guesses prior to the experiment)

In the classroom, the concept cartoons were presented to the students by projecting them on the screen. The students were then asked to form groups of 3 or 4 for the presentations about concept cartoons. During these presentations, the students held discussions about the opinions presented in the concept cartoons first in their own groups, and later among the groups in the classroom. As a result of various opinions expressed by the students, an environment of cognitive conflict was attempted to be created in the minds of students, and thus, they were encouraged to perform experiments or conduct research about the subject so that they can test their opinions in an experimental environment to attain a new state of cognitive balance. After the applications, the students compared their previous opinions with the new knowledge they obtained after experimental applications or research. In some cartoons, on the other hand, there was no need for experimental application and the students could attain the correct answer scientifically by their teacher who asked them different questions in line with their previous knowledge. Throughout the process of experimental applications, a total of 11 concept cartoons were developed and implemented about the activities involved in the science and technology curriculum. The duration of applications was confined to four weeks in the experiment group. The four-week applications continued for a total of sixteen course sessions. Following these applications, the students in this group were administered the scales in the study as a posttest.

Control Group Applications

In the study, the control group applications were only based on the methods, techniques and activities included in the Turkish science and technology curriculum. Before and after the applications, the students were administered the scales in the research as the pretest and posttest. As was the case with the experiment group, the control group applications were also limited to four weeks and sixteen course sessions. The applications were carried by the class teacher (the same individual) both in the experiment and control groups. All the methods and techniques used for the unit taught to both groups were the same. The only difference between the applications in the two groups concerned the applications about concept cartoons used during the courses in the experiment group.

Data Analysis

To analyze the data obtained from the study, parametric statistical techniques were used by taking into consideration the data characteristics such as their closeness to normal distribution (Shapiro-Wilk) and homogeneous distribution of variances (Levene test). In order to determine whether there was any significant intergroup difference according to the dependent variables in the pretest measurements of the study, ANOVA and the Welch correction were applied by taking into account the equivalence of the variances. Furthermore, 2x2 ANOVA (application x duration) was employed for repeated measurements in problem solutions with regard to the dependent variables addressed in the study. However, because the number of data for the dependent variables was less than 30 when compared to the group variable, the analyses were retested by using Mann Whitney U, a parametric test. The results of non-parametric and parametric analyses were found to be in total agreement in all hypothesis tests. Therefore, the reporting process only includes the results of parametric tests. In the analyses, partial eta-squared effect size was calculated and the significance value was taken as .05.

Results

Before the experimental procedure and following the four-week application, measurements were carried out with regard to the three dependent variables, which are academic achievement (AA), motivation toward science learning (MTSL), and perception of inquiry learning skills (PILS). By considering the homogeneity of the variances, examination of histogram graphs, and the closeness of the data to normal distribution, ANOVA was used to determine whether there was any significant difference between the pretest scores of the experiment and control groups. The analyses revealed no significant difference in the groups' pretest academic achievement ($F_{(1, 46)}$= 0.91, *p*=.765), motivation toward science learning ($F_{(1,46)}$=0.46, *p*=.832), and perceptions of inquiry learning skills ($F_{(1,46)}$=0.80, *p*=.376). Table 2 presents the descriptive statistics about the results obtained from the scales.

Table 2. Descriptive statistics about the students' scores of academic achievement, perceptions of inquiry learning skills, and motivation toward science learning

Dependent Variables	Experiment group (*n* = 24)						Control group (*n* = 24)				
	Pretest			Posttest			Pretest			Posttest	
AA	7.50	2.93		11.50	4.38		7.25	2.81		9.95	4.42
PILS	89.75	11.59		95.29	8.85		86.66	12.31		84.95	14.47
MTSL	97.50	8.43		96.45	8.53		96.95	9.08		96.45	9.99

AA Academic Achievement, *PILS* Perception of Inquiry Learning Skills, *MTSL* Motivation toward Science Learning

The Impact of Concept Cartoons upon Students' Academic Achievement

In order to determine the impact of using concept cartoons in science courses upon students' academic achievement, ANOVA for repeated measurements was used in the study in accordance with 2 (group) x 2 (duration) factor design. The analyses revealed that only the effect of time upon academic achievement was significant ($F_{(1,46)}$ = 49.39, *p* = .000, *ηp2* = .518). On the other hand the combined effect of time x group ($F_{(1,46)}$ = 1.83, *p* = .183, *ηp2* = .038) and only the effect of group ($F_{(1,46)}$ = 0.867, *p* = .357, *ηp2* = .018) were not significant. Figure 2 shows the change in the experiment and control group students' academic achievement scores in the pretest and posttest. From the result of the analyses it could be concluded that there was a significant improvement in the groups' achievement scores between the pretest and posttest measurements. However, this improvement did not significantly differ between the experiment and control groups according to the variable of academic achievement. In other words, concept cartoons arguably did not lead to a significant improvement in the students' academic achievement.

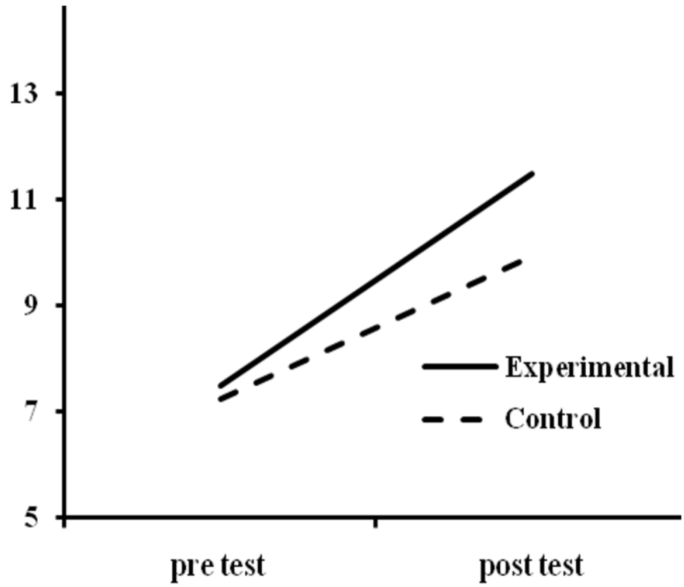

Figure 2. The mean pretest and posttest scores of the experiment and control groups with regard to their academic achievement

The Effect of Concept Cartoons on Perceptions of Inquiry Learning Skills

ANOVA for repeated measurements was performed to determine the impact of concept cartoons upon the students' perceptions of inquiry learning skills in the study and its results demonstrated that main group effect ($F_{(1,46)} = 4.26$, $p = .045$, $\eta p2 = .085$) and the combined effect of group x time was significant ($F_{(1,46)} = 9.36$, $p = .004$, $\eta p2 = .169$). Furthermore, the main time effect upon the students' perception of inquiry learning skills is insignificant ($F_{(1,46)} = 2.62$, $p = .112$, $\eta p2 = .054$). Figure 3 shows the change in the experiment and control group students' pretest and posttest scores of perceptions of inquiry learning skills. As revealed by the results, although the improvement in the groups' perceptions of inquiry learning skills between the pretest and posttest was not significant, the experiment group students exhibited a significantly higher improvement in their perceptions of inquiry learning skills when compared to the students in the control group. In addition, the effect value for the combined effect of group x time was high ($\eta p2 = .169$). Thus, it could be argued that concept cartons have favorable effects upon the students' perceptions of inquiry learning skills.

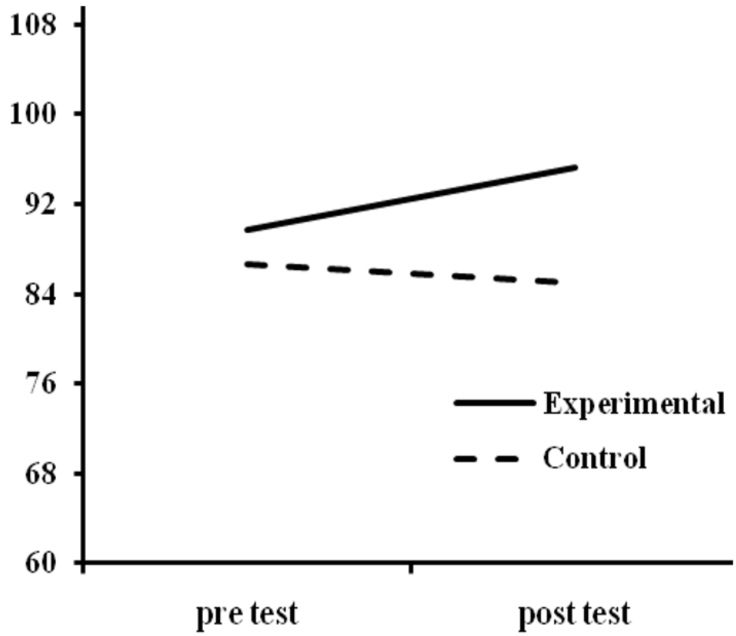

Figure 3. The mean pretest and posttest scores of the experiment and control groups with regard to their perceptions of inquiry learning skills

The Effect of Concept Cartoons upon Motivation toward Science Learning

ANOVA for repeated measures (2x2) was used in the study to determine the impact of concept cartoons upon the students' motivation toward science learning. The results of the analyses demonstrated that the main time effect ($F_{(1,46)} = 0.263$, $p = .610$, $\eta p2 = .006$), the main class effect ($F_{(1,46)} = 0.16$, $p = .899$, $\eta p2 = .000$) and the combined effect of time x class upon the students' motivation toward science learning were insignificant ($F_{(1,46)} = 0.32$, $p = .858$, $\eta p2 = .001$). Figure 4 shows the change in the experiment and control group students' pretest and posttest scores of motivation toward science learning. As a result, it was found that there was no improvement between the pretest and posttest measurements in the students' motivation toward science learning and that the scores of the experiment group and the control group student did not differ. To put it differently, the concept cartoon applications were found to have no significant effect upon the students' motivation toward science learning.

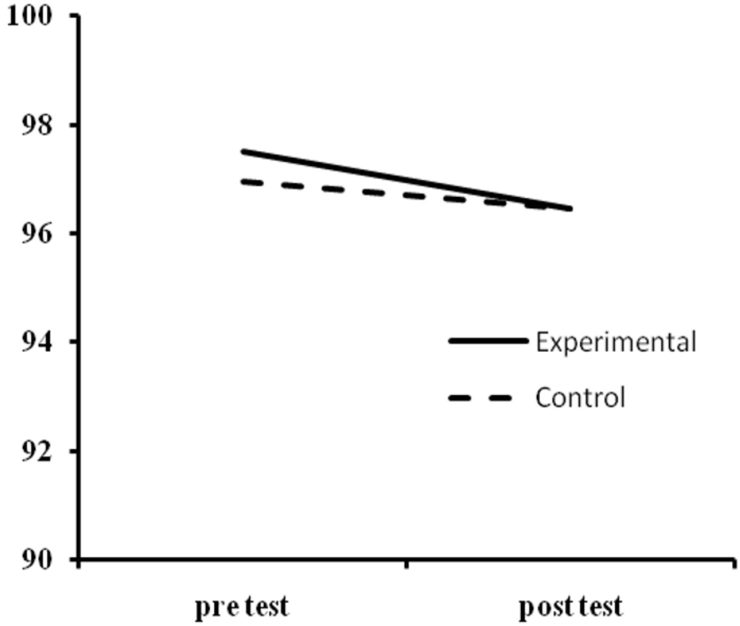

Figure 4. The mean pretest and posttest scores of the experiment and control groups with regard to their motivation toward science learning

The Relationship between Academic Achievement, Perception of Inquiry Learning Skills, and Motivation Toward Science Learning

Pearson product-moment correlation was used in the correlation analyses performed in the study. The analyses carried out for pretest measurements revealed a significant correlation between the students' perceptions of inquiry learning skills and their motivation toward science learning (r = 0.61, p = .000). Moreover the analyses made for posttest measurements demonstrated that there is a significant relationship between the students' academic achievement and perceptions of inquiry learning skills (r = .37, p = .009) and between their perceptions of inquiry learning skills and motivation toward science learning (r = .55, p = .000). The correlation analyses performed for posttest measurements separately for the experiment and control groups showed a significant correlation in the experiment group between all the variables. On the other hand, the analyses in the control group revealed no relationship between motivation toward science learning and academic achievement, while the relationship between the other variables was significant.

Discussion

The present study attempted to determine the effects of using concept cartoons in teaching the unit of "Matter and Heat" in the sixth-grade science and technology curriculum in Turkey upon students' achievement, perceptions of inquiry learning skills, and motivation toward science learning. To this end, a semi-experimental application was carried out, which lasted for a total of six weeks. It is believed that concept cartoons may have been the main reason for the significant improvement in the students' perceptions of inquiry learning skills at the end of the experimental application. However, the results indicate that concept cartoons did not have any significant effect upon the students' academic achievement and motivation toward science learning.

Academic achievement or conceptual understanding are among the most important variables of cognitive acquisition investigated with regard to the effects of any experimental applications about the subject of study in educational research. In this context, academic achievement was one of the dependent variables examined with regard to the effects of concept cartoons in this study. Concept cartoons support progression in students' understanding of scientific ideas (Kabapinar, 2005). Warwick & Stephenson (2002) argue that if learning is acknowledged as a social process, concept cartoons serve as an instrument both to improve and to explain conceptual understanding. This study's result that concept cartoons applications did not lead to a significant increase in students' academic achievement is compatible with Balim, Inel and Evrekli's (2008) result that experimental applications supported by concept cartoons did not lead to a significant difference in the academic achievement of the students in the experiment and control groups and Dogru and Keles's (2010) result that concept cartoons do not significantly influence retention of learning. Nevertheless, there are other studies in the literature reporting that courses taught on the basis of concept cartoons enhance students' academic achievements (Durmaz, 2007; Ozyilmaz-Akamca, Ellez and Hamurcu, 2009; Ozuredi, 2009; Ozyilmaz-Akamca and Hamurcu, 2009; Evrekli and Balim, 2010). Yet, there is a striking difference arising from a comparison of the studies reporting on the significant difference caused by concept cartoons in academic achievement and those reporting the opposite result. In the studies reporting no significant difference, there is an arrangement based on the constructivist approach in each of the experiment and control groups and the applications were supported by concept cartoons in the experiment groups. On the other hand, in the studies which found that concept cartoons result in a significant difference on academic achievement, concept cartoon applications were carried out on the basis of the constructivist approach in the experiment groups, while the control groups received applications based on the traditional and objectivist approach or the concept cartoons used for the experiment groups were supported by various teaching methods and techniques. In this context, the impact of concept cartoons upon the variable of academic achievement in the present study could be attributed to the fact that both of the experiment and control groups were subjected to applications based on the constructivist approach.

According to the National Science Education Standards (NRC, 1996, p. 214), scientific inquiry should be a main component of science education in all branches of science and at all grade levels. A similar vein, Krajcik, Blumenfeld, Marx, Bass & Fredrics (1998) argue that inquiry is a main component of science learning. This learning approach in which inquiry serves as a main component is inquiry learning, which also supports the constructivist approach. The arguments are expanding for the use of inquiry learning as an educational instrument and particularly the technology and materials that support this educational experience are becoming widespread (Kuhn, Black, Keselman & Kaplan, 2000). In their study Sampson and Clark (2007) claim that discussion is a part of the inquiry process. Duschl (2007) considers classroom discussions as an important element in organizing inquiry learning environments. It is highlighted by research that concept cartoons as one of the visual aids that support this educational experience encourage students toward inquiry particularly with the process of discussion it entails. Ozyilmaz-Akamca, Ellez and Hamurcu (2009) argue that the discussion process involved in concept cartoons is purposeful and scientific research and inquiry is often used to resolve an argument. Dalacosta, Kamariotaki-Paparrigopoulou, Palyvas & Spyrellis (2009) maintain that concept cartoons appear to provide possible starting points for relevant scientific investigations. Clearly, concept cartoons support scientific research with the discussion process it entails. It also facilitates for students to inquire knowledge by using the scientific method process to solve a problem presented by the characters in the cartoons. Thus, another research problem handled in the study was the impact of concept cartoons upon students' inquiry thinking skills and the result obtained suggest that the teaching application supported by concept cartoons did create a significant difference between the groups. In other words, a significant improvement in the perceptions of inquiry learning skills of the experiment group students who were taught by using concept cartoons when compared to the students in the control group. As a result, the improvement in the students' perceptions of inquiry learning skills could be mainly attributed to the inquiry of the ideas of concept cartoon characters through experimenting. Bravo & van Joolingen (2006) note that in inquiry learning as a didactic approach, students acquire knowledge and skills through a process of experiencing. As a confirmation of this argument, an environment of inquiry learning was created in the present study by the elementary students who experienced the ideas expressed by the characters in concept cartoons following a discussion process, which enhanced their inquiry learning skills. In parallel to the results of this study, Balim, Inel and Evrekli's (2008) pretest-posttest control group semi-experimental study with seventh-grade elementary students also found that the scores of perceptions of inquiry learning skills were higher in the experiment group students who received curricular teaching supported by concept cartoons, when compared to the students in the control group.

In the present study, the concept cartoon applications were observed to cause no significant difference in the motivation of the sixth-grade elementary students. In contrast to this result, Keogh and Naylor (1999) reported in their multidimensional study on the use of concept cartoons in science education that concept cartoons enhanced students' motivation. Concept cartoons appear to provide a possible means of enhancing children's motivation (Dalacosta, Kamariotaki-Paparrigopoulou, Palyvas & Spyrellis, 2009). In parallel to this view, Kabapinar (2005) demonstrated in a study based on classroom observations that concept cartoons increased students' motivation. Morris et al.'s (2007) study similarly reported that concept cartoons promoted motivation. In a study examining pre-service teachers' opinions about concept cartoons integrated with a modular teaching design, Cengizhan (2011) found that concept cartoons positively influence learning and ensures motivation. Differently from these results in the literature, concept cartoons did not create a significant difference on the elementary students' motivation in our study, which we might attribute to the fact that the duration of the applications was limited to a total of six weeks.

Conclusion and Implications

This article reports on an empirical research of concept cartoons in science and technology course by Turkish elementary students. Given their use in science classrooms, concept cartoons have been handled in very little empirical research apart from those of their inventors, although they serve as an application strategy (Chin & Teou, 2009). In this context, the study has certain important findings. First, the study found that concept cartoon applications did not create a significant difference upon the students' achievement, which might have resulted from the fact that both application groups were taught according to the curriculum based on the constructivist learning approach. Furthermore, a suggestion could be made to investigate the results if the duration of applications is extended or if a broader sample is used. On the other hand, some recent studies have used concept cartoons along with other techniques that reflect the constructivist learning approach, such as animations and diagnostic branched tree (Sahin & Cepni, 2011), drawings and group discussion (Chin & Teou 2010), analogies and predict-observe-explain technique (Ozyilmaz-Akamca & Hamurcu, 2009), and investigated their impact on learning products. In this context, it could be suggested to conduct research that aims to determine the effect of the combined use of concept cartoons with other techniques upon students' academic achievement or conceptual understanding.

Secondly, the study found that concept cartoon applications resulted in a significant difference on the students' inquiry learning skills. As argued by Krajcik et al. (1998), constructivist approaches acknowledge the fact that mainly inquiry plays a significant role in realizing learning in science teaching and students need opportunities to find out solutions to problems by asking questions, designing and implementing research, collecting and analyzing data, interpreting, concluding, and reporting on their findings. Teachers require adequate knowledge about science content and effective teaching strategies so that students can understand and engage in inquiry discourse about science (Lee, Hart, Cuevas & Enders, 2004). In this context, another suggestion would be to inform in-service and pre-service teachers about concept cartoons so that they can effectively use this visual aid to improve their students' inquiry learning skills. To this end, we believe that it would be appropriate to inform in-service teachers through in-service training courses or workshops and pre-service teachers during the courses about teaching methods in their departments about concept cartoons as well as other visual aids. In parallel to this view, the science and technology curriculum implemented in Turkey and based on the constructivist learning approach also suggests that teachers should use numerous different student-centered teaching methods, techniques, and strategies to activate students so that they can be trained as inquiring and questioning individuals. Finally, the study also found that concept cartoon applications did not have any significant effect on the students' motivation. Given that affective behavioral changes like those in motivation and attitude cannot occur in a short time, the lack of any significant difference could be attributed to the limited six-week application period of the study. So we suggest conducting further research on the subject with longer application periods.

The recent research in the literature on concept cartoons includes studies that present examples of technology-assisted applications and evaluate their effects on learning outputs. For instance, Dalacosta, Kamariotaki-Paparrigopoulou, Palyvas & Spyrellis (2009) used concept cartoons in animations in their research arranged as multimedia application in elementary science education; Ozyilmaz-Akamca, Ellez and Hamurcu (2009) used computer aided concept cartoons in science and technology education with elementary students; and Yarar (2010) used learning objects in their study with elementary students, which they supported by concept cartoons developed by using a flash software. In this context, a suggestion could be made to carry out comparative empirical studies using computer-assisted concept cartoons at different education levels.

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