The effects of computer-aided concept cartoons and outdoor science activities on light pollution

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Abstract

The purpose of this study is to create an awareness of light pollution on seventh grade students via computer aided concept cartoon applications and outdoor science activities and to help them develop solutions; and to determine student opinions on the practices carried out. The study was carried out at a middle school in Muğla province of Aegean Region in Turkey. It was single group pre test-post test model that was used in the study. The data in the study were collected via open-ended questions about light pollution and semi-structured interview questions. Open ended questions about light pollution were applied on students as a pre-test and post-test. After the post-test was applied, semi-structured interviews were carried out with students. The qualitative analysis of the data collected from the open-ended questions and semi-structured interview questions were made and student expressions were quoted. After the implementations, it was found that there was an increase in the correct answers of students on light pollution. Also, all students interviewed stated positive opinions regarding the implementations. The implementations carried out are convenient for students to develop an awareness of the ecological, astronomics and economical results of light pollution and to develop solutions for preventing light pollution.

Keywords: Light pollution, Concept cartoons, Outdoor science activities

Introduction

Human is inseparable whole with its environment and should especially be a part of solutions related to human-induced environment issues. Due to rapid increase in population, over urbanization, industrialization and consequently, excessive uses of natural resources environmental issues, today, have become global issues. Light pollution, defined as the wrong utilization of light in a disturbing way, has become an important environment issue all around the world and this made environment education a necessity. Scientists around the world give light pollution levels they measured in different parts of the world in numbers and continue to create a light pollution map of the sky (Cinzano, Falchi & Elvidge, 2001; Aslan et al., 2011). However, studies towards determining the existing state of light pollution are insufficient in

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terms of preventing this pollution. Because the main way of preventing light pollution is to make educational studies on the issue and to create an awareness among individuals. The reasons and effects of light pollution have been revealed with various studied. Crawford (2001) states that wrong outdoor lighting causes light pollution. Osman, Isobe, Nawar & Morcos (2001) and Çetegen & Batman (2005) state that light pollution is a significant problem for astronomical studies, environment and economy and made some suggestions on what should be done. In their studies on the reasons, results and solutions of light pollution, Percy (2001) and Hanel (2001) found that the people are not conscious about light pollution.

In seventh class Science curriculum, various environmental issues are emphasized; yet light pollution, which is a significant issue in ecological, economic and astronomical terms, is not mentioned. In this study, the "Light Pollution" topic within "Environmental Problems and Their Effects" issue under "Human and Environment" unit in seventh grades is discussed and the aim was to help students learn the issue of light pollution via computer-aided concept cartoons and outdoor science activities. The learning outcomes of the issue are given below:

Students collect information about one of the environmental problems in our country and the world, present this information and discuss about it.

Students suggest solutions for cooperation on one of the environmental problems in our country and the world and attend to activities.

The research problem can be stated as: "what is the impact of computer-aided concept cartoons and outdoor science activities on students' learning of light pollution and what are student opinions on the practices carried out?". In this current study, the scenarios related to light pollution were supported via computer-aided concept cartoon animations in order to grab students' attention. In teaching with concept cartoons, some alternative ideas about a certain scientific fact is drawn on a working paper in the form of a cartoon. However, only one of these ideas is scientifically correct. Concept cartoon starts a discussion on the concepts between the characters in the cartoon and present it (Keogh, Naylor & Wilson, 1998; Keogh & Naylor, 1999) and thus, scientifically correct idea is worked to be achieved. In concept cartoons, it is generally the questions or ideas of three or more characters on a subject given in speech balloons; and ideas are discussed by the whole class through the characters in the cartoons.

The purpose of the study is to create an awareness of light pollution on seventh grade students via computer aided concept cartoon applications and other outdoor science activities and to help them develop solutions; and to determine student opinions on the practices carried out. Smith described outdoor education as "a learning climate for the things which can be learned best outside the classroom" (Priest, 1986). Science education in elementary schools should expand beyond the four walls of the classroom; many opportunities abound in the outdoor setting for learning about science (Carrier, 2009). Outdoor science activities include topics such as night sky brightness measurements, ecological awareness, and the taking photos about light pollution, allowing students to personally experience many learning opportunities in the outdoor setting. Within the scope of outdoor practices, the brightness of the sky at night at chosen settlements in Muğla province of Aegean Region in Turkey, at chosen dark areas and natural habitats are measured with sky quality meter. Along with numeric measures, the sky was photographed with machine that could take wide-angle photographs and the light pollution was shown in photographs. Moreover, students took photographs showing light pollution in the city and carried out studies on what could be done to remove the existing light pollution. In this study, scientific working and thinking environments, where students are active and carry out activities to solve a daily life issue,

were created. In addition, they shared the results of the observations and measurements they made and thus, they were made to understand the significance of sharing knowledge in theorizing basic science concepts. Computer animated activities enriched with concept cartoons and outdoor science activities were carried out in order to ensure meaningful learning among students and to create awareness among students on the significance of the issue and their opinions about the practices carried out were taken. Taking the results of the studies indicating the positive effects of materials prepared using animations in computer-aided teaching in student success and in removing misconceptions (Yılmaz & Saka, 2005; Rotbain, Marbach-Ad & Stavy, 2008; Çepni, 2009; Özyılmaz Akamca, Ellez & Hamurcu, 2009) into consideration, this study used animations in preparing concept cartoons on light pollution.

One of the most efficient practices to make learning more fun and interesting is computer animations (Arıcı & Dalkılıç, 2006). Combining color and movement, animations increase memorability; and make it easier to materialize abstract events or things and to visualize them (Rieber, 1990). Thus, it becomes possible to create rich learning environments for students.

In the current study which aims to create an awareness among students on light pollution during Science Education classes, scenarios on the reasons and effects of light pollution and concept cartoons were prepared considering the negative effects light pollution causes in ecological, economic and astronomical terms (Osman et al., 2001; Percy, 2001; Demircioğlu Yıldız & Yılmaz 2005). Concept cartoons were tried to be made visually interesting for students through the use of computer animations. In addition, activity work sheets prepared for each concept cartoon animation activity were implemented on students. Among the characters in concept cartoons, only one of the character's statements on light pollution is scientifically correct. In the activities prepared and developed, students were asked which character's idea they agree with among the concept cartoons in the animations and a discussion was started; thus, they were made to find the correct idea. Students worked in groups and expressed which cartoon character's idea they agreed with.

Method

Participants

Because this was an experimental study, a study group was taken instead of sample. In 2013-2014 academic year, 19 seventh grade students in a middle school in Muğla province of Aegean Region in Turkey were chosen as the study group and the experimental study lasted two weeks.

Research Design

In the current study, single group pre-test-post-test model, an experimental model, was used.

Table 1. *Research Design*

Before Experiment	Experimental Process	After Experiment
Pre-test (T1)	Computer-aided concept cartoons and teaching through outdoor science actitivies	Post-test (T1, T2)

T1; This represents open-ended questions related to light pollution,
T2; This represents semi-structured interviews related to light pollution and the practices carried out.

Data Collection

The data in the study were collected using open ended questions on light pollution and semi-structured interview questions. Expert opinions from two academics working in the field of science education were taken for the open-ended questions prepared. Organized based on the expert opinions, this assessment tool was implemented on five students to finalize it. Seven open-ended questions on light pollution were administered as a pre-test and post-test on students. Students were provided with scenarios on light pollution which include computer animated concept cartoons and in groups, they expressed which cartoon's idea given in the scenario they agree with. Besides, outdoor science activities were carried out with students (taking photos related to light pollution and night sky brightness measurements). The scientific content of the concept cartoons in computer animations were examined by two experts in science; and the draft animations were examined by experts preparing animations in flash programme. And the determined shortcomings were filled accordingly. After the post-test was administered, semi-structured interviews were carried out with five students in order to find out their opinions on light pollution and the practices carried out and these interviews were recorded with a voice recorder.

Data Analysis

The descriptive analyses of the data collected via open-ended questions were made and these informations were put in tables and student expressions were also quoted. The decodings of the semi-structured interviews recorded in the tape recorder were controlled by the two researchers to ensure the correctness of the decodings. The data from the interviews were examined by the two researchers and themes and codes of interviews were formed; and the reliability percent between the two was found as 92%. Descriptive analyses of the answers of students to semi-structured interviews were made; the data were reduced, categorized and put into tables. Besides, in order to reflect the opinions of the individuals interviewed, direct quotations were included.

Findings

The frequencies and percentages of the answers that students gave to the open-ended questions in pre-test and post-test as well as students' expressions are given in the tables below..

Table 2 shows frequencies and percentages and quotes from the answers students gave to the pollution types that could be considered as an environment problem today:

Table 2. *Frequencies and Percentages related to Question: "What are the types of pollutions that could be considered as an environment problem today?"*

Types of Pollution	Pre-test		Post-test		Students' expressions
	f	%	*f*	%	
Air Pollution	13	68.42	16	84.21	…air pollution… (14th student)
Water Pollution	12	63.16	14	73.68	…water pollution… (17th student).
Soil Pollution	8	42.10	9	47.37	…soil pollution… (1st student).
Sound Pollution	8	42.10	10	52.63	…sound pollution… (12th student).
Light Pollution	6	31.50	16	84.21	…light pollution… (4th student).
Nuclear Pollution	1	5.26	1	5.26	…nuclear pollution… (16th student).

When Table 2 is analyzed, it is seen that whilst 31.50% of the students labelled light pollution as an environmental issue in the pre-test, 84.21% of the students labelled it as an

environmental issue in the post-test. It is seen that computer-aided concept cartoon activities and outdoor science activities carried out had a positive effect on student answers to open-ended questions in the post-test. Table 3 shows frequencies, percentages and quotes of students' answers to the reasons of light pollution:

Table 3. *Frequencies and Percentages on Question: "What do you think are the reasons of light pollution?"*

Reasons of Pollution	Pre-test		Post-test		Students' expressions
	f	%	*f*	%	
Unnecessary/ excessive lighting	13	68.42	19	100.00	Unnecessary lighting in big cities, the lights that bars reflect on the air, excessive brightness in billboards (13th student).
Unconscious lighting	3	15.79	10	52.63	Wrong lighting in unnecessary locations (4th student).

When Table 3 is analyzed, it is seen that students think that the reasons of light pollution are unnecessary/excessive lighting and unconscious lighting; and that there is an increase in the percent of the students who gave these answers in the post-test. Table 4 shows frequencies, percentages and examples of quotes of students' answers to how to determine whether there is light pollution in a specific area:

Table 4. *Frequencies and Percentages on "Is it possible to determine whether there is light pollution in a specific area? And how?"*

Determination of light pollution	Pre-test		Post-test		Students' expressions
	f	%	*f*	%	
With a light measurement device	2	10.53	18	94.74	...with devices measuring light pollution (4th student).
With naked eye	2	10.53	1	5.26	It can be seen by looking at the sky with naked eye... (12th student).

When Table 4 is analyzed, whilst 10.53% of the students in the pre-test stated that light pollution could be determined using a light measurement device, 94.74% of them gave the same answer in the post-test. Measurement of light via sky quality meter outside the school was efficient in the increase in the percent of the correct answer to the open-ended question in the post-test.

Table 5 shows frequencies, percentages and examples of quotes of students' answers to what kind of negative effects light pollution has on environment question:

Table 5. *Frequencies and Percentages on "What kind of negative effects does light pollution have on environment?"*

Negative effects of light pollution	Pre-test		Post-test		Students' expressions
	f	%	*f*	%	
In terms of eye health	2	10.53	2	10.53	…Our eye health will be at risk (6th student).
In terms of astronomical observations	4	21.05	9	47.37	The lights reflected on the space makes it difficult for astronomers to examine the sky… (13th student).
Harms living things.	6	31.58	17	89.47	…It could cause to failures in natural activities of some living things (Migrant birds – sea turtles) (13th student).
Health problems	2	10.53	4	21.05	It causes to health problems in people (9th student).
Damages natural environment	-	-	5	26.32	…It damages natural balance (6th student).
Damages the economy.	-	-	1	5.26	…It causes to loss of money (12th student).

When Table 5 is analyzed, it is seen that in addition to an increase in the correct answers to the negative effects of light pollution in the post-test, there is an emphasis by the majority of the students (89.47%) on the fact that light pollution harms living things. Table 6 shows the frequencies, percentages and examples of quotes of students' answers to what should be done to prevent light pollution:

Table 6. *Frequencies and Percentages on "What is your suggestion on what should be done to prevent light pollution?"*

Things to be done to prevent light pollution	Pre-test		Post-test		Students' expressions
	f	%	*f*	%	
Preventing unnecessary lighting	5	26.32	10	52.63	Closing unnecessary lightings… (1st student).
Decreasing excessive lighting	5	26.32	8	42.10	…Sufficient light should be used instead of excessive light… (14th student).
Organizing informative seminars (Informing people)	4	21.05	6	31.58	Light should be used consciously, the direction and level of the light should be adjusted correctly (12th student).
Ensuring correct lighting (Conscious utilization)	2	10.53	12	63.16	…ensuring light insulation in street lamps and thus ensuring that the lamps only enlighten downwards (1st student).

When Table 6 is analyzed, it is seen that there is an increase in the percent of students making suggestions on what could be done to prevent light pollution in the post-test, and that

majority of the students (63.16%) made suggestions related to ensuring correct lighting/conscious utilization and preventing unnecessary lighting (52.63%). Table 7 shows the frequencies, percentages and examples of quotes of students' answers to what kind of benefits could prevention of light pollution have:

Table 7. *Frequencies and Percentages on "What kind of benefits, do you think, could prevention of light pollution have?*

Benefits of Preventing Light Pollution	Pre-test		Post-test		Students' expressions
	f	%	f	%	
Making astronomical observations	4	21.05	6	31.58	...astronomers could easily make observations... (16th students).
Preventing the damages it will cause in environment	4	21.05	8	42.10	...environment pollution will reduce ... (14th student).
Preventing visual pollution	1	5.26	3	15.79	...prevents visual pollution (9th student).
Reducing eye problems	1	5.26	3	15.79	...helps to protect people's eye health (4th student).
Energy saving	1	5.26	1	5.26	...We prevent excessive light accumulation in the atmosphere (13th student).
Preventing the damage it could cause in living things	1	5.26	10	52.63	Migrant birds could easily migrate. ...The number of sea turtles remain stable (16th student).
Preventing economic loss	-	-	3	15.79	...and helps to save (12th student).
Protecting ecological balance	-	-	3	15.79	...balance in the nature remains undamaged (5th student).
Preventing health problems	-	-	1	5.26	...has benefits for the health of living things (7th students).

According to Table 7, there is an increase in the percentages of students answers in the post-test to what the kind of benefits could preventing light pollution have; students stated that preventing light pollution will particularly stop the damages it will have on living things (52.63%) and on environment (42.10%) and will enable astronomical observations (31.58%).

The findings of the semi-structured interviews carried out with 5 students after the post-test was administered in order to identify student opinions on light pollution and the practices carried out; and examples of student expressions are given below:

Interviewed students were asked the following question: "What do you think could be the negative effects of the excessive and wrong lighting in the cities?"; 60% of the students stated that it will effect astronomical observations negatively, 40% of the students stated that it will cause migrant birds to lose their way, 10% of the students stated that it damages the economy of the country, 10% of the students stated that it negatively effects the health of the living things, 10% of the students stated that it causes to a bad view of the city.

Examples of student expressions are given below:

It could effect the life of living things negatively. It could have negative effects on our health. It could cause to a bad view of the city. It could lead to environmental problems (4th student).

Astronomical observation could be prevented. It could be dangerous for birds and swallows. Because they will go to wrong ways while migrating, celestial bodies might not be clearly seen during space research due to excessive light (1st student).

Interviewed students were asked the question given: "If you were an environment planner, what would you do to prevent wrong lighting?";

20% of the students stated that they would ensure that unnecessary lights would be closed, 40% of the students stated that they would ensure that the lamps are designed to face down, 10% of the students stated that they would ensure that necessary lighting would be made, 10% of the students stated that they would ensure that the lighting in shopping malls would be reduced, 10% of the students stated that they would ensure that photocell lamps would be used, 10% of the students stated that they would ensure that awareness is created among people.

Examples of student expressions are given below:

> You know that light scatters around. I would focus it to a certain direction. Not all around. I would close the top of the lamp and focus it down, to where it is necessary to light. I would not use much light. I would use sufficient number of lights with adequate power (6th student).

> This is a comprehensive question...I would first start with the city's street lamps. I would design in a way that they face down, in a way that they just light up its environment only (3rd student).

Interviewed students were asked the question given: "Do you think that correct and just required amount of lighting is important in cities? Why?"

All the students stated that it is important. And in addition; 60% of the students stated that it is important for the health of living things, 40% of the students stated that it is important for eye health, 10% of the students stated that it is important in economical terms, 10% of the students stated that it is important in order not to damage ecological balance, 10% of the students stated that it is important in order not to cause light pollution.

Examples of student expressions are given below:

> Yes. High electrical bills are bad for the family and the state. It is economically important. It is important for the health of living things. Birds are effected from the lights in the migration area (1st student).

> It is important. Because if it is more than necessary it causes to light pollution. If everywhere is full of lights, people might lose concentration. Not only people but also other living things such as birds, turtles could lose their ways. So we should provide necessary lighting (6th student).

Interviewed students were asked the question given: "Is it possible to determine the level of light pollution in a certain area? And if yes, how?" All of the interviewed students stated that the level of light pollution at a certain area can be determined. With regards to how it can be determined, the students said that it is possible to determine it with a light pollution measurement device.

Examples of student expressions are given below:

> Yes. It can be determined with a light pollution measurement device (5th student).

In order to identify student opinions on the activities and practices carried out, the students were asked: "Are there any differences in the way you were taught the "Light Pollution" topic that you have just learned in your Science classes from the other topics you have learned before?" and 80% of the students stated that there were differences. 20% of the students stated that they learned visually, whilst 40% of the students stated that the activities were different and fun, 20% of the students stated that the studies created awareness.

Examples of student expressions are given below:

> Teachers used to tell. Here we learned with visuals (2nd student).

We learned more. The activities were different and fun (4th student).

Students were asked what caught their attention most when they were taught the "Light Pollution" topic and 40% of the students stated that it was the negative effects of excessive lighting that caught their attention whilst 40% of the students stated that it was the light pollution problems and solutions and 20% of the students stated that it was animals being negatively effected from the light pollution.

Examples of student expressions are given below:

The light pollution problems caught my attention. And the solutions... (2nd student).

Light pollution, in order words, the results that unnecessary lighting might cause caught my attention as well as how to make necessary lighting (5th student).

Students were asked the given question: "What do you think about the studies and activities carried out while "Light Pollution" topic is taught in Science classes? And 60% of the students stated that the activities created awareness and 60% stated that the activities were useful.

Examples of student expressions are given below:

I believe that it will provide me benefits and I think that I will be more conscious on this issue (3rd student).

I did not know about light pollution. I learned it when we were taught the subject and understood how to use the light source (5th student).

Students were asked the given question: "Will you please tell us which activity you liked most while you were taught the "Light Pollution" issue?". 60% of the students stated that they like the sea turtles activities while 40% of the students stated that they liked the animations.

And among these students; 10% of the students said they liked the activities because they loved animals, 10% of the students said they liked the activities because it was fun, 10% of the students said they liked the activities because it created awareness, 10% of the students said they liked the activities because the fact that the sea turtles lose their ways because of artificial lighting was interesting to them.

Examples of student expressions are given below:

I liked the one about the animals. I love animals. It was good to inform animal lovers more. That the turtles' attraction is distracted and they go towards the light (1st student).

I was interested with the fact that turtles lose their ways. Because the artificial lights catch their attention and they go towards the light and not towards the sea (5th student).

Students were asked the given question: "Would you like other subjects in your Science classes to be taught in the same way as you are taught the "Light Pollution" issue?" and all the students answered this question as "yes". And as the reason 40% of the students stated that it was easier to remember this way, 40% of the students said it was fun and 20% of the students stated that it was interesting.

Examples of student expressions are given below:

Yes. Because animations make it easier to remember... (1st student).

Of course. It is different when all these things are taught with animations. It grabbed our attention. Of course it is better (5th student).

The given question was asked to the students: "Do you think that learning Science class

subjects with activities and studies similar to the ones you did in the "light pollution" subject will be good for you? And if so, why?" All the students answered this question as "yes" and as a reason, 40% of the students said it was easier to remember, 40% of the students said it created awareness, 40% of them said it was fun, 20% of the students said it enabled deep learning, 20% of them said it was enjoyable and 20% said it enabled them to be active.

Examples of student expressions are given below:

Yes. Learning with a different way was certainly better. I learned more. So, it is better. I also become conscious and I enjoyed and learned (1st student).

Yes. I think that I will be more conscious and I can be an example to the people around me. I think that we can learn more easily this way. We are being more active by doing such activities. I think that this was a fun work and we learned new things (4th student).

Students were asked: "Did you like the activities and practices outside the classroom? And if yes, why?" All the students answered this question as "yes" and as the reason behind, 20% of the students said because it was a good practice, 20% said it created awareness, 20% said it was enjoyable, 20% said it was fun, 20% said it taught where there was a light pollution, 20% said because it taught them why stars were not seen well at nights and 20% said it was the first time such a practice was carried out.

Examples of student expressions are given below:

Yes. We can not see the stars lately. I liked to learn the reason behind. The reason is the light pollution. We made measurements in the coast and in a place far from the city. There was too much light in the city. The result of the measurement outside the city was better (3rd student).

Yes I liked. Because I like to learn new things and I also think that it was enjoyable. Measurements were made in two different places and there was a big difference between them. The first place had a lot of lighting and the second place was on a hill and it was darker. There was light pollution in the first place because of unnecessary and excessive lighting (4th student).

Discussion and Conclusion

Through the computer-aided concept cartoon practices and outdoor science activities carried out, the level of correct answers in open-ended questions in the post-test increased. While the number of students who stated that light pollution was an environmental problem was small in the pre-test, this number increased in the post-test. Similarly, Sadık, Çakan & Artut (2011) examined the perceptions of 206 students studying in 5th grade in three primary schools at different socio-economic backgrounds about environmental problems via the pictures students draw; and saw that students drew the loss of forests, air pollution, decreasing species, spoiling ozone layer, sound pollution, soil pollution, global warming etc. as environmental problems in a reason-result relationship yet they saw that only one student drew a picture about light pollution. Taşlıdere (2013), in his study, stated that work sheets enriched with concept cartoons have positive effects on students' understanding of concepts.

Using the data collected through sky measurements in different points in Muğla province and data on light pollution, the study will create awareness about light pollution among students, will create an awareness of dark sky and encourage struggling against light pollution. The practices carried out with seventh grade students are believed to help students to develop an awareness of the ecological, astronomics and economical results of light pollution and to develop solutions for preventing light pollution. Students interviewed stated that in order to prevent wrong lighting, it is important to make necessary lighting and lamps should be correctly curtained and awareness should be created among people.

In their studies that they carried out to determine the perceptions of 8th grade students on

environmental issues via cartoons, Seçgin, Yalvaç & Çetin (2010) revealed that the number of students who expressed that light pollution, as an environmental problem, could be prevented via energy saving was very small.

All the interviewed students in the class in which computer- animated applications enriched with concept cartoons and outdoor science activities were carried out stated positive opinions about the practices. Students stated that they learned the reasons and effect of light pollution very well and that they wanted to make projects and studies towards preventing light pollution. In addition, during some of the interviews, it was observed that students could not think that light pollution gives harm to certain living things. Students stated that they enjoyed making computer-animated activities, making discussions with their friends and doing activities with their classmates outside the classroom.

Students stated that "Light Pollution" subject was taught in a different way compared to previous Science classes they had, that they made visual activities and activities that created awareness and said that they found what they learned useful. Students expressed that the problems that light pollution could cause and possible solutions to such problems grabbed their attention. Ersoy & Türkkan (2010), in their studies they carried out in order to analyze social and environmental problems via the cartoons primary school students draw, stated that one of students they interviewed said: "...I can not see the stars in the sky at night. Because high buildings open their lights. I really missed watching the sky." Similarly, in the activity carried out in this study, with regards to difficulty of seeing celestial bodies in the city, students said: "Street lights should not light up unnecessary locations but only necessary locations. And in order to see celestial bodies better it is necessary not to use excessive lighting but only required lighting."

Students stated that they enjoyed sea turtles activities and computer animations and said that such activities were fun and created awareness. All the students stated that from then on, they wanted to learn all other subjects in Science classes as they learned "Light Pollution" subject; they expressed that it was easier to remember, enjoyable, interesting, fun to learn that way and that it enabled deep learning and being active.

Students said that they did this kind of a practice for the very first time that it was a nice and the activities created awareness and were enjoyable, that they learned where there was light pollution, and they liked the activities they carried out outside the classroom.

Suggestions for the study could be as given below:

Concept cartoons, which prevent students from having misconceptions and that support them to learn by questioning, could be used both in determining misconceptions and changing them.

It is belived that emphasizing light pollution, which is not included in the environment pollution issue in Science curriculum, and its ecological, astronomical and economic importance will help to create awareness among students and thus, among future generations on the issue and to be responsive to the issue.

Using computer-aided concept cartoons in learning environments and learning science through outdoor science activities is believed to contribute to meaningful learning among students and to making the classes more attractive.

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APPENDIX A: Figures related to Implementations

Figure 1. Implementation of Computer-Aided Concept Cartoon Animations and Activity Worksheets in the Classroom

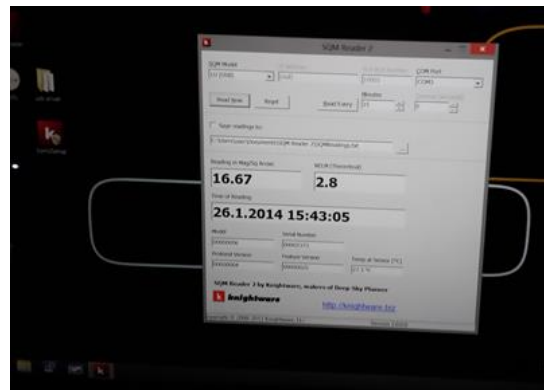Figure 2. Outdoor Activity on Measuring Night Sky Brightness with a Sky Quality Meter

Figure 3: Night Sky Brightness Value in the City Center

APPENDIX B: An Example of Computer Animated Activity