THE EFFECT OF MADE-UP INSTRUCTION BASED ON OPEN AND CLOSED-ENDED EXPERIMENTAL TECHNIQUES ON THE ACHIEVEMENTS AND ATTITUDES OF SCIENCE EDUCATION STUDENTS

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ABSTRACT

The aim of this study is to examine the effect of teaching on open and closed end experimental techniques on the achievements and attitudes of students taking Physics Laboratories III course. In the study, geometrical optics experiments in Physics Laboratories III course were chosen as research area. The research was conducted with 56 students studying in the second class in the Science Teacher Education Program. Experimental and control groups were formed in the research and teaching based on the open-ended experimental technique prepared by the researchers was applied to the experimental group and closed-ended experimental technique was applied to the control group. The following questions were tried to be answered. Is there a meaningful difference between the pre-test and the post-test mean scores of the Optical Achievement Test of the students who have been taught by the open-ended test technique? Is there a meaningful difference between the pre-test and the post-test mean scores of the Optical Achievement Test of students who have been taught by closed-end test technique? Is there a significant difference between the mean scores of the Optical Achievement Tests of the open and closed end experimental groups? Is there a meaningful difference between the mean scores of the Physics Laboratory Attitude Scale of open and closed end experimental groups? Physics Laboratory Attitude Scale and Optical Achievement Test were used as data collection tools in the study. They were applied before and after the application. It was concluded that the test and control group

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students had a significant difference in the final test scores in favor of the final test scores of the experimental group. There was no significant difference between attitude scores in the post test scores of the experimental and control groups. It was concluded that there was a significant difference in the pre-post test success and attitude scores of both groups in favor of the post test scores.

STRUCTURED ABSTRACT

Introduction
The fact that non-applied topics do not pass through concrete from abstract and relate to life prevent science teaching from being effective. It is possible for the students to learn how to use the theoretical knowledge in practice by laboratory studies. Laboratories are an inseparable part of science teaching because students perform activities in the laboratory environment based on learning by doing and living. In order to perform science teaching efficiently, laboratory practices are obligatory (Cepni and Ayvaci, 2006). However, it is considered that the objectives specified in the laboratory practices have not been achieved as all stages of education in our country do not give due importance to the laboratory practices (Yıldız, 2012).

Open-ended experiments allow students to develop behaviors such as thinking, decision making, providing original perspectives in line with the decisions they make and making accurate deductions by obtaining findings as well as developing their psychomotor skills (Cepni and Ayvaci, 2006).

Aim of the study
In the lesson of General Physics Laboratory III, lesson materials based on the open ended experimental technique for teaching geometric optics were designed. The effects of the designed materials on the students' academic achievements and their attitudes towards the physics laboratories were investigated. The purpose of this study is to examine the effect of teaching based on open-ended experimental techniques on the achievement and attitudes of students taking Physics Laboratories III lesson.

Method
This research was designed in a semi-experimental model. The study was conducted with 56 second-year students studying at a state university faculty of education science teaching department during the fall semester of 2017-2018 academic year. Experimental and control groups were established and teaching based on open-ended experimental technique (OEET) prepared by researchers was applied in test group, and closed-ended experimental technique (CEET) was applied in control group.

Universe and Sampling
Students in the 2nd grade studying at a state university faculty of education science teaching department in the fall semester of 2017-2018 academic year are the universe of this research; while students of two classes studying at 2nd grade at a state university faculty of education
science teaching department in the fall semester of 2017-2018 academic year are the sampling of this research.

Data Collection Tools

Physics Laboratory Optical Achievement Test (OAT) and Physics Laboratory Attitude Scale (PLAS) were used as data collection tools in the study. The OAT KR-20 value developed by Demircioglu (2011) was found to be 0.70. The test consists of 25 items. PLAS, developed by Nuhoglu and Yalcin (2004) in order to determine the attitudes of the students towards the physics laboratory, consists of a total of 36 items, 19 of which are positive and 17 of which are negative. The scale contains likert type items with five options (strongly agree, agree, indecisive, disagree, strongly disagree). The Cronbach-alpha reliability coefficient of PLAS was found to be $\alpha = 0.89$. OAT and PLAS were applied before and after the application.

Analysis of Data

It has been checked whether the data on the scores of the students provide the necessary assumptions for the parametric tests. Firstly; normality, homogeneity and linearity assumptions were controlled. Then, descriptive statistics were examined among the groups. Later; covariance analysis (ANCOVA) results were interpreted by taking pre-test (co-variable), post-test (independent variable) and group (independent variable). Dependent t test was used in the groups themselves. The degree of the relationship between the variables was analyzed and the relations between the variables were interpreted according to the results.

Findings

First Sub-Problem:

There was a significant difference between pre-test and post-test average scores of OAT, $p < 0.05$. The average scores of the students on the OAT before the lesson was taught by the OEET ($X=5.15$) is lower than the average scores obtained by the students from the OAT after the lesson was taught by OEET ($X=12.89$).

Second Sub-Problem:

There was a significant difference between pre-test and post-test average scores of OAT, $p < 0.05$. The average of the students' scores from the OAT before the course was taught with CEET ($X=6.38$) is lower than the average score of students from OAT after taking the course with CEET ($X=11.69$) According to the results, CEET significantly improved the students' achievement in Geometric Optics course.

Third Sub-Problem:

According to the ANCOVA results, it was found that there was a significant difference between the test scores, corrected in accordance with the OAT, of the test and control groups, $F(1, 52)=4.03$, $p \leq .05$. OAT scores are related to the teaching method used. Accordingly, the OAT average scores of the students whose courses are taught by OEET ($X=12.90$) are higher than the OAT average scores of the students whose courses are taught by CEET ($X=11.36$).
Fourth Sub-Problem:

According to the ANCOVA results, it was found that there was no significant difference between the test scores, corrected in accordance with the OAT, F(1, 52)=12.13, p>0.05. PLAS scores are related to the teaching method used. Accordingly, OAT average scores (X=138.27), for students whose courses were taught with OEET are higher than OAT average scores (X=136.62) for students whose courses were taught with CEET.

Results and Discussion

In the study, the following conclusions were reached based on the findings and interpretations obtained from the data collection tools.

According to the OAT pre-test averages and the post-test averages of OEET students, the OEET increased the success of the students in the Geometric Optics course significantly. According to the OAT pre-test averages and the post-test averages of the students who were taught by CEET, the CEET increased the students’ success in the Geometric Optics course significantly. There was no significant difference between OEET and CEET groups in terms of their pre-test and post-test OAT mean scores. Our study corresponds to the findings of Celik (2009); it was observed that there was a significant difference between the pre-test and post-test scores, obtained from the achievement test, of the groups to which the open and closed-ended experimental technique was applied, but no statistically significant difference was found between the post-test scores of the groups. This situation shows that both techniques are equally affect student achievement.

There was no significant difference between PLAS and OAT pre and post-test average scores of the OEET and CEET groups.

Keywords: Geometric optics, physics laboratory attitude scale and optical success test

AÇIK VE KAPALI UÇLU DENEY TEKNİKLERİNE DAYALI YAPILAN ÖĞRETİMİN FEN BİLGİSİ EĞİTİMİ ÖĞRENCİLERİNİN BAŞARILARINA VE TUTUMLARINA ETKİSİ

ÖZET

Açık ve kapalı uçlu deney tekniği gruplarının Optik Başarı Testi son test ortalama puanları arasında anlamlı bir farklık var mıdır? Açık ve kapalı uçlu deney tekniği gruplarının Fizik Laboratuvarı Tutum Ölçeği son test ortalama puanları arasında anlamlı bir farklık var mıdır? Sorularına yanıt aranmıştır.


Anahtar Kelimeler: Geometrik optik, Fizik laboratuvarı tutum ölçeği ve Optik başarı testi

Introduction

The fact that non-applied topics do not pass through concrete from abstract and relate to life prevent science teaching from being effective. It is possible for the students to learn how to use the theoretical knowledge in practice by laboratory studies. Laboratories are an inseparable part of science teaching because students perform activities in the laboratory environment based on learning by doing and living. In order to perform science teaching efficiently, laboratory practices are obligatory (Cepni and Ayvaci, 2006). However, it is considered that the objectives specified in the laboratory practices have not been achieved as all stages of education in our country do not give due importance to the laboratory practices (Yildiz, 2012). In the studies carried out on optic teaching, it has been determined that learning difficulties are experienced at primary, secondary and university levels (Colin and Viennot, 2001). Science Education students need to be competent enough to guide their students in the construction process of the optics in their minds within the scope of science courses after starting their professional life. Therefore, everyone agrees on the fact that candidate teachers should have knowledge of the field to perform experiments related to optics within the scope of Physics laboratory lessons (Yildiz, 2012). Galili and Lavrik (1998) concluded that the failure of students in the teaching of optics was due to the inadequate teaching methods and materials.

Open-ended experiments allow students to develop behaviors such as thinking, decision making, providing original perspectives in line with the decisions they make and making accurate deductions by obtaining findings as well as developing their psychomotor skills (Cepni and Ayvaci, 2006). In the open-ended experiments, by giving the materials they will use in the experiment and specifying the purpose of the experiment, the students are asked to find out the sequence of operations, how to conduct the experiment, to find, analyse and determine the result of the data in some of the open-ended experiments, the choice of materials, such as other steps, can be left to the students by giving only the purpose of the experiment (Bayraktar, Erten and Aydogdu, 2006). Students perform laboratory activities in the closed-end experiments as if they're preparing meals by looking up the guide book. In these experiments, students only demonstrate known theories. The students are not entitled to determine the methods they will follow in solving the problem. In open-ended experiments, the student will act as a scientist in determining the experimental procedure; in this way, they will acquire advanced thinking skills (Celik, 2009).

Another variable to consider for an effective learning activity is the attitude (Bahadır and Tuncer, 2017). Positive or negative attitudes towards the course can be said to affect learning in a
positive or negative way. It can be stated that firstly it is important and necessary to determine the attitude levels and the factors that are affected in order to make negative attitudes toward the course positive and to increase the positive attitudes further (Yıldırım and Kansiz, 2017).

In this study, an application based on an open-ended test technique was performed and the aim of the experiment and tools were mainly used on the experimental worksheets while determination of the other operation steps were left to the students.

In the lesson of General Physics Laboratory III, lesson materials based on the open ended experimental technique for teaching geometric optics were designed. The effects of the designed materials on the students' academic achievements and their attitudes towards the physics laboratories were investigated. The purpose of this study is to examine the effect of teaching based on open-ended experimental techniques on the achievement and attitudes of students taking Physics Laboratories III lesson. Taking this into consideration, answers to the following questions were sought:

1. Is there a meaningful difference between the pre-test average scores and the post-test average scores of the Optical Achievement Test of students who have been taught by the open-ended experimental technique?

2. Is there a meaningful difference between the pre-test average scores and the post-test average scores of the Optical Achievement Test of the students who have been taught by the closed-ended experimental technique?

3. Is there a significant difference between the post-test average scores of the Optical Achievement Test of the groups which are applied the open and closed-ended experimental technique?

4. Is there a meaningful difference between the Physics Laboratory Attitude Scale post test average scores of the groups which are applied the open and closed-ended experimental technique?

Method

This research was designed in a semi-experimental model. Semi-experimental models are subordinate to the true experimental models in terms of scientific value. Semi-experimental models are used in many cases where the controls required by true experimental models are not provided or even not sufficient (Karasar, 2013, p. 99). The study was conducted with a total of 56 teacher candidates who are studying in the second year of a state university at the faculty of education science teaching department in Ankara during the fall semester of 2017-2018 academic year. Experimental and control groups were established and teaching based on open-ended experimental technique (OEET) prepared by researchers was applied in test group, and closed-ended experimental technique (CEET) was applied in control group.

Universe and Sampling

Students in the 2nd grade studying at a state University at the faculty of education science teaching department in the fall semester of 2017-2018 academic year are the universe of this research; while students of two classes studying at 2nd grade at a state university faculty of education science teaching department in the fall semester of 2017-2018 academic year are the sampling of this research.

Application Process

Examples of teaching activities based on the open-ended experimental technique in the literature have been examined. A month before the actual application, a pilot application was made with 8 students after teaching activities based on the open-ended experimental technique were examined by 3 experts on the subject. The activities related to the open-ended experimental technique
developed by the researchers and the pilot applications of the prepared materials were made and then the actual application was started. The actual application lasted 6 weeks.

In the control group where the closed-ended experimental technique is applied, the activities to be carried out for each week are detailed in the experimental guide and are mentioned in the steps to be followed effectively by the responsible instructor before the activity starts. The laboratory sheet was prepared by using the Gazi Education Faculty Physics Education Department's Optical Laboratory Experiment Guide. In this method, while the students were performing the experiments, the researcher circulated the groups and asked questions about the experiment that each group performed. After the experiments, the students wrote their reports in the direction of the data they obtained. The experimental guide provides students with the necessary theoretical knowledge about the activity, how to make the activity, and even how the results should come out. In this context, although the students seem to play an active role during the activity, they actually only apply the given instructions. In the control group, activities carried out with the closed-ended experimental technique were performed in 6 weeks.

Data Collection Tools

Physics Laboratory Optical Achievement Test (OAT) and Physics Laboratory Attitude Scale (PLAS) were used as data collection tools in the study. The OAT KR-20 value developed by Demircioglu (2011) was found to be 0.70. The test consists of 25 items. PLAS, developed by Nuhoglu and Yalcin (2004) in order to determine the attitudes of the students towards the physics laboratory, consists of a total of 36 items, 19 of which are positive and 17 of which are negative. The scale contains likert type items with five options (strongly agree, agree, indecisive, disagree, strongly disagree). The Cronbach-alpha reliability coefficient of PLAS was found to be $\alpha = 0.89$. OAT and PLAS were applied before and after the application.

Analysis of Data

It has been checked whether the data on the scores of the students provide the necessary assumptions for the parametric tests. Firstly; normality, homogeneity and linearity assumptions were controlled. Then, descriptive statistics were examined among the groups. Later; covariance analysis (ANCOVA) results were interpreted by taking pre-test (co-variable), post-test (independent variable) and group (independent variable). Dependent t test was used in the groups themselves. The degree of the relationship between the variables was analyzed and the relations between the variables were interpreted according to the results.

Findings

Findings Related to Sub-Problems

First Sub-Problem: Is there a meaningful difference between the OAT pre-test and post-test average scores of students whose lesson was taught with OEET?

In order to determine whether there was any difference between the OAT pre-test scores and the post-test scores of the students who were taught by the OEET, dependent t test was applied to the pre-test and post-test average scores of the students. Statistical data on OAT pre-test and post-test scores are shown in Table 1.

Table 1. Dependent Sampling t-test Results of OAT Pre-test and Post-Test Average Scores of Students in the Test Group in which the Lesson was Taught with OEET

<table>
<thead>
<tr>
<th>OAT</th>
<th>N</th>
<th>X</th>
<th>$S$</th>
<th>df</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre test</td>
<td>27</td>
<td>5,15</td>
<td>3,16</td>
<td>26</td>
<td>8,52</td>
<td>.00</td>
</tr>
<tr>
<td>Post test</td>
<td>27</td>
<td>12,89</td>
<td>3,55</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$p < .05$

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The t-test results of the related samples according to the tests of the OAT scores for examining the success of the OEET are shown in Table 1. There was a significant difference between pre-test and post-test average scores of OAT, p <0.05. The average scores of the students on the OAT before the lesson was taught by the OEET (X=5.15) is lower than the average scores obtained by the students from the OAT after the lesson was taught by OEET (X=12.89).

The average scores of the students from the OAT before the lesson was taught by the OEET is lower than the average scores after the lesson was taught by the OEET. According to the results, the OEET significantly improved the success of the student in the geometric optics lesson.

**Second Sub-Problem**: Is there a meaningful difference between the OAT pre-test and post-test average scores of students whose lesson was taught with CEET?

In order to determine whether there was any difference between the OAT pre-test scores and the post-test scores of the students who were taught by the CEET, dependent t-test was applied to the pre-test and post-test average scores of the students. Statistical data on OAT pre-test and post-test scores are shown in Table 2.

<table>
<thead>
<tr>
<th>OAT</th>
<th>N</th>
<th>X</th>
<th>S</th>
<th>df</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre test</td>
<td>29</td>
<td>6.38</td>
<td>2.63</td>
<td>28</td>
<td>7.15</td>
<td>.00</td>
</tr>
<tr>
<td>Post test</td>
<td>29</td>
<td>11.69</td>
<td>4.11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The t-test results of the related samples according to the tests of OAT scores for examining the effect of CEET on the success are shown in Table 2. There was a significant difference between pre-test and post-test average scores of OAT, p <0.05. The average of the students' scores from the OAT before the course was taught with CEET (X=6.38) is lower than the average score of students from OAT after taking the course with CEET (X=11.69) According to the results, CEET significantly improved the students' achievement in Geometric Optics course.

**Third Sub-Problem**: Is there a meaningful difference between OAT post test scores of open and closed-ended experimental technique groups?

The normality, homogeneity and linearity assumptions provided by the assumptions for the parametric tests of the data of students' scores were examined. As a result of normality test according to OAT pre-test mean scores variable, the results were found as [Skewness Test = -0.67 Kurtosis Test = -0.13]. According to these results, we can say that these values correspond to the range of values stated both by Tabachnick and Fidell (2013) and George and Mallery (2010), and in this sense they provide normality assumption of groups. Homogeneity and linearity assumptions of the groups are provided.

**Table 3. Levene Test Results of the OAT Pre Test Scores**

<table>
<thead>
<tr>
<th>TEST</th>
<th>N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>OAT</td>
<td>54</td>
<td>.79</td>
</tr>
</tbody>
</table>

**Table 4. Descriptive Statistics of Open and Closed-End Experiment Technique Groups’ OAT Final Test Average Scores According to the Groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Average</th>
<th>Corrected Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close ended</td>
<td>29</td>
<td>11.69</td>
<td>11.36</td>
</tr>
<tr>
<td>Open ended</td>
<td>27</td>
<td>12.89</td>
<td>12.90</td>
</tr>
</tbody>
</table>
According to the results of Table 4 related to the corrected OAT average scores, OAT test point average of open-ended experimental technique group was higher than closed-ended experimental technique group. The results of the ANCOVA on whether the difference between the groups’ corrected OAT mean scores are meaningful are given in Table 8. According to the corrected OAT average scores, the test score average of the OEET group was higher than the control group. The results of the ANCOVA on whether the difference between the groups’ corrected OAT mean scores are meaningful are given in Table 5.

**Table 5. ANCOVA Results of OAT Pre-test and Post-Test Average Scores of Open and Closed-Ended Experimental Technique Groups**

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Squares Averages</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>57.35</td>
<td>1</td>
<td>57.35</td>
<td>4.03</td>
<td>.05</td>
</tr>
</tbody>
</table>

*p<0.05

According to the ANCOVA results, it was found that there was a significant difference between the test scores, corrected in accordance with the OAT, of the test and control groups, F(1, 52)=4.03, p ≤ .05. OAT scores are related to the teaching method used. Accordingly, the OAT average scores of the students whose courses are taught by OEET (X=12,90) are higher than the OAT average scores of the students whose courses are taught by CEET (X=11,36).

**Fourth Sub-Problem:** Is there a meaningful difference between PLAS post-test mean scores of open and closed-ended experimental technique groups?

The normality, homogeneity and linearity assumptions provided by the assumptions for the parametric tests of the data of students’ scores were examined. As a result of normality test according to PLAS pre-test mean scores, the result was found as [Skewness Test = -0.66 Kurtosis Test = -0.35]. According to these results, we can say that these values are appropriate to the range of values stated both by Tabachnick and Fidell (2013) and George and Mallery (2010), and in this sense they provide the assumption of normality.

**Table 6. Levene Test Results of the PLAS Pre Test Scores**

<table>
<thead>
<tr>
<th>TEST</th>
<th>N</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLAS</td>
<td>54</td>
<td>.37</td>
</tr>
</tbody>
</table>

**Table 7. Descriptive Statistics of Open and Closed-End Experiment Technique Groups’ PLAS Average Scores According to the Groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Average</th>
<th>Corrected Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Close ended</td>
<td>29</td>
<td>134.28</td>
<td>136.62</td>
</tr>
<tr>
<td>Open ended</td>
<td>27</td>
<td>140.56</td>
<td>138.27</td>
</tr>
</tbody>
</table>

**Table 8. ANCOVA Results of PLAS Pre-test and Post-Test Mean Scores of Open and Closed-ended Experimental Technique Groups**

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Squares Averages</th>
<th>F</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>12.13</td>
<td>1</td>
<td>12.13</td>
<td>0.11</td>
<td>0.73</td>
</tr>
</tbody>
</table>

*p<0.05
According to the ANCOVA results, it was found that there was no significant difference between the test scores, corrected in accordance with the OAT, F(1, 52)=12.13, p>0.05. PLAS scores are related to the teaching method used. Accordingly, OAT average scores (X=138.27) for students whose courses were taught with OEET are higher than OAT average scores (X=136.62) for students whose courses were taught with CEET.

Results and Discussion

In the study, the following conclusions were reached based on the findings and interpretations obtained from the data collection tools.

According to the OAT pre-test averages and the post-test averages of OEET students, the OEET increased the success of the students in the Geometric Optics course significantly. According to the OAT pre-test averages and the post-test averages of the students who were taught by CEET, the CEET increased the students' success in the Geometric Optics course significantly. There was no significant difference between OEET and CEET groups in terms of their pre-test and post-test OAT mean scores. Our study corresponds to the findings of Celik (2009); it was observed that there was a significant difference between the pre-test and post-test scores, obtained from the achievement test, of the groups to which the open and closed-ended experimental technique was applied, but no statistically significant difference was found between the post-test scores of the groups. This situation shows that both techniques are equally affect student achievement. However; Hofstein, Shore and Kipnis (2004) found that there were significant differences in favor of the open-ended experimental technique group in their study. The reason why we obtain such results is that both techniques provide an applied learning environment and that our study was carried out in a short period of time.

There was no significant difference between PLAS and OAT pre and post-test average scores of the OEET and CEET groups. Similarly, in the studies of Duru, Demir, Onen and Benzer (2011) on open-ended experimental applications, no significant difference was observed in the laboratory attitudes of Science Teacher candidates participated in the application group. Akpinar and Yildiz (2006) found that the attitudes of science teaching department students towards the necessity of laboratories were positively and significantly improved while the attitudes of maths teaching department students towards the necessity of laboratories were positively but insignificantly improved.

Suggestions

In this study, it was determined that the techniques used had a positive effect on increasing the students' achievement. In the light of these results, the following suggestions can be offered:

1. In General Physics Laboratory III, open-ended experiments should be included in the laboratory courses in order to conduct the teaching process systematically and teach the optics subjects involved in the curriculum.

2. Optics subjects should be integrated with different disciplines in order to link the subjects that students learn in lessons with possible situations in daily life.

3. While using OEET, discussions can be considered as one of the most effective ways to be followed in revealing the current understanding of the students. For this reason, discussion opportunity should be given frequently to the students during the course. Thus, the opinions of the students on the subject will be determined and they will find the experiments themselves.

4. The experiments of OEET and CEET groups can be made more attractive for students by enriching the experiments visually and graphically during application. For example, in the case of spherical mirrors or reflections, while drawing related to image formation is made, the behavior of
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rays coming from the light source to the object should be emphasized and the position of the observer in the environment should be noted.

5. The results of this research are limited to university level. Similar studies should be conducted with the students at primary and secondary school level.

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