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## Journal of Science Learning

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# Role-Play Simulation for Assessing Students' Creative Skill and Concept Mastery

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**ABSTRACT** This study treats students by role-play simulation for learning the human circulatory system. Creative skill and concept mastery to be assessed aspects at the end of learning. The method used in this research is the quasi-experimental method. The sample was taken by cluster random sampling technique with the population of students in 8th grade at one of Junior High School in Bandung. The samples in the experimental class n=24 and control class n= 24.the data obtained using the rubric of creative skill consist of process and product. For treatment in experiment class, implemented the role play while for the control class conducted the group discussion. This study aims to examine the effect of role-playing on students' concept mastery and creative skills. The data result of students' concept mastery was taken by pretest and posttest. The result of students' concept mastery was indicated by mean of posttest score in the experimental class, which is implemented the role play is higher than the control class, 79.50 > 64.00, respectively. Creative skills in the process that will be seen during the implementation of the role play and creative skills in product measured by the scenario of the role play. This research indicated that role play could be implemented in the teaching-learning process. The research findings show that there is a significant effect of role-playing on students' concept mastery and lead students to be skillfully creative.

**Keywords** Roleplay, Concept mastery, Creative skills, Human circulatory system

## 1. INTRODUCTION

Teaching and learning process should be raised by students engagement. Especially in science learning, the student has the probability of taking all procedures to be a scientist. Role-play simulation be student engagement tools for enhancing learning effectiveness, collaborative capacity, and facilitating social learning (Rumore, Schenk, & Susskind, 2016). Although role-play simulation has given benefit for students, the teacher also should consider how format and preparation for teaching (Stevens, 2015).

Many of Indonesian students have been found a lack of interest in the lesson on their school during the learning activity, and it is influencing their ability to mastery the concept (Azra, 2002). This has been observed by Bjork (2005) and ascribed to the long tradition of the way of teaching-learning and rote learning in the Indonesian Classroom. In our modern society, science and technology play central role various method for education or education method were developed for teaching science in a school to create scientific knowledge, understanding of the impacts to society and its underlying social process (Önkal, Sayım, & Lawrence, 2012). Role-play simulation is one of the methods for teaching science, which is unique, new, and revolutionary. Besides that, there are rarely researchers focused on the scope of role-playing which is used by real people in a real situation (Daniau, 2016).

Teaching method, which is used in Indonesia, commonly are not varieties and tends to be teacher-centered. It makes students less interested, feel bored, and do not engage in the teaching-learning process that is why students consider human circulatory as a difficult subject. Students have difficulties in imagining biology phenomena in real life, so they remember the aspects without knowing what is happen there. Students tend to be passive and listen

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to what their teacher explains. Students' attitude toward biology lesson should not be that passive, and students should be more active since attitudes are integrally linked to learning achievement (Freire, Baptista, & Freire, 2016). Roleplay activities can develop students' visualization through a range of modalities, which included embodied sensation and andromorphic metaphors. The essence of science role play at school is to shape a contextualization for science and technology to trigger imagination, raise questions and stimulate debate among students to increase the science concept mastery (Prima, Putri, & Sudargo, 2017).

Drama typed activities such a role play can support the learning of cognitive, affective and technical objective especially higher-order thinking skills related to analysis, synthesis and evaluation and it has been claimed (Anderson, 2001). Roleplay can enable meaningful learning, and it is already suggested by experimental studies. A central characteristic of these activities is that they are seen to promote opportunities for "interactive dialogue," dialogic teaching (Edmiston, & Wilhem, 1998), and students centered discourse (McSharry & Jones, 2000). Furthermore, the literature consistently highlights findings of high motivation among students, imbued in part of their perception of empowerment and ownership during these events (Prima, Putri, & Rustaman, 2018).

Although role-play simulation was proved to be successful, there is a possibility that students personally do not to be able to grasp the material maximally through this method since each student has their characteristic and because of they are uniquely different attitude and characteristics toward role play. Some of the students are well to learn by role-play method, and some of them are not. One of the students' learning characteristics is students' multiple intelligence. Based on various intelligence theory written by Yasin, Prima, & Sholihin (2018), identifying each student's information has substantial ramifications in the classroom. If a child's intelligence can be defined, then teachers can accommodate different children more successfully according to their orientation to learning. Teachers in the traditional classroom primarily teach verbal/linguistic and mathematical/logical intelligence. It has been claimed that drama or drama typed activities such as role-plays, can support learning cognitive, affective and technical objective, especially higher-order thinking skills related to analysis, synthesis, and evaluation (McSharry, & Jones, 2000).

## 2. METHOD

The research method used in this study is the Quasi Experiment. This is related to the research, which is to investigate the effectiveness of role-playing on students' concept mastery and students' creative skills in learning the human circulatory system. Creswell (2012) stated that


**Figure 1** Design illustration of one group pretest-posttest

quasi-experiment include assignment, but not the random assignment of participant groups. This is because the experiment cannot artificially create a group for the test. The quasi-experiment provides research with the opportunity to assess the effects of interventions or treatments. By applying this method, there was two groups which are experiment and control class.

This research finds students to be tested. Then the researcher introduces a role play that should change the people and test to see if there were any changes. The pre-test post-test that would be taken in this research as following steps (a) Test the students' prior knowledge regarding of circulatory system as the topic (b) Perform the experimental through role play (3) Test the students after the role-play completed to be done as the post-test to see the changes in students' concept mastery and creative thinking. The research design was used in this research is one group pretest and posttest design (Figure 1).

This research is conducted in one of school in Bandung, which applied Kurikulum 2013 in the teaching and learning process. The data collection was done in May 2018. Based on Anderson and Krathwohl (2001) stated that population is a set or collection of an element processing one or more attributes of interest all subject in research. The data population was conducted from all students' school in 8th grade in investigating the teaching-learning process in the classroom. The sample of this research is one of 8th-grade class in one of junior high school in Bandung that applying Kurikulum 2013 using cluster technique sampling. Cluster random sampling is determining sample randomly, which give a better probability for this research.

The population in this research was an 8th-grade student at Junior High School is one of the Bandung School years 2017/2018. After observation, the taken sample was 8th-grade students from two different classes in Junior High School "X" Bandung. The researcher researched in the 8B Class, which learn the topic about a human circulatory system by implementing of role play as a learning method for the experiment class. Another class for compare is the 8C as the control class, which learn the same topic by implementing of the joint project, group discussion and communicate the result in front of the course as the task for students.

## 3. RESULT AND DISCUSSION

### 3.1 Role Play

The role play implementation data is obtained by the observation sheet, which was written by two observers in both the first and second meeting. Since the teaching-learning process is two-way action from teacher and

Table 1 Classroom activity data

| No. | Dimension | 1st Meeting | 2nd Meeting |
|---|---|---|---|
| 1 | Opening Activity | 100% | 100% |
| 2. | Core Activity | 100% | 100% |
| 3. | Closing Activity | 80% | 100% |
| Average | | 93% | 100% |

students. Thus, in this research, is observation sheet for the classroom activity rubric. This activity rubric is a concern on classroom activity that is done in the classroom. This rubric will show the action whether it is according to the lesson plan or not. The largest the percentage the more representative is the activity. The rubric is divided into three main dimensions. Those are opening, core, and closing activity. Each aspect has different events, from opening the class, gaining students' attention, teaching the material until closing the lesson. The result of the calculation can be seen in Table 1.

Based on the table above, it could be seen over all the score is relatively high, so it means that the activity is quite representative based on the lesson plan. It shows that the first meeting, the opening as well as score activity, was conducted according to what the researcher planned on the lesson plan.

Therefore, for the closing activity was only 80% because the researcher should divide the allocation time with the implementation role play by doing the drama based on the scenario of human circulatory system made by themselves, while the researcher was observing their expressions and their activity according to the creative skills rubric to determine the level of their creative skills. After they have done with the role-play, the researcher was giving more time to discuss what they had learned during the whole activity by the question and answer session doing by teacher and students, also conclude the lesson for the human circulatory system. After the discussion session was done, they were doing the posttest given by the researcher to measure how far they mastery the concept by implementing the role play.

## 3.2 Students' Concept Mastery

The instrument that used to measure students concept mastery is objective tests in the form of 25 multiple choice questions as pretest and posttest in the topic of learning the human circulatory system by implementing the role play. The data was collected by 24 participants of students in each class. The parameter that is used was revised of Bloom's cognitive domain. The item tests are based on the indicator of the learning process.

Item test has been tested in term of validity, reliability discriminating power, distractor, and difficulty level. Item test also judged by some experts, then revised. Therefore, it is adequate to be used as a research instrument to get data about students' concept mastery. The item tests measured by cognitive level domain based on Taxonomy Bloom used

Table 2 Recapitulation of students' pretest and posttest based on cognitive level domain

| Class | Data | Cognitive Level | |
|---|---|---|---|
| Experiment | | C1 | C2 |
| | Pretest (%) | 40.48 | 17.26 |
| | Posttest (%) | 80.35 | 77.40 |
| | Gain (%) | 39.87 | 60.14 |
| | <g> | 0.7 | 0.7 |
| | Category | High | High |
| Control | Pretest (%) | 38.09 | 27.98 |
| | Posttest (%) | 73.80 | 50.60 |
| | Gain (%) | 35.71 | 22.62 |
| | <g> | 0.6 | 0.3 |
| | Category | Medium | Medium |

the questions level C1-C6. C1 -C5 are shown by multiple-choice, and C6 level is determined by instruction in project design sheet for students make a scene as the product.

Based on objective tests before that had given both in experiment and control class, there is the following table shows the result of students' concept mastery in learning human circulatory system based on the cognitive level domain (Table 2).

Based on Table 2, the data are influenced by score pretest and posttest in each category of the cognitive domain. Thus, the experiment class could give a significant effect compared to the control one. Discrimination of item test domain incudes the validity, reliability, discriminating power, difficulty level, and distraction of item test. The researcher also considered the result of judgment that is judged by some expert.

Based on Table 2, it clearly can be seen that there is a significant effect in all of the cognitive domain, the scores are increasing, which get C5 level in both of class. It can be analyzed that C5 is the highest level in item test in the form of objective analysis given by the teacher to the students. Based on Bloom's taxonomy, this question includes higher-order thinking skill to evaluate categories that must be able to check and critiquing ability. The data collected from the

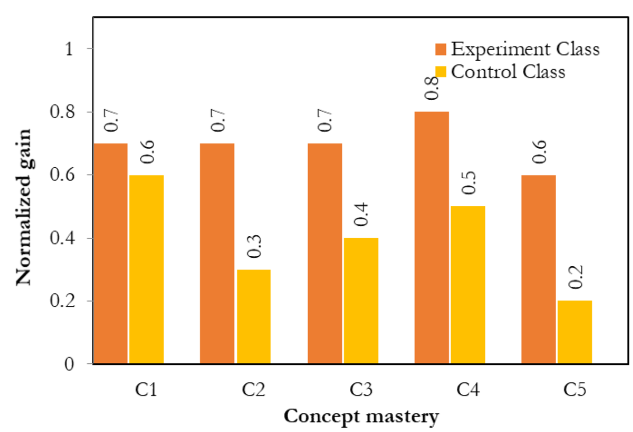


Figure 2 Students' concept mastery based on the normalized gain score in experiment

**Table 3** Result of the pretest and posttest score based on the structural result in experiment and control class

| Test | Score | Experiment Class | Control Class |
|---|---|---|---|
| **Pretest** | Highest | 40 | 60 |
| | Lowest | 16 | 16 |
| | Mean | 32.17 | 38.67 |
| | Standard Deviation | 5.96 | 12.41 |
| **Posttest** | Highest | 96 | 88 |
| | Lowest | 44 | 44 |
| | Mean | 79.50 | 64.00 |
| | Standard Deviation | 11.99 | 13.71 |
| **Gain** | | 47.17 | 24.34 |
| **N-Gain** | | 0.7 | 0.4 |
| **Criteria** | | High | Medium |

result pf pretest and posttest score. The comparison in the experiment class and control class can be seen in Figure 2.

The result got from <g> in each cognitive level (C1-C5) in both experiment and control class. It clearly can be seen that in the experiment class, the students' concept mastery is higher than the control one. From the data shown that in level C5 get the lowest score form both types. There are six cognitive domains stated (C1-C6), but there is no C6 included in the objective test. The C6 is investigated in the form of a project sheet that contains students to create an analogy about the topic through the scenario of role play. In the experiment class, the teacher only gives the students instruction to make a scenario according to the issue after the teacher explaining or giving the outline of the human circulatory system topic. Therefore, for the control class, the teacher provides instruction to them gaining the information about the human circulatory system based on textbook and internet and discuss it in pairs before communicating it in front of the class.

Based on Table 3, it can be seen for both classes experienced an increasing score, thus that the students generally experienced the effect of mastery the concept. The highest score in experiment class on pretest is 40, and the lowest score is 16 meanwhile in posttest the highest score is 60, and the lowest score is 16. The posttest result shows that the highest score is 88 and the lowest is 44. The effect of students' concept mastery determined by calculating the score of normalized gain or <g>. The calculating of this score using formula and get the data in experiment class <g> is 0.7 that categorize as high and in control class <g> is 0.4 that categorize as the medium.

Based on the data can be seen the range of mean in experiment class on pretest is 32.17 and posttest shown the score is 79.50 while in control class the pretest is 38.67 and posttest is shown the score is 64.00. Those are taught that in the pretest of experiment class lower than the control class but the posttest, the experiment class is higher than the control class. From the result of calculation statically, the difference between the pretest and the posttest is stated

**Table 4** Result of normality test on students' concept mastery

| Components | Pretest Experiment Class | Pretest Control Class | Posttest Experiment Class | Posttest Control Class |
|---|---|---|---|---|
| Sig | 0.131 | 0.200 | 0.200 | 0.133 |
| Normality Test Kolmogorov-Smirnov | Sig. ≥ Normal | | Sig. ≥ 0.05= Normal | |
| Conclusion | Normal | Normal | Normal | Normal |

**Table 5** Result of homogeneity test on students' concept mastery

| Components | Experiment Class | | Control Class | |
|---|---|---|---|---|
| | Pretest | Posttest | Pretest | Posttest |
| Sig. | 0.057 | | | |
| Lavene's Homogeneity Test | Sig ≥ 0.05 = Homogenic | | | |
| Conclusion | Homogenic | | Homogenic | |

**Table 6** Result of hypothesis test on students' concept mastery

| Components | Experiment Class | | Control Class | |
|---|---|---|---|---|
| | Pretest | Posttest | Pretest | Posttest |
| Sig. | 0.000 | | | |
| Independent T-Test | Sig (2-tailed) ≤ 0.05, $H_o$ = Rejected | | | |
| Conclusion | $H_o$ Rejected, $H_1$ Retained | | | |

by gain score (G) as much as 47.17 in experiment class and 24.34 in the control class. Means that the effect of students' concept mastery in experiment class is better than the control class shown by the increasing score.

Based on the pretest and posttest score, learning process that applied in class also affects the level of students' concept mastery, this is in line with the statement from Newman and Flaherty (2012) when checked all students' levels of concept mastery through each lesson it sets tine that everyone's thinking is essential and necessary and it can forward the learning and engagement of all. Some techniques are time-consuming to use as quick pulse checks, but use this essential technique together in all lessons allow tracking learning and adapting instruction appropriately on the spot. Teacher use guided practice to enhance their understanding and, in this research, implementing the role play that guided practice for students those stages are planning, creating, evaluating that implemented in lesson plan (Daniau, 2016).

Implementation of role-playing in the learning process improves the students' understanding based on Önkal, Sayım, & Lawrence (2012) state that role play is an effective way to involving students in active social studies learning. Roleplay for learning human circulatory system also analogically describe what's happening in the human's body and human's heart.

The statistical data of pretest and posttest in experiment class and control class calculated to determine whether the normality, homogeneity, the hypothesis is accepted or rejected. All test using the statistical measurement was conducted. The result is shown in Table 4.

Based on the result of normality test use Kolmogorov Smirnov through the pretest score in experiment class the sig value is 0.131 and control class is 0.200 while through posttest score is normal distribution in experiment class and control class where sig. ≥ 0.05. So that the data continued to homogeneity test using One Way ANOVA (Table 5).

The homogeneity test called Lavene's test to know that the data has the same variants or not with the rules if the sig. Value ≤0.05 shows that the data has the same options (homogenous). This measurement uses the gain score of experiment class and control class. The gain score gets from the result of pretest and posttest score in both of course. Due to all of the data shown the normal and homogeneity so that the hypothesis test is conducted by using parametric T-test (Table 6).

In this research, the hypothesis relation with the students' concept mastery in both of class that is already implementing the role play and group discussing. The study has an independent variable and a dependent variable. For independent variable determined by students' concept mastery and students' creative skills and for the dependent variable is the role-play itself. The instrument that used is an objective test for measure the students' concept mastery and student's creative skills and rubrics of the creative skills so that the analysis of students' concept mastery can be seen in the result of statistical calculation.

Based on Table 6 shows that the sig. Value is 0.000; it means that Ho is rejected and H1 is retained. So that the hypothesis that employs is "There are significant differences for students' concept mastery at roleplay in learning the human circulatory system." It can be concluded that the experiment class, which is implemented the role-play has different knowledge in learning the human circulatory system.

The study gives the result that the gain score is experiment class and control class is 47.17, and 24.34 respectively could be seen in Table 2 that means the experiment class has a better result than control class regarding measure about students' concept mastery in learning the human circulatory system. So that the implementation of the role play in determining human circulatory system is more effective than the group discussing class.

Based on the expert activity that conducts during the learning process should be interactive to improve students' concept mastery. The role-play is used as a learning method to help teachers shows the students' understanding of their concept mastery in a particular subject matter. And we could see from the result data that role play is a success, and it indicates that the implementation of role-play has impact improving the cognitive aspect of students' concept mastery (Nurkencana, 2005).

**Table 7** Summary of creative skills in the process

| **The Result of creative skill in the process** | | | | | **Total** |
|---|---|---|---|---|---|
| **Criteria** | **1** | **2** | **3** | **4** | **Score Affective** |
| Score | 50 | 40 | 43 | 49 | 230 |
| % | 79.4 | 63.5 | 68.3 | 77.8 | 72.25 |
| Categories | High | Medium | Medium | High | High |

Notes:
1= Dare to take a risk; 2= Feel the challenge; 3= Curiosity and 4= Imagination

In students' concept mastery, role-play is one of the methods in teaching-learning process which can interpreted to implement the plan that prepare to achieve the learning objectives in the form of concrete activities and practical teaching, because teaching is an ability that needs to be owned by a teacher in presenting the material lessons to their students (Craciun, 2010). It already is proven based on Nurkencana, (2005) said that the implementation of role-playing could improve students' cognitive aspect that can be noticed by processing the difference between pretest and posttest.

For calculating the statistical data use the score of pretest and posttest in experiment class and control class. Besides that to hypothesis test using the gain score from the range of pretest and posttest score in both courses in that attach on the appendix. All of the result shown the positive effect and the effectiveness of the implementation of the roleplay to improve students' understanding or concept mastery in the human circulatory system.

### 3.3 Students' Creative Skills

This research will measure creative skills with the element that included in creative talent such as creative skill in-process and creative skill in a product based on the model or creative ability, cognitive aspect included in product of creative skills while affective and psychomotor dimension included in creative skills as the product. These result of creative skills process and product that would explain the data set based on the research will describe as following:

#### Creative Skills in Process

The data result from creative skills in the process can be taken from the observation sheet and video made of implementation role play as a teaching-learning process. The data in the result of learning about creative skills in operation that can be seen in Table 7.

Based on Table 7 described the result of criteria in the process of creative skills. A criterion number one dares to take risk has score 50 with percentage is 79.4%, and categories of creative ability are high. The second criteria or the criteria to feel the challenge with score 40 and the percentage 63.5% resulted in the ordinary creative skills. The third criteria, which is curiosity with a number score

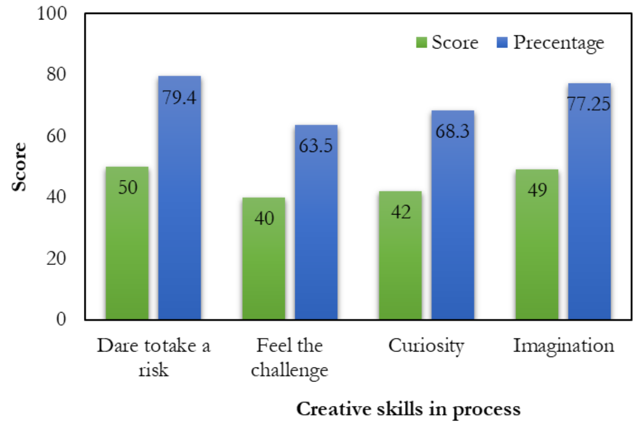


**Figure 3** Comparison creative skills in process

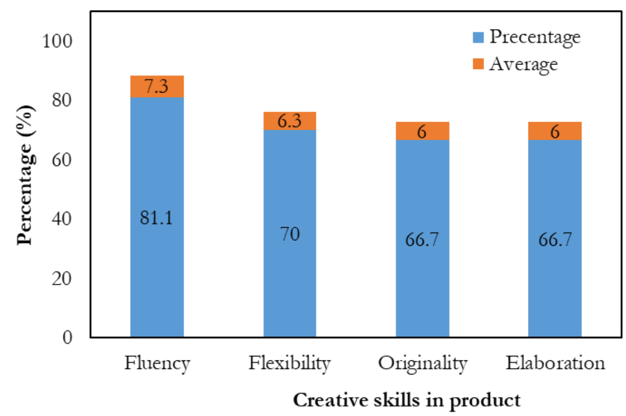


**Figure 4** Comparison of creative skills in product

of 43 and the percentage 68.3% occurred in the average creative skills. For the last tests, the forth, which is the students' imagination got the score 49, and 77.8% and the category of the creative skill is high. Based on the data, the total valid score is 230 as the process of creative talents as the process is high — the comparison of creative skills in operation that can be seen in Figure 3.

Based on Figure 3 about that can be seen the creative skills in the process that dare to take a risk has the higher score which is 50 with percentage 79.4% rather than other criteria as creative skills in the process while feeling the challenge is the smallest score which is 40 with the percentage of 63.5%. In the middle position, curiosity has 42 ratings with the rate 68.3 and imagination with score 49 that the percentage of 77.25%.

### Creative Skills in Product

The data result from creative skills in the product could be taken from the rubric of creative ability in the product. The data in the result of creative talents in the product that can be seen in Table 8.

Table 8 described the criteria of creative skill in the product such as completeness score with an average 7.3 from the maximum rating is 9, with percentage is 81.1%. Thus, the requirements of completeness score category are high. Average of content accuracy (fluency) score is 7.3 from the maximum score is 9, with percentage is 81.1%, so the category is also high. Average of label, organization (flexibility) score is 6.3 from 9, with percentage is 70%, and it means the category is medium. Average of step (elaboration) score is six from maximum score 9, with percentage of 66.7% the category is medium. Average of relevancy is 6 over 9 with the percentage 0f 66.7%and the category is medium. Average of effectiveness (originality) score is 81.1% and the category is high. Average of communication score is 6.3 from 9 with the percentage of 70% and the category is medium. Average of science content dialog score is 6.3 from maximum score is 9 and the percentage of 70% categorized as medium. The last one is the average of time, effort and energy score is 7.6 over 9 with 84.4% as the percentage and the category is high. Thus, total score of creative skill in product is 68.4 from the maximum score of 90 with the percentage of 76% those mean the category is high.

The product of creative skills based on Mijares-Colmenares, Masten, & Underwood (1993) is fluency, flexibility, originality, and elaboration so the result will be showed on Figure 4. The product of creative skills such as criteria of fluency has 7.3 with percentage is 81.1% and flexibility 6.3 with percentage of 70%. Thus, indicated that criteria of fluency greater rather than the criteria of flexibility. While for the requirements of originality and elaboration based on Figure 4. have the same value the average is 6 from the maximum score is 9, with the percentage is 66.7%.

### 3.4 The Correlation of Students' Concept Mastery and Students' Creative Skills

Tanner (2012) stated that the correlation could be defined as the strength of the relationship between two variables; for this research, those are students' concept mastery and students' creative skills. As the previous explanation that each group has posttest score can be analyzed based on the group result got individually. The

**Table 8** Summary of creative skill product

| Component | Creative Skills in Product | | | | | | | | | | Total Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Criteria | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 68.4 |
| Average | 7.3 | 7.3 | 6.3 | 6 | 6 | 8 | 7.3 | 6.3 | 6.3 | 7.6 | |
| % | 81.1 | 81.1 | 70 | 66.7 | 66.7 | 88.9 | 81.1 | 70 | 70 | 84.4 | 76 |
| Categories | High | High | Medium | Medium | Medium | Very High | High | Medium | Medium | High | High |

analysis is calculation the average of posttest score in one group presentation score got by their performance.

Based on the data can be seen the range of mean in experiment class on pretest is 32.17 and posttest shown the score is 79.50 while in control class the pretest is 38.67 and posttest is shown the score is 64.00. Those are taught that in the pretest of experiment class lower than the control class but the posttest, the experiment class is higher than the control class. From the result of calculation statically, the difference between the pretest and the posttest is stated by gain score (G) as much as 47.17 in experiment class and 24.34 in the control class. Means that the effect of students' concept mastery in experiment class is better than the control class shown by the increasing score.

Based on Figure 3 about that can be seen the comparison creative skills in the process that dare to take a risk has the higher score which is 50 with percentage 79.4% rather than other criteria as creative skills in the process while feeling the challenge is the smallest score which is 40 with the percentage of 63.5%. In the middle position, curiosity has 42 score with the percentage 68.3 and imagination with score 49 that the percentage of 77.25%.

Based on Figure 4 shows that the product of creative skills such as criteria of fluency has 7.3 with percentage is 81.1% and flexibility 6.3 with a percentage of 70%. Thus, it indicated that standards of fluency greater rather than the criteria of flexibility. While for the criteria of originality and elaboration based on Figure 4. have the same value, the average is six from the maximum score is 9 with the percentage is 66.7%.

Those results mean that the implementation of the role play in learning the human circulatory system is effective as the learning method. the product created by the students, the cognitive level is C6 (Creating) that expressed in scenario design as the product. means that inside the product must conduct the concept of the human circulatory system that related to their understanding. Based on the definition of creativity is something that must be applied approximately to a task and must utilize the form of media as a vehicle of communication, which is completely aligned with the Revised Bloom Taxonomy. Bloom's Taxonomy puts creating at the top level of higher-order thinking because of the nature of the thinking involved in the creative process, which requires students to move beyond basic understanding. This makes sure that there is a correlation between students' concept mastery and students' creative skills.

According to the data result we could compare that the experiment class got a higher score than the control class, it makes the experiment class was success to prove that the implementation of role-play could give an effect to the students' concept mastery and creative skills than the control class that only did the ordinary group discussion instead of implementing the role play like the experiment class did and it is supported by what Freire, Baptista, & Freire (2016) said that the role play influenced students' achievement in score that the achievement here means students' concept mastery based on the cognitive domain.

While the creative skills from both students could be seen by the result of the data of the experiment class and those results, show the percentage from each category that the students did the role play well and triggered them to be more creative. The control class one could not do the same way because by doing the ordinary group discussion, they were not getting an equal chance to be more creative. The flexibility and the opportunity to communicate their idea is limited by the ideas compare to the experiment class, which implemented the role-play; they free to move during the learning process. They even made their design by themselves by making the scenario of the human circulatory system before they do the role-play in front of the class.

The role play indeed could effectively develop students' creative skills (Agustin, Liliasari, Sinaga, & Rochintaniawati, 2017) it is proved also based on this study about the effect of role-playing not only on students' concept mastery but also students' creative skills in learning the human circulatory system.

## 4. CONCLUSION

The research about the effect of role-playing on students' concept mastery and students' creative skills in learning the human circulatory system has been conducted systematically. According to the result of research, those are the conclusions for this study as follow (1) The implementation of role-playing in learning the human circulatory system is effective in increasing the students' concept mastery. The results got from the average of the N-Gain that conducted in the experiment class, which is 0.7, and the control class is 0.4. The result showed that the N-Gain in the experiment class is higher than the control class categorized whether it is as medium or high, the result also indicated by the mean of the experiment class is higher than control class which is 79.0> 64.00 respectively. The improvement of students' concept mastery supported by the acceptance of the H1 so that the H0 is rejected.it means that there is a significant effect of the implantation of the role play on students' concept mastery. (2) Students' creative skills toward the role play in learning the human circulatory system are effective to increase the creative abilities and give the improvement of current aspect in creative skills dimension. The result of percentage in experiment class that implementing the role play is higher than the control class which is only the classic group discussion. (3) The result of the research inlined with others researches which study the same variable that found there is an effect about implementing the role play. Not only on students' concept mastery and students' creative skill, but also the role-play could influence the students' enthusiasm and triggering students being more interesting (Prima, Putri, & Sudargo, 2017). Obviously, students can more actively participate during the learning process compared by the experiment class and the control class activity observed during the learning process.

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# The Effect of Guided Inquiry Laboratory Activity with Video Embedded on Students' Understanding and Motivation in Learning Light and Optics

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**ABSTRACT** This research aims to investigate the effect of guided inquiry laboratory activity with video embedded on students' understanding and students' motivation in learning lights and optics topic. The method used in this research was pre-experiment. The sampling technique used in this research was convenience sampling, and the samples were taken from grade 8 in one of junior high school in Bandung. The sample was 20 students. The class implemented guided inquiry laboratory activity with video embedded in learning light and optics. The students' understanding was measured using test given at pretest and post-test while students' motivation was calculated using software ministeps (RASCH Model). The t-test paired sample also was performed on the average level of 95% to identify the significant difference of students' understanding before and after the implementation of guided inquiry laboratory activity with video embedded. The results of this research show that the use of guided inquiry laboratory with video integrated gives an improvement of students understanding. Even though the value of n-gain is 0,264 (categorized as low level), the statistical test shows that there is a significant difference between students understanding before and after the implementation of guided inquiry laboratory activity with video embedded. There are 15 students from 20 students who are motivated in learning light and optics by using guided inquiry laboratory activity with video embedded. Students are motivated by the implementation of guided inquiry laboratory activity with video embedded.

**Keywords** Guided inquiry laboratory activity, Video embedded, Students' understanding, Students' motivation, Light, and optics

## 1. INTRODUCTION

Physics is a branch of science that studies about natural phenomena that are physically by observation, experiment, and theory. Physics is taught through learning activities in schools by a set of activities that are designed to support student learning (Prima, Utari, Chandra, Hasanah, & Rusdiana 2018). The principle of learning physics is to prioritize scientific processes to produce products and to be based on scientific attitudes. The scientific process in learning physics is identical to the implementation of activity with the scientific method (Sari & Sunarno, 2018). There are lots of learning models, approach, and learning methods that can support the process of learning physics. Based on the 2013 curriculum of Indonesia, current science learning need to use a scientific approach. Scientific learning is learning that adopts scientific steps in building knowledge through the scientific method (Puspitasari, Lesmono, & Prihandono, 2015). In line with curriculum 2013, teachers must have learning support devices in the form of teaching materials, worksheets, discussion sheets, and media used to facilitate students in understanding the material (Sunarya, & Mudzakir, 2017; Prima, Putri, & Sudargo, 2017).

Students' learning outcomes for physics subjects are relatively still low. When learning physics, it is found that the lack of seriousness of most students in learning physics is that students do not play an active role in the class and still focus to teacher center (Sari & Sunarno, 2018). Most students' do not have right learning motivation and a positive attitude in learning physics (Prima, Putri, & Rustaman, 2018). This indicated by the lack of the seriousness of students' in learning physics and the negligence of students' to do assignments from the teacher. In addition, there are several factors that affect students' learning result; which are in the instrument, learning device such as curriculum, program structure, learning facilities and learning media, and teachers as learning designers.

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There are several ways to support the physics learning process is using media is one kind of innovative learning. By watching the video, students' emotions are triggered by specific visual scenes, the actors, and background music. A video can have a substantial effect on students' mind (Berk, 2009). Video is a combination of images and sound, create a powerful medium for an explanation of concepts while instructing learners with content that provides multiple senses (Pratiwi, Rochintaniawati, & Agustin, 2018).

Laboratory activity is significant in learning science. The purpose of laboratory work is to developing students understanding related to scientific content, problem-solving skill, and science processes skills. Students have to know the connection between experiment and scientific theory. By scientific inquiry, students determine the problems, developing solutions, and alternative solutions for these problems, search for information, evaluate the information, and communicate with their friends (Salsabila, Wijaya, & Winarno, 2018).

Learning with guided inquiry is an effective way to vary the atmosphere of classroom teaching patterns. Guided inquiry learning is group learning where students are given the opportunity to think independently and help each other with friends and guide students to have individual responsibilities and responsibilities in groups or partners (Ambarsari, Santosa, & Maridi, 2013).

In guided inquiry laboratory activity, student search for an experiment by the given problem. Usually, Guided Inquiry experiments are based on discovery, the procedure is predetermined (Kumdang, Kijkuakul, & Chaiyasith 2018). The use of Guided Inquiry laboratory activity, in which students have principal autonomy in the design and execute the experiment (Fakayode, 2014). Teachers should move away from traditional lecturing and cookbook-style laboratories to active learning strategies that help students to develop their cognitive processes (Tessier & Penniman, 2006).

In the guided inquiry laboratory method, student search for an experiment by a given problem. In this activity, the experiments are similar to the expository experiments, but a lab manual is not given to the students. Students search for the experiment process and reach scientific information by the test (Ural, 2016a). Guided inquiry laboratory enhanced students' learning.

Using video have an advantage which is can help students to observe the phenomena that too fast or too long happened. The use of animation video can attract students to more focus on the explanation of the concept and can saving time in explaining the concept. Learning with video animation can give the opportunity to student and teacher to teaching and learning faster and combine active learning and technology.

The characteristic of the video is in the form of animation with colorful and cheerful visual and audio, the source of the video is from YouTube. There is a YouTube channel named Peek a boo that contains some educative video for any subject, peek a boo make a character that is used to explain the material named dr. Binocs with the title of the video is The dr. Binocs Show.

In this research, the topic of Light and Optics is chosen because based on the information from the student learning method that is used in the class still teacher center. The teacher only delivers the concept based on the handbook, and then students were asked to answer the questions from the book. And also still lack laboratory activity in learning light and optics, the teacher even uses lecturing method to delivers the concept. Students are too difficult to focus and pay attention to the teacher during teaching-learning activity. It caused students learning outcome are low.

Previously, there are several research conducted to improve students' understanding in light and optics topic by implementing several approach, method or models, such as Virtual Laboratory Flash Animation (Permana, Widiyatmoko, & Taufiq, 2016), interactive module with LCDS program by Arbai, Edie, and Pamelasari (2014) and using Direct Instruction Model by Anggraini, Zainuddin, and Miriam (2017). However, there is no research about guided inquiry laboratory activity with video embedded in learning Light and Optics. Such research could further suggest changes in educational practices. For this reason, this research was initiated to investigate students' understanding and motivation by using Video embedded - guided inquiry laboratory activity among 8th Grade students. It is thought that by using guided inquiry laboratory activity with video embedded will increase students' understanding of light and optics topics and motivate students' in learning light and optic.

Such research could further suggest changes in educational practices. For this reason, this research was initiated to investigate students' understanding and motivation by using guided inquiry laboratory activity with video embedded among 8th Grade students. It is thought that by using guided inquiry laboratory activity with video embedded will increase students' understanding of light and optics topics and students' motivations and students' understanding of learning light and optic.

## 2. METHOD

The research method that was used in this research was pre-experiment. Pre-experiment a type of research that uses a single subject to determine the causal relationship between the independent variable and dependent variable without any extraneous variable (Anderson, & Krathwohl, 2001). This method is appropriate with the purpose of this research that investigates the effect of Guided Inquiry Laboratory Activity with Video embedded on students' understanding and motivation in learning light and optics. It can determine the change of independent variable but not due to extraneous factors. The pre-experimental

**Table 1** Research design of one group pre-test and post-test

| Pre-test | Treatment | Post-test |
|---|---|---|
| $O_1$ | X | $O_2$ |

**Table 2** Descriptive statistic of objective test, pre-test and post-test

| Component | Pre-test | Post-test |
|---|---|---|
| N | 20 | 20 |
| Average Score | 37,25 | 53,25 |
| Maximum Score | 55 | 75 |
| Minimum Score | 20 | 20 |
| | Normality | |
| Significant (sig $\alpha$=0,05) | 0,134 | 0,472 |
| Information | Normally distributed | Normally distributed |
| | Homogeneity | |
| Significant (sig $\alpha$=0,05) | 0,032 | |
| Information | The data are Homogen | |
| | Hypothesis Test | |
| Significant (sig $\alpha$=0,05) | 0,000 | |
| Information | H1 accepted, there is a significant difference | |

method may able to approach the true experimental process (Cohen, Manion & Morrison, 2007).

The research design that was used in this research was one group pre-test and post-test as seen in Table 1, which means that the researcher only takes an experimental group to measures the groups' dependent variable (O1), that usually called as a pre-test. The pre-test was given to the subject using an instrument in the form of multiple choices. The next step was giving an experimental manipulation (X), by learning with Video embedded with Guided Inquiry Laboratory Activity, before conducting post-test.

The research was taken in private Junior High School in Bandung. The school uses Bahasa Indonesia in their learning activity of Science. The curriculum of the Junior High School is National Curriculum of 2013.

The population in this research was 8th-grade students' of the public Junior High school in Bandung. The samples were 8th-grade students from one class consist of 20 students. Consist of 12 male and 8 female with age around 14 years old. The sampling technique that was used was convenience sampling, which is a selection of the subjects that selected by the willingness of the researcher and its available to be studied (Cohen, Manion, & Morrison, 2007).

The objective test was developed to measure students' understanding of Light and Optics. This test was given to the students in pre-test that was before any implementation of Guided Inquiry Laboratory with Video Embedded, and post-test that was after the treatment given the students. The purpose of post-test was given to measure students' understanding after the treatment.

The type of question that was given in the pre-test and post-test are multiple-choice, contained 25 questions. All test items were judged by the experts and tested to the students' that have learned about light and optics.

To determine students' motivation in learning light and optics with Video Embedded with Guided Inquiry Laboratory Activity that is used in this research, a questionnaire is developed by using 4 point Likert-scale (Strongly agree, agree, disagree, strongly disagree). The Students' Motivation Toward Science Learning (SMTSL) was used to assess students' motivation in learning light and optics and the students' answer was to analyze by statistical software, namely RASCH model.

## 3. RESULT AND DISCUSSION

### 3.1 The effect of Guided Inquiry Laboratory Activity with Video Embedded on students understanding in learning light and optics

The objective test was given to the subject of the research to determine their understanding. The instrument was distributed twice, pre-test and post-test, the concept that was used are the same, which is Light and Optics. Moreover, the score that has been obtained from all research subjects were analyzed to determine the normality of items, homogeneity test of items, also hypothesis of the research. The SPSS software was used to analyze the data that consist of 25 questions in the form of multiple choices.

Table 2 shows that the average score of post-test is higher than the pre-test. From 20 students in the pre-test, the maximum score is 55. It is proving that the students' prior knowledge is still low. In this research, the average is too low to be categorized as a good score in line with the minimum criteria of mastery learning in the school, which is 65. There only three students who get score 50. The other scores are below 50; even the worst is 20. Meanwhile, after the implementation of learning using the Guided Inquiry Laboratory with Video Embedded, the maximum rating is 75.

The post-test score is higher than pre-test, it is because after the post-test and re-check their answer most students can answer the questions that they cannot respond in the pre-test. This is because during teaching-learning activity students more active and more explore their activity. Some students relish learning with guided inquiry laboratory activity with video embedded, it makes students easier to absorb new knowledge. It is because guided inquiry laboratory activity with video embedded improves students understanding about light and optics by involving students in a scientific atmosphere where they are allowed to try how a scientist works. During the teaching-learning process with guided inquiry laboratory activity, they are stimulated to pose scientific questions, collect and analyze the data from hypothesis, design and conduct a scientific investigation, formulate the explanation and communicate the arguments.

The normality test result of pretest and posttest shows that the data are typically distributed because the result shows the values which are more than 0,05. The method of calculating normality using Shapiro-Wilk because the sample is only 20, which was a small number and this method is effective to reduce the error of normality in a few amounts (Cohen, Manion, & Morrison, 2007). The improvement of students understanding can be indicated by the average gain score which is 16.00. The average normalized gain score is 0.264. It means that the average normalized gain score is at a medium level. The same with the normality test result, the homogeneity test result of pretest and posttest shows a value which is more than 0,05, it can be said that the data is homogeny.

Because the data were normal and homogeny, than it decided to compare the mean used parametric statistics which was Paired Sample T-Test. Obtained that the sig. value 2 –tailed of T-test paired sample is 0.000. Compared to the significance ($\alpha$), which has the value 0.05, the sig. amount 2-tailed is smaller than the significance ($\alpha$) value. Then it can be concluded that $H_1$is accepted, which means that there is a significant difference in students understanding between pre-test and post-test using Guided Inquiry Laboratory with Video Embedded in Learning Light and Optics.

In line with the other research about guided inquiry, the students in the guided-inquiry condition demonstrated significant improvements in both conceptual understanding and their levels of explaining the concept (Ambarsari, Santosa, & Maridi, 2016). The result of implementing guided inquiry shows that there has been a significant increase in students' attitudes, and their academic achievement (Ural, 2016b).

### 3.2 Students' Motivation in Learning Light and Optics

Students' Motivation in Learning Light and Optics, in this research, determined using questionnaire using 4 – Likert scale. In the questionnaire only use a 4-Likert scale because the neutral option is meaningless, a neutral option does not express whether it positive or negative opinion. The neutral option was excluded as a strategy to encourage students to express either a positive or negative opinion, rather than remaining neutral. The questionnaire was given to research subject after conducting post-test. The overview of this questionnaire is the motivation of students in learning science using Guided Inquiry Laboratory with Video Embedded, especially in learning Light and Optics topic. The RACSH model was used to analyze the instrument that consists of 25 statements in the form of the questionnaire. The neutral option was excluded as a strategy to encourage students to express either a positive or negative opinion, rather than remaining neutral. The questionnaire was given to research subject after conducting post-test. The overview of this questionnaire is the motivation of students in learning science using Guided Inquiry Laboratory with Video Embedded, especially in learning Light and Optics topic.

After the questionnaire was given to the subject, then the score that has been obtained were analyzed used ministep software from RACSH model to determine the profile of students motivation in learning light and optics. The RACSH model was used to analyze the instrument that consists of 25 statements in the form of a questionnaire as shown in Figure 1. The result shown in the form of Variable maps, there is two areas in the maps which is person area and item area. Person map indicates students meanwhile item indicates the students' motivation statements. This variable map arranges the students from the students who have high motivation for the students who have low motivation in learning Light and Optics (top-bottom). The top item indicates the hardest students' motivation statement to approve and the bottom item indicates the easiest students' motivation statement to approve.

From the data 09L is the person who stands higher in the top than other people, that means the person with code 09L is the most person that approves with the statement in the questionnaire or 09L is the most motivated students that other subject of the research. In the result, person 09L can answer all the states in the survey even the hardest statement to be approved. Then, there was 19L that stand in the bottom than other people, that is mean the person 19L is the hardest to agree with the statements in the questionnaire or 19L is the less motivated students after the treatment.

The data shows there were 15 persons that more motivated than the other person, 15 persons consisted of 9 male and 6 female. And there were 2 persons that less motivated that consist of 1 male and 1 female. Based on the limits of the data above, there are 3 students whose

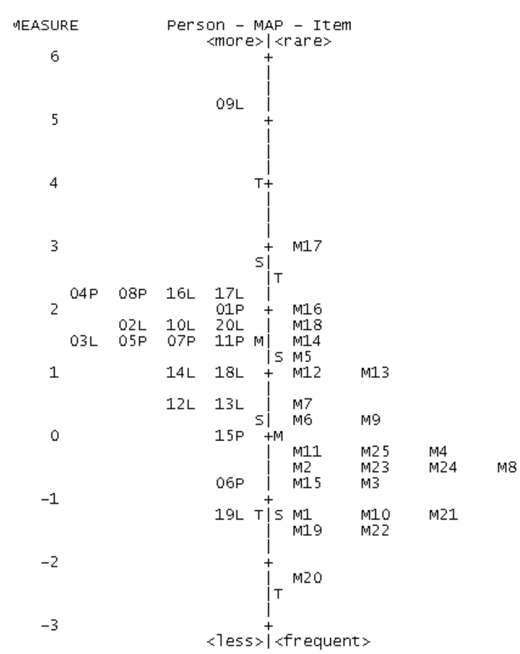


**Figure 1** The result of students' motivation

learning motivation is so-so. That consists of 2 male and 1 female.

On the data not only person who more motivated or less motivated, but there also obtained data about the item motivation that easiest to approve and the item motivation that hardest to approve. Based on the data shows that there was an item that hardest to approve that is M17 or item number 17, which states "I participated in learning light and optics so I would look smarter than other students". There also shows an item that easiest to approve that is M20 or item number 20, which is a state "I feel delighted when I can solve complex problems". Based on the data persons 04P, 08p, 16L, 17 L, and 01P cannot approve the statement M17 or item number 17 as stated above. Then, persons 02L, 10l, and 20L cannot agree with statement M17 and M16, but they approve statement M18 and the rest of the statements.

Next are persons 03L, 05L, 07P, and 11P they cannot approve M17, M16, and M18 but they can approve M14 and the rest statement. Contrast with 10L, 03L, 05L, 07P, and 11P recommend statement M14 that has been stated above, it may indicate they prefer to ask the answer to other as an easy way to answer the assignment rather than they think and find the answer by themselves. Then, persons 14L and 18L cannot approve statement M17, M16, M18, M14, and M5 but they agree statement M12 and M13 and the rest of statements. M5 stated "I want to take part in learning light and optics because it is exciting", they did not approve the statement may indicate learning light and optics cannot attract their interest or they not attract in learning physics.

Persons 12L and 13L only approve M7 and the rest of the statements and cannot approve M12 and M13, M12 stated "I believe I can do test in chapter light and optics" and M13 "If there is assignment in light and optic that have difficult part, I will pass it and try the easiest one". It may indicate a lack of confidence in answering questions from the test or assignment.

Statement M7, M6, and M9 cannot be approved by person 15P, M6 stated "When I was learning a new concept in chapter light and optics I relate the concept with my experiences" and M9 "During learning light and optics I try to relate every concept I've learned before." But person 15P can approve the rest of statements, this may indicate person 15P lack of previous mastering concept. Person 06L cannot approve statement M11, M25, M4, M2, M23, M24, and M8, but 06L can approve M15 and M3. M15 stated, "I participated in learning light and optics to get good scores" and M3, "I think it is important to learn how to solve the problem in chapter light and optics." It may indicate, a person during the teaching-learning process 06L try to learn how to solve a problem in chapter light and optics to get a good score in the final test.

Not an only variable map, there also scalogram as the result of data analyzed using RASCH model. Scalogram

```
GUTTMAN SCALOGRAM OF RESPONSES:
Person |Item
       |212 12 1  22 12    11 1111
       |0921013528344156972354867
       |-------------------------
     9 +4344344344444444433444333  09L
     4 +3343433433333333333332343  04P
     8 +4333333333343343333333333  08P
    16 +3333334333333333333433333  16L
    17 +4443343433342343322334222  17L
     1 +4434433343333333343222322  01P
     2 +4433433333333333333423232  02L
    10 +4333343333334333333231333  10L
    20 +3343334343333333333232333  20L
     3 +4333333333333333333333322  03L
     5 +3334333333333333333333232  05P
     7 +3333333333333333233333333  07P
    11 +4443343433333324232432311  11P
    18 +2333333333333333332332333  18L
    14 +3334333333343333333132231  14L
    12 +3333333333332333333232322  12L
    13 +3333333333333333333132231  13L
    15 +3333333333333232222323222  15P
     6 +3323323333333322332322111  06P
    19 +3332332222222322222323222  19L
       |-------------------------
       |212 12 1  22 12    11 1111
       |0921013528344156972354867
```

**Figure 2** Scalogram showing the response pattern systematic between students' motivation (sorted from high to low ability vertically, top to bottom) and items' motivation (classified from manageable to severe horizontally, from left to right)

shows the response pattern systematic between students' motivation (sorted from high to low ability vertically, top to bottom) and items' motivation (classified from manageable to severe horizontally, from left to right) as seen in Figure 2. Both scalogram and variable maps. The students who have high motivation is 09L, and the students who have low motivation is 19L.

There are a number of students who have unique response patterns. Some students have unique patterns such as 17L, 18L, 06P, and 19L. Students with 17L code, on motivation item 4 answered disagree even though for the following items that had a higher difficulty level (more difficult to agree), he actually answered strongly agree. Likewise, students with code 06P, inconsistent because on motivation items 21 and 22 answered no agree, even though there should be a pattern and showing from variable maps that 06P must answer agree. The last unique thing that can be analyzed is that students with the 19L code where students are less motivated can be seen from the answers, which most patterns disagree with the statement of motivation in learning light and optics.

From the data, it was obtained that guided inquiry laboratory activity with video embedded in learning Light and Optics can motivate students. The improvement of students motivation with guided inquiry laboratory activity can happen because students feel challenged or new things to find the concept by the experiment, then students look enthusiastic and interested during the teaching-learning process. Learning with guided inquiry laboratory activity can make learning activity more meaningful for students because the experience that they get from the experiment activity can help students to relate and explain the event that connects with daily life. The experiment that was conducted to get the data can increase students self-confidence. Discussion activity that was conducted after the experiment activity can make students more confident for the asking and deliver their opinion. This is in line with previous research, teaching using guided inquiry can increase students motivation in learning science (Yuniastuti, 2013). **S**cience laboratories in schools support and promote student motivation and learning strategy use (Milner, Templin, & Czerniak, 2011).

## 4. CONCLUSION

Be rooted in data analysis, the use of guided inquiry laboratory activity with video embedded gives an improvement of students understanding. Even though the value of n-gain categorized as low level, the statistical test shows that there is a significant difference between students' knowledge before and after the implementation of guided inquiry laboratory activity with video embedded.

Students are motivated by the implementation of guided inquiry laboratory activity with video embedded in learning light and optics. There are 15 students from 20 students who are motivated in learning light and optics by using guided inquiry laboratory activity with video embedded. Almost all statements related to students motivation toward science learning can be approved by students.

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# Analyzing Student's Problem Solving Abilities of Direct Current Electricity in STEM-based Learning

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**ABSTRACT** This research has been conducted to analyze students' problem-solving abilities in direct current electricity in STEM-based learning. The implementation of STEM in this research is to train the domain of scientific practices and engineering practices that are associated with model problems and project-based learning. The research method used was pre-experiment with the design of one group pretest-posttest. The subjects of the research consist of 27 students at the 10th grade of one of the Vocational Schools in Kabupaten Bandung Barat. The instrument of problem-solving ability in this study are four structured description questions, each of which consists of 5 questions, indicators of problem-solving ability, namely visualize the problem, describe the problem in physics description, plan the solution, execute the plan, and check and evaluate. As a result of the research, it was found that there was an increase in students' problem-solving abilities with the application of the integration model problem and project-based learning in STEM-based learning.

**Keywords** STEM, Problem based learning, Project-based learning, Problem solving ability

## 1. INTRODUCTION

In the life of the 21st century requires a variety of skills that must be mastered by someone in facing every life problem, so that education can prepare students to learn the various skills needed to live life in the 21st century (Pacific Policy Research Center, 2010). The attachment was issued by the Minister of Education and Culture Regulation number 21 of 2017 concerning the contents of Primary and Secondary Education Standards. The 21st century skill is used to meet the future needs and to meet Indonesian Gold Generation in 2045. It has established Competency Standards for Graduates based on 21st Century Competence consisting of four competencies. Consequently, students must have communication, critical thinking, and problem-solving, collaboration, and creative and innovative. This ability must be owned by graduates in Indonesia (Kemendikbud, 2016).

One of the 21st-century skills is problem-solving ability. Problem-solving ability as a mental and intellectual process used by students to relate previous knowledge and problems they face, and also recall the experience of solving problems in the past so that they get a solution to the problem. Problem-solving ability is one of the competencies that students must have. In another opinion, Adolphus, Alamina, & Aderonmu (2013) problem solving is identifying the gap between the issues and solutions using information (knowledge) and reasoning. With the adequate problem-solving ability, it will facilitate students in facing work situations that are filled with various problems that must be solved by them (Yulindar, 2018).

Problem-solving ability is needed by students to face global competition. Thus, students will be ready to jump in and participate in the real word (Patnani, 2015). Therefore, various efforts need to be made to improve problem-solving ability in students. These efforts include improving students' skills related to solving their problems and improving the quality of teaching by improving teacher methods and characteristics. Thus, it is expected that students will be better prepared to face some problems, especially if they have been directly involved in the community. This is because when solving problems, an individual not only needs to think, but they need to think critically to be able to see the issues and think creatively to be able to solve problems.

The ability to solve problems, in essence, learning to think or learning to reason, namely thinking or reasoning, applies the knowledge that has been obtained previously to

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address new problems that have never been encountered (Heller & Heller, 2010). Whereas according to Ahiakwo (in Adolphus, Alamina, & Aderonmu, 2013) states that, problem-solving is identifying gaps between problems and solutions using information (knowledge) and reasoning.

To solve the problem at hand, an individual will take steps related to the problem-solving process. Steps or steps that must be passed by students in solving problems there are five stages, namely (1) visualize the problem, (2) describe the problem in physics description, (3) plan the solution, (4) execute the plan, and (5) check and evaluate by Heller and Heller (2010).

Based on the facts in the research that has been done before, it was found that students' problem-solving abilities were still low. As in the study conducted by Yulindar (2018); Sutiadi & Nurwijayaningsih (2016); Jua, Sarwanto, & Sukarmin (2018); and from the results of a preliminary study in one of the high schools in West Bandung district, it was found that students' problem-solving abilities for each indicator were still low.

From the research that has been done before, it is known that, students' physics problem-solving abilities are improved by using appropriate learning models and approaches such as problem based learning models as in the research conducted by Sutiadi & Nurwijayantidingsih (2016), Wahyu, Sahyar, & Ginting (2017), Sahyar, Sani & Malau (2017), Sahyar & Fitri (2017), and Argau, Haile, & Ayale (2017), Ferreira & Trudel (2012); collaborative learning (Adolphus, 2013); direct instruction models; inquiry-based on just in time teaching-learning training models (Turnip, Wahyuni, & Tanjung 2016); engineering design-based modeling approach (Li, Huang, Jiang, & Chang, 2016); project-based learning (Tamba, Motlan, & Turnip, 2017); Real Engagement in Active Problem Solving (Yulindar, 2018); and so forth. So it can be concluded that the problem-solving abilities of students in Indonesia are deficient.

In practicing problem-solving skills, the right learning process is needed where students are motivated to solve problems faced. The difficulties faced cannot be separated from the use of technology, so the use of technology in learning is essential, so STEM-based knowledge is suitable learning in fostering community interest (Yasin, Prima, & Sholihin, 2018; Wandari, Wijaya, & Agustin, 2018).

STEM approach (science, technology, engineering, and mathematics) is learning by integrating science, technology, engineering, and mathematics. The application of STEM in learning can encourage students to design, develop, and utilize technology, sharpen cognitive, manipulative, and affective, and apply knowledge (Kapila & Iskander, 2014). Therefore, the application of STEM is suitable for use in physics learning. STEM-based learning can train students to apply their knowledge to create designs as a form of solving problems related to the environment by utilizing technology. In applying STEM can be supported by various learning methods. Integrative STEM allows multiple learning methods to be used to support its application (Wirkala & Kuhn, 2011).

There are three essential domains in STEM, namely: (1) Practice: scientific practice and engineering practice, (2) Discipline core ideas, and (3) crosscutting concept (National Research Council, 2011). In this study, the researcher took one domain, namely, practice. For scientific PBL models are used while for engineering practices, PjBL is used.

In the National Research Council explained that Scientific practice is a domain that discusses student involvement in science practice. The experience will help students understand how scientific knowledge develops; such direct relationship gives them an appreciation for the various approaches used to investigate, model, and explain the world. Moreover, engineering Practice or engineering practices assume that student involvement in engineering practice will help students understand the work of engineers, as well as the relationship between engineering and science. Participation in these practices also helps students form an understanding of the concepts and ideas of overlapping scientific and engineering disciplines; Besides that, it makes students' knowledge more meaningful and puts it deeper into their worldview.

The PBL model is used for scientific practice because this learning model is a model that presents a problem related to physics concepts to students and provides opportunities for students to solve problems by conducting investigations or experiments. PBL can provide opportunities for students to apply knowledge to issues/problems as a form of problem solving. Indirectly, the use of PBL also encourages students to master the knowledge needed to solve these problems (Permanasari, 2016). This knowledge can be in the form of information or data which is then used as material for consideration to choose the right way of solving the problem through logical, critical, and systematic thinking. Meanwhile, PjBL that is applied to engineering practices is able to guide students to solve the problem given and emphasize more on the product produced (ChanLin, 2008). The products produced can be ideas or ideas that can be seen. Products produced from the use of PjBL in science learning can be a student's contribution to improving the quality of life. The PjBL model is a student-centered learning model to develop and apply concepts from projects produced by exploring and solving real-world problems independently.

According to Bybee (Awad & Barak, 2014) STEM realizes the importance of science and mathematics, and places particular emphasis on technology and engineering as a field that influences our lives, and is very important for people who are interested in continuing to renew. Integration of STEM in learning models in this case PBL and PjBL can improve problem-solving ability and help build relationships in real life. Therefore it is possible to use the STEM approach to further enhance students' problem-solving abilities.

## 2. METHOD

In this study used the pre-experimental method with one group pretest-posttest design. The dependent variable in this study is the ability to solve students' physical problems in direct current electricity (O). While the learning model used is the PBL and PjBL model that is integrated into the STEM approach is an independent variable (X). Therefore, the study subjects used only one group without a comparison group. The design of one group pretest-posttest can be seen in Table 1.

The population in this study were all students of class 10th grade in one of the Vocational Schools in Kabupaten Bandung Barat, Jawa Barat who were enrolled in the even semester of the 2018/2019 academic year. The sampling technique of this study is by taking a class randomly (random class). This sampling technique is because it does not allow changing the formation of students in an existing class if randomly chosen individual samples. So that one class is taken to be used as the research subject group.

The instrument for problem-solving abilities used is tests and non-tests. The problem-solving ability test is given in two trials. The pretest and posttest in the description of the problem questionnaire consist of 4 structured items. Each item consists of five problem-solving indicators. It refers to the indicator of problem solving according to Heller where there are five steps to solving the problem, namely (1) visualize the problem, (2) describe the issue in physics description, (3) plan the solution, (4) execute the plan, and (5) check and evaluate each item. The non-test instruments used are student worksheets, which refer to the Heller problem-solving indicators which consist of three meetings, namely Ohm's law, electrical circuit and Kirchoff's law, and household electrical installations.

The instrument test was carried out by three experts. After the data is collected, the problem-solving ability score is from the pretest, posttest, and worksheets by calculating the average N-gain.

## 3. RESULT AND DISCUSSION

The integration of the problem-based learning (PBL) and project-based learning (PjBL) models with the STEM approach in this study aims to analyze the problem-solving abilities of SMK students. Learning is carried out in five meetings with direct current electricity. The first and fifth meetings were used to do the test and posttest while the meeting for learning used three meetings with the first and second learning details to train the scientific practices using the PBL model with the STEM approach and the third meeting to prepare engineering practices using the PjBL model with the STEM approach. Direct current electricity is taught divided into three submissions, namely Ohm's law, electrical circuits, and electrical installations.

**Tabel 1** *One group pretest-posttest* design

| Pretest | Treatment | Posttest |
|---|---|---|
| O | X | O |

Data on students' problem-solving abilities obtained in this study were from the data from the pretest and posttest results as well as student answers to the worksheet. The results of the pretest and posttest were measured using a problem-solving ability test in the form of a description problem with a score range of 0 - 4. The distribution of students' problem-solving abilities can be shown by comparing the average scores of the pretest and posttest and the gain and N-Gain scores of all students direct current electricity. The improvement of students' problem-solving abilities as a whole from the results of the pretest, posttest, and gain data is presented in Figure 1.

Students' problem-solving abilities are abilities that students must possess along with the development of the 21st century (OECD, 2014). The problem-solving ability referred to in this research is the ability of students to use their knowledge based on their experience in electricity or dynamic electricity laws that they learn to solve various problems that are often encountered in everyday life, especially those related to equipment or technological work. Figure 1 is the average value of students ' problem-solving abilities before learning, which is measured using the problem-solving ability test shows 17.55 from a maximum amount of 100. Whereas, the average value of students' problem-solving abilities after learning shows 73.75 from the maximum value 100. It is increasing students' problem-solving ability based on average gain values of 56.2. The average gain is then normalized into N-Gain; the result is 0.68. The N-gain results were confirmed by the category from Hake (1999), so the improvement of students' problem-solving abilities as an impact of the integration of PBL and PjBL models in STEM-based

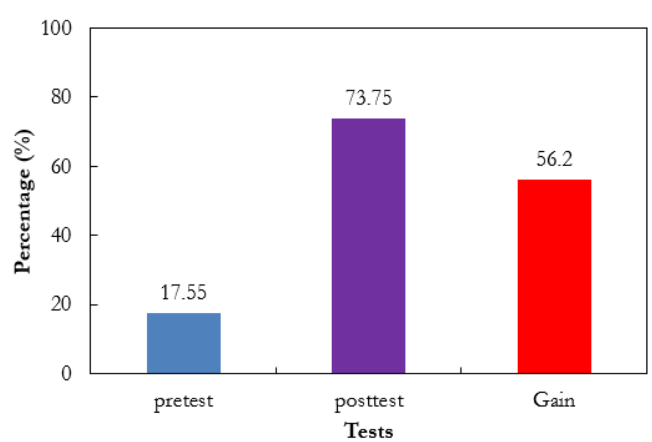


**Figure 1** Percentage diagram of the average problem-solving ability of students

**Table 2** Percentage of the number of students in each category of improvement in problem-solving ability

| Category | Number of students | Percentage (%) |
|---|---|---|
| low | 0 | 0 |
| medium | 15 | 55,6 |
| high | 12 | 44,4 |

learning was included in the medium category. As explained earlier, this assessment was carried out by integrating two models, namely the PBL and PjBL models as stages of scientific practices and engineering practices. The same was found by other studies that conducted research to analyze the problem-solving abilities of students using problem-based learning models such as in research by Wahyu, Sahyar, & Ginting (2017); Sahyar, Sani, & Malau (2017); Sahyar & Fitri (2017); Ferreira & Trudel (2012) which could improve problem-solving abilities. The results of the study were the improvement of students' problem solving and critical thinking skills. A similar study was conducted by Tamba, Motlan, and Turnip (2017) which aimed to analyze the effect of a project-based learning model (PjBL) on creative thinking skills and problem-solving. This finding also supports Berry's (2012) statement that STEM integration in learning models can improve problem-solving ability and can help with relationships in real life.

Based on Table 2 it is known that there are 15 students experiencing an increase in problem-solving ability in the medium category with a percentage of 55% and 12 students in the high grade with a percentage of 45%. None of the students experienced an increase in the low category. This shows that the integration of PBL and PjBL models in STEM-based earning can improve students' problem-solving ability in direct current electricity.

The improvement of problem-solving ability in learning on direct current electricity is the impact of the integration of PBL and PjBL models in STEM-based learning that is built through five stages in PBL (equipped with eight steps of scientific practices) and six stages in PjBL (equipped with eight engineering practices). Each stage in the PBL and PjBL models is done using experiential learning. Learning through direct experience is a process to get meaningful learning from direct encounter by Mughal & Zafar (2011). Direct experience, including active experiments, makes it possible to implement STEM in dealing with real situations (Gilmore, 2013). This can strengthen the results of the study that the integration of PBL and PjBL models with STEM-based learning can improve problem-solving abilities.

In this study, the problem-solving abilities used in this study consisted of the ability to focus problems, describe problems in physical descriptions, plan problem-solving solutions, use problem-solving solutions, and examine and evaluate problem-solving solutions (Heller, Ronald & Scott, 1992). The percentage of the average score of the pretest and posttest in each indicator of the problem-solving abilities measured is shown in Figure 2.

Figure 2 shows the percentage of the average score of the results of the pretest and posttest of students' problem-solving abilities in each indicator. The average rate of the pretest score on the indicator (a) visualize the problem of 35.69%, (b) describe the issue in physics description of 26.16%, (c) plan the solution of 14.81%, (d) execute the idea of 7, 87%, and (e) check and evaluate of 3.24%. While the posttest results on the indicators focusing the problem were 94.91%, described the problem as 87.73%, planned a solution of 80.09%, used a solution of 61.11%, and evaluated 51.85%. Based on Figure 2, it can be seen that when compared between the average percentage of pretest scores and posttest on all indicators, the problem-solving ability has increased. The improvement of students' problem-solving skills based on the calculation of N-Gain for each indicator is shown in Figure 3.

Based on Figure 3, it can be seen that the highest N-Gain is in the indicator visualize the problem. It was namely 0.92 as the high category. The lowest is to describe the issue in physics description with the N-Gain value of 0.83 in the high category. Planning the solution with the N-Gain value

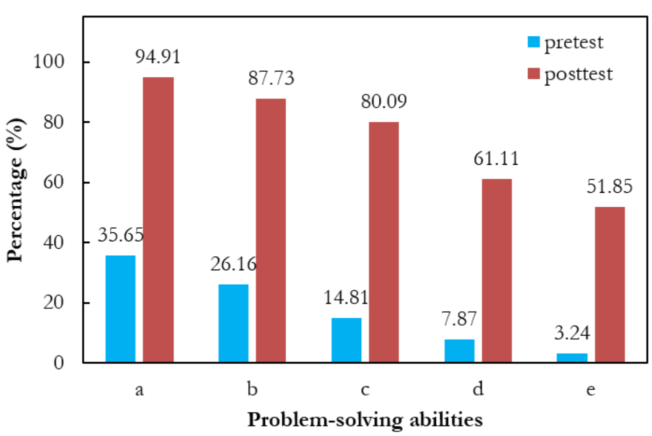


**Figure 2** Percentage of the average pretest-posttest score of students' problem-solving abilities for each indicator

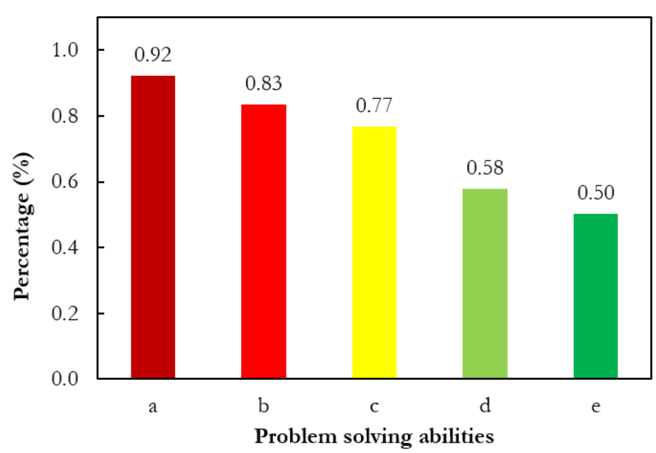


**Figure 3** Average N-Gain score of students' problem solving abilities for each indicator

of 0.77 is in the high category. Executing the plan with an N-Gain value of 0.58 in the medium category, and the lowest increase in the indicator and check and evaluate with an N-Gain value of 0.5 at the medium category. So it can be concluded that indicators with a high category are visualized the problem, describe the problem in physics description, plan the solution, execute the plan, and check and evaluate. The indicator checks and evaluate is the indicator with the lowest increase. This happened because at the first and second meeting, there were still many students who ignored the indicators check and assess. Some students do not review whether the problem-solving solution is in accordance with the problem or not. In general, the ability to solve problems in dynamic electrical material on each indicator has increased as a result of the integration of PBL and PjBL models in STEM-based learning.

Based on the description of the data described illustrates that the integration of PBL and PjBL models in STEM-based learning can improve students' problem-solving abilities on each indicator. Increasing the indicator of the problem-solving skill which is calculated using the highest N-Gain is the indicator visualize the problem (0.92), while the lowest is the indicator check and evaluate (0.50) this is similar to the findings of the research conducted by Yulindar (2018) and Sutiadi & Nurwijayaningsih (2016).

Improved problem-solving skills at pretest and posttest both overall average and each indicator of problem-solving is not directly increased but first students are trained in solving problems in learning with the integration of PBL and PjBL models in STEM-based learning. The value of problem-solving ability of each meeting which is reviewed from the student's worksheet answers can be seen in Figure 4.

Based on Figure 4 can be seen for each student's problem-solving abilities at each meeting. The meeting in this study was divided into three meetings, namely the first meeting to discuss Ohm's law, the second meeting discussed the electric circuit and Kirchoff's 1 law, and the third meeting discussed household electrical installations. For meeting 1, the average score of students is 38.31%, meeting 2 is obtained by the average value of students is 53.20%, and meeting 3 is obtained the average value of students is 75.32%. With the value of N-Gain for meeting 1 to meeting 2 is 0.32 which is in the medium category and an increase in problem-solving ability from meeting 2 to meeting 3 increases to 0.47 which is still in the medium category. This proves that from each meeting the students' problem-solving abilities are increased seen from the value of N-Gain students.

The percentage of problem-solving abilities at each meeting for each indicator of problem-solving ability which is reviewed from the student's worksheet answers can be seen in Figure 5. From Figure 5 it can be seen that the score for each indicator is getting to the high indicator level, the smaller the score the student receives. Based on Figure 5, it can be seen that when compared to the average percentage of the first, second, and third meeting scores on all indicators, the problem-solving ability has increased. For further information, we will look at the capacity of each student's problem-solving in each of the indicators.

From the findings, it can be concluded that the ability to visualize the problem has the highest increase taken from the scores obtained by students on the pretest and posttest problem-solving abilities in each question in part a with indicators focusing the problem. This is assumed because this learning model trains students to focus on problems. Students must first understand the problem before solving a problem that must be faced. The question that is to be solved in the learning process is based on issues that have been encountered by students in everyday life. The ability to focus problems is trained with the STEM approach in the Asking Questions and Defining Problems stage and in the PBL and PjBL models respectively at the first stage/phase, namely student orientation to the problem and determining the necessary questions. At this

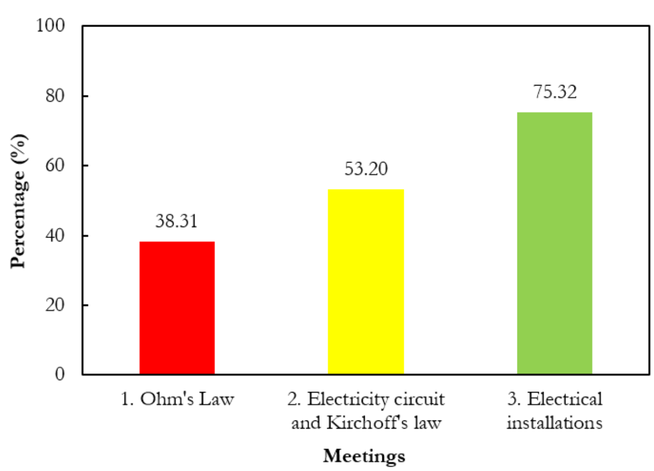


**Figure 4** Average percentage diagram of students' problem-solving abilities at each meeting

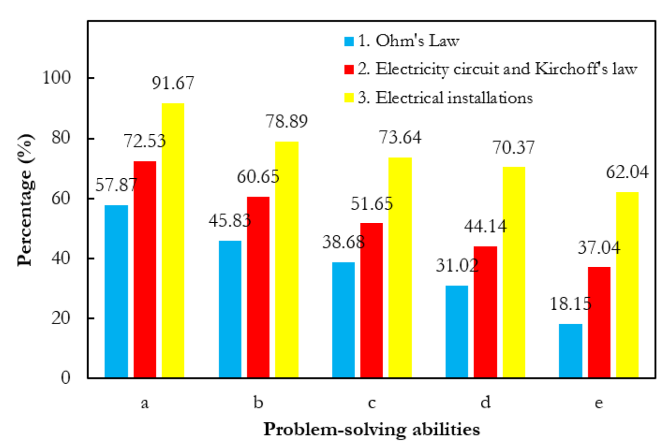


**Figure 5** Percentage of the average score for students' problem-solving abilities for each meeting for each indicator

stage, the teacher acts as a facilitator who guides students to visualize the problem based on issues/problems that have been known or experienced by students. Issues related to the topic regarding energy cycles that occur in the world, especially electricity. Data on the implementation of teacher and student activities at this stage are in the overall category of activities carried out or are in an excellent grade (100%), meaning that both teachers and students do this stage very well.

Unlike indicators visualize the problem that has the highest increase, indicators check and evaluate the lowest growth, which is equal to 0.50 but still in the medium category. Indicators check and assess at this meeting were trained with the STEM approach at the Engaging in Argument from Evidence and Obtaining, Evaluating, and Communicating Information stages in the PBL model and Obtaining, Evaluating, and Communicating Information on successive PjBL models at the last stage/phase, namely Analyzing and evaluating problem solving process (PBL) and experience evaluation (PjBL). At this stage, students are trained to test the solutions they have made. The teacher guides students to evaluate problem-solving solutions that students make. Then students evaluate whether the solutions they have made are by the problems they face or not. But this was done in one of the groups who made the presentation. This can be one of the causes of low ability to evaluate problems. From the data on the implementation of teacher activities the overall category of events was carried out or was in an excellent category (100%) but global student activities only 94% were in an outstanding category but not all were implemented, but in categories meant that both the teacher and students did the stages this very well.

Other factors that might cause a low average increase in evaluating data-based solutions are the form of a problem-solving ability test instrument in the form of a structured description. The disadvantage of structured description questions is that students must be able to answer the initial questions in order to work on the next question (Prima & Kaniawati, 2011). The ability to check and evaluate in test instruments is measured on the last item, after other abilities. Therefore, the results obtained depend on the ability of students to work on the questions in the previous items. This is what causes the indicator to evaluate the solution is the indicator that has the lowest average increase among other problem-solving ability indicators.

## 4. CONCLUSION

Problem-solving ability with the integration of Problem and Project-based Learning models in STEM-based learning as a whole have improved both overall in the value of the pretest, posttest, and worksheets as well as the indicator of problem-solving. If seen from each indicator, it is found that the highest increase is found in the indicator visualize the problem decreases according to the Heller indicator stage where at the check and evaluate stage it has the lowest increase compared to other indicators and if it is seen from the tendency of the scoring results, the score decreases sequentially from visualizing the problem to check and evaluate. This is because the problem-solving ability is a series of mutually sustainable processes, where when you want to reach a good final stage you must go through the initial stages well.

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# The Effect of The Science Web Module Integrated on Batik's Local Potential Towards Students' Critical Thinking and Problem Solving (Thinking Skill)

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**ABSTRACT** The 21st-century learning paradigm requires teachers to provide teaching materials that can develop students' thinking skills. This research aims to determine the effect of the web module science integrated local batik potential toward the thinking ability of seventh-grade students of junior high school. The research method used was quasi-experimental design with a posttest-only design. The instrument used is about thinking skill. The data analysis technique is a Kruskal Wallis test and Effect Size. The results of the research showed that there were differences in students' thinking skill between the experimental class and the control class, as indicated by the Kruskal Wallis test, gives significant results. Web science module integrated with local batik potential has a significant influence on students' thinking skill as indicated by Cohen's effect size score of 0.8. The results of this research can be used to provide insights to science teachers create innovative learning materials to make students more interested in learning science and practicing thinking skills of students.

**Keywords** Science web module, Local batik potential, Thinking skill

## 1. INTRODUCTION

The 21st century is known as the century of the development of science and technology, which has developed rapidly in all aspects of human life. The problems that occur in this century can only be solved by improving and mastering science. Science can be enhanced through education. The 21st-century learning paradigm demands a change in school to produce excellent human resources. Therefore, a school must be able to develop all the potential in students so that students have adequate provision to overcome global challenges and competition.

Partnership for 21st Century Learning (P21) developed 21st-century educational frameworks throughout the world. One of the 21st-century skills in the context is learning and innovation skills. Learning and innovation skills include critical thinking skill and problem-solving as thinking skills. These skills are keys in learning to generate superior human resources and essential competency required to overcome global competition.

Thinking skill is an essential ability that trains the brain to think critically and logically in understanding information, using analytical ability, solving the problem, and appropriately increasing decision-making ability (Prajapati, Sharma, & Sharma, 2017; Salonen, Hartikainen-Ahia, Hense, & Keinonen, 2017; Butterworth, & Thwaites, 2013; Prima, & Kaniawati, 2011). According to Salih (2010), Smit (2015), Roekel (2011), thinking skill is essential so that students can optimize thinking skill so that they can improve problem-solving ability in daily life, analyze thinking to ensure that students have made the right decision, and can be a provision to compete in a global world.

Efforts to develop students' thinking skill can be made through learning activities, one of which is learning Science. Science is a systematic and holistic knowledge associated with natural phenomena obtained through scientific methods. Through science learning, humans not only gain understanding regarding natural phenomena but also their interaction with technology and society (Wisudawati, & Sulistyowati, 2014; Susilowati, 2015).

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Science learning in schools mostly explains about the development of science in the west so that knowledge is not contextual because students cannot see directly and very far, even though science learning should be taught contextually by integrating the local potential of the area where students live. Ibrohim, Afiat, Nurdiana, Estiningsih, & Martiana (2014); Novana, Sajidan, & Maridi (2014); Mulyanto, Masykuri, & Sarwanto (2017) suggested the integration of local potential in the region so that learning can improve thinking skill and process skill, be more contextual and meaningful, and knowledge can also improve care and responsible for the environment.

One of the local potentials that develop in Yogyakarta is batik. Parmono (2013); Wijayanti (2014) explained that batik is a cultural heritage that contains local values; each motif has symbolic and philosophical meaning. Batik initially may only be used by the royal family, but now it can be used by all people. Batik until now is used for performances of dance, ceremonies, and Kraton rituals of Yogyakarta. Batik is made through several processes; in that process, science content can be analyzed that can be raised in learning. Batik making is using chemicals if batik industrial waste is disposed of into the environment without being processed, it will cause environmental pollution. This environmental pollution is found in the necessary competency in Curriculum 2013 in KD 3.8, namely 'analyzing the occurrence of environmental pollution and its impact on the ecosystem' and KD 4.8, which is writing about the idea of solving pollution problems in the environment based on observation.

One of the efforts to develop students' thinking skill, learning activities are carried out by actively involving students. The implementation of learning requires appropriate learning tools, one of which is teaching the material. Teaching material is used to support the learning process and achieve basic competency. Based on the observation in junior high school of 2 Gamping, teaching material used by teachers are in the form of conventional teaching material in the form of printed media which include government-sponsored textbook, lesson textbooks and student worksheets purchased through school suppliers. Teachers have not maximized computer and internet facilities in the school, especially in the learning process and for creating website-based teaching material, even though now they have entered the era of developing technology and information.

The use of ICT in learning has the benefit of making it easier for students to find information, concretize abstract messages, and improve efficiency and effectiveness in learning activities to enhance the quality of learning (Rahmayanti, 2015). For this reason, it is necessary to provide innovative teaching materials to improve the quality of learning. Kusuman, Mukhidin, & Hasan (2016) stated that the use of innovative teaching materials creates interesting learning, fosters interest, motivation, reduces dependency and gets ease in learning each indicator contained in the learning tool compiled by the teacher. Teaching material that can be used is the science module web. The module is chosen because it has the characteristics of self-instruction and self-contained, so students are trained independently to manage their learning time and understand the subject (Kaur, Singh, & Singh, 2017). In addition, the module is made in the form of a web module so that students can learn independently by accessing the module at school or at home (Weni, & Isnaini, 2016; Linda, Herdini, & Putra, 2018). Based on the explanation above, this research was conducted to determine the effect of the science web module integrated on batik's local potential towards students' thinking skill.

## 2. METHOD

This research is classified as quasi-experimental research with posttest only design, according to Creswell (2012) that can be seen in Table 1. This study has two variables, namely independent variables and dependent variables. The independent variable in this study is a science web module integratedpotential local batik (X), while the dependent variable is thinking skill (Y2).

The population of this study was 192 students of grade VII of junior high school of 2 Gamping in the academic year of 2018/2019 divided into six classes; those are class VII A-VII F. The sampling technique used was cluster random sampling. Each class is assumed to have the same ability because class grouping has been determined by the school based on knowledge and gender that has been spread equally. The sample in this study were students from two classes used, namely VII E as the experimental class

**Table 1** *Postest control group design*

| Group | Treatment | *Posttest* |
|---|---|---|
| Control class | $X_a$ | $O_2$ |
| Experiment class | $X_b$ | $O_2$ |

**Table 2** *Thinking skill* questions blueprint

| Aspect | Indicator | Number of Items |
|---|---|---|
| Comprehend the information | Identify problems from the information obtained from many resources. | 1 |
| Using thinking | Analyzing information obtained in full/complex. | 2 |
| Make consideration and decision. | Formulate the strategy to solve the problem. | 1 |
| Reflecting the decision and process critically | Choosing the best solution for solving problems. | 1 |

(Adapted and modified: Trilling, B., & Fadel, C., 2009 & Pacific Policy Research Center, 2010) and VII F as the control class. Each class consists of 32 students.

The instrument used to collect data in the form of questions about thinking skill. Thinking skill questions are used to measure students' thinking skill after learning using the science web module integrated with potential local batik. Thinking skill questions are arranged based on the thinking skill blueprint that can be seen in Table 2.

The data analysis technique used is the K-Independent Sample Test / Kruskal Wallis test and effect size. The K-Independent Test / Kruskal Wallis test was used to find out there were no differences in students' thinking skills using the web science module with students' thinking skills using teaching materials used by the teacher, while the effect size was used to determine the effect of the science module on students' thinking skills

## 3. RESULT AND DISCUSSION

The thinking skill of students is known from the results of the students' scores after carrying out on thinking ability. Data on the thinking skills of experimental class and control class students can be seen in Table 3. Table 3 shows that the average thinking skill value of experimental class is 80.16, and the average thinking skills value of control class is 75.31. Based on these results, the average of the thinking skills value of the experimental course is higher than the average value of thinking skills in the control class. The value of students' thinking skill can be seen in more detail by looking at the comparison of the data thinking skills value of the experimental class students and the control class of each indicator that can be seen in Figure 1.

Figure 1 shows that the average thinking skill of each indicator in the experimental class and control class is different. The trial class has an average of each thinking skill indicator that is higher than the average for each control class thinking skill indicator. This shows that there are differences in thinking skill of students who use the

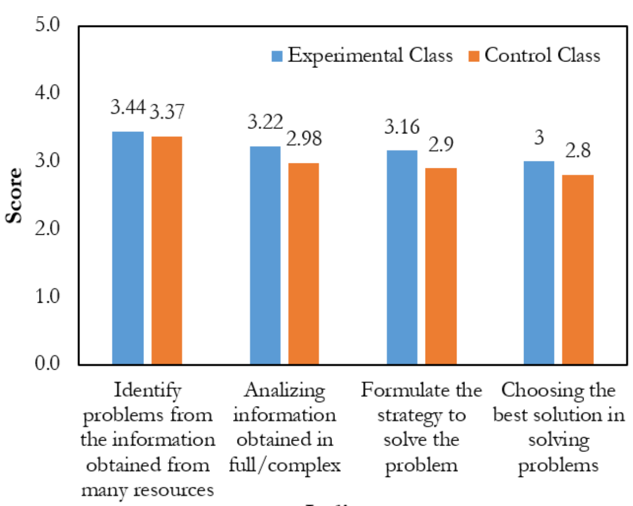


**Figure 1** Average comparison of thinking skill for each indicator

**Table 3** Score data *thinking skill*

| Description | Experimental class | Control class |
|---|---|---|
| N | 32 | 32 |
| Maximum score | 100 | 80 |
| Minimum score | 75 | 40 |
| Average | 80,16 | 75,31 |

**Table 4** Kruskal Wallis thinking skill test results

| Kruskal Wallis | Results |
|---|---|
| Chi-Square | 13.199 |
| Df | 1 |
| Asymp. Sig. | .000 |

science module web with thinking capability of students who use teaching material used by teachers. The difference is supported by the results of the K-Independent Sample Test / Kruskal Wallis test with SPSS 22 using the 0.05 significance level presented in Table 4.

Table 4 shows that the result of the Kruskal Wallis test obtained the Asymp value. Sig. Amount of 0,000 so Asymp. Sig. < α with α of 0.05, H0 is rejected. Therefore, it can be concluded that there is a difference in thinking skill of students who use the science web module integrated with potential local batik by thinking ability of students who use natural science teaching material commonly used by teachers. The subsequent analysis is to find out the magnitude of the effect of the science module web integrated local potential batik towards thinking skill of students using Cohen's effect size. Based on the results of the calculation of the thinking skill value using the Cohen effect size equation, it obtained a score of 0.8 with a high category. It can be said that science web module integrated local potential batik has a high influence on students' thinking skill. The results showed that learning to use the science web module can train students ' thinking skills. In this study, it was found that there was the difference in thinking skills learners who use the science web module with thinking skills learners use learning materials commonly used science teachers, as well as the web module science, integrated potential local batik has a high influence against the thinking skills learners.

Science learning using the science web module not only displays a series of material but contains learning models, images, videos, practice / task questions, downloads, other website link related to the content contained in a web page that can be accessed online so students can learn independently with or without the help of the teacher in order to achieve the specified competencies (Fitri, Kurniawan, & Ngazizah, 2013; Setiyadi, Ismail, & Gani, 017; Tambunan, 2013). According to Kaur, Singh, & Singh, (2017), Mangesa, & Dirawan, (2016); Johar, Risdianto, Fera, & Indiyati, (2014) explained that the science module web has the characteristic of being able to teach in a language that is easily understood by students. For learners, science module web can help students to think holistically and systematically related to the learning material and can be used for independent learning. For teachers, it can make more accessible to design learning because the content is presented in one complete competency which includes learning objectives, material, learning activities, assessment, and assessment feedback. Science module web learning is learning that refers to constructivism theory that helps students gain the learning experience and knowledge to find and formulate knowledge through the exploration of material-related information together with other students so that they can train students' thinking skills (Noel, 2014; Smit, 2015; Pattiwael, 2016).

Thinking skills are the necessary capabilities that train the brain to think critically and logically in understanding information, using the analytical capabilities, solve issues, as well as improved decision-making ability (Trilling & Fadel, 2009). Science web module integrated potential local batik is made with joining the material, and the concept of content had known by the students toward their environment. Hence, the pupils can relate the knowledge that already gained with the new experience easier. The local potential of batik integrated into science web module can be seen by students in the process of making batik using chemicals that have heavy metal content. Batik waste containing heavy metals if not treated properly can cause pollution of the environment.

Learning activities with the science web module asks learners to discuss problems of the identification of the related environmental pollution arising out of batik waste, analyzing the causes of the occurrence of environmental pollution due to debris the results of activities batik making, interpreting the results of a laboratory test related waste batik, formulate the best strategy in providing solutions that can be done to solve the problem of environmental pollution due to waste batik, as well as suggested solutions best solve the problem of environmental pollution due to waste batik. Therefore, the learners thinking skills can be adequately trained. Science web module learning integrated the local potential of batik encourages teachers to connect material taught with real/contextual world situation so that they can prepare to identify concept related to potential local batik, practice logical thinking skill, critical, and problem-solving, are interested in science, and grow concern for the environment (Lia, Udaibah, & Mulyatun., 2016; Agung, 2015; Ilmiyah, Wasino, & Utomo, 2019; Syabandari, Firman, & Rusyati, 2017).

The results of this research are consistent with the research that has been done Anafidah, Sarwanto, & Masykuri (2017) conduct research-based CTL module development to improve thinking skills. The module used contains material application law of Newton in life to improve thinking skills. Indicators used include thinking skills provide an explanation, the skills of solving problems is appropriate content, concluded, and organize problem-solving strategies and tactics. The results showed that the learning modules could improve thinking skills based on N-gain of 0.36 categorized are, and there is a difference in the average mastery of physics students before and after using the module based on paired t-test earned *Asymp. Sig* (2-tailed) less than 0.05 i.e. 0.000.

Other studies conducted Pistanty & Mingle (2015) related science module to improve thinking skills. The module used contains material pollution and its impacts on humans and the environment to train thinking skills. Indicators used include thinking skills to understand the problem, analyze the problem, make the right decisions, logical, and systematic, and consider the most appropriate choices from various viewpoints. The results showed that the module could improve thinking ability based on normalized N-Gain categorized are by a score of 0.62.

## 4. CONCLUSION

Based on the formulation of the problem, exposure to data, the result of research, and discussion, this study concludes that there are differences in thinking skill of students between the experimental class and the control class as indicated by the result of the Kruskal Wallis test with the Asymp value. Sig. of 0,000. The science web module integrated with potential local batik, has lots of influences on students' thinking skill as indicated by the Cohen effect size score of 0,8.

For the researchers who will conduct similar research, the advice given to further researchers is expected to examine more about the effect of the science module web that is integrated with different local potential and the influence of the natural science web module on different variables with different background setting.

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# The Effect of Documentary Films on Preservice Science Teachers' Views of Nature of Science

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**ABSTRACT** Understanding the nature of science, one of the most important dimensions of scientific literacy, is regarded as an absolute necessity in science education. To teach students the nature of science, science teachers should emphasize the nature of science in the classrooms. This is possible through the training of science teachers with knowledge of the nature of science. In this study, documentary films were used to teach preservice science teachers about the nature of science. This study aims to investigate the effect of nature of science course conducted with documentary films on preservice science teachers' views of nature of science. The study, in which the experimental design was used, was conducted with 30 preservice teachers in nature of science and history of science courses. Throughout the courses, documentary films were watched, and nature of science aspects of the documentary films was discussed. The Views of Nature of Science Questionnaire (VNOS-C) was used as pre-test and post-test, and the data were analyzed with SPSS. As a conclusion, preservice science teachers' views regarding the nature of science were enhanced after the implementation.

**Keywords** Nature of science, Preservice science teachers, Documentary films

## 1. INTRODUCTION

The developments in science and technology have affected the education policies of countries, and these alter education systems necessary. In parallel to those alterations, significant education institutions like the American Association for the Advancement of Science (AAAS) and the National Research Council (NRC) emphasize that educating each individual as scientifically literate is one of the main goals of science education (American Association for the Advancement of Science, 1990; National Research Council, 1996). In this context, understanding the nature of science (NOS), which is one of the key components of scientific literacy, is accepted as an absolute need in science education (Meichtry, 1992; Lederman, 2007).

Nature of science is typically described as an epistemology of science, values, and beliefs inherent to the scientific knowledge, science as a way of knowing, and also it includes the historical, philosophical and sociological aspects of science (Lederman, 1992). Nature of science involves understanding what science is and what role it plays; who scientists are and what roles they play; the nature of scientific evidence, observations, facts, rules, laws, and the scientific method; and how science is done (Taşar, 2003).

Since nature of science has a complex structure, which includes different disciplines like sociology of science, philosophy of science and history of science, researchers focus on specific features to make definitions and put emphasize on these features. These features, which are called aspects of NOS, are: Scientific knowledge is tentative (subject to change); science is empirically based (based on or derived from observation of the natural world); science is inferential, imaginative and creative; science is subjective and theory-laden; science is socially and culturally embedded (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002).

Because technology has become an essential part of education, videos, movies, and documentaries have started to play a role in the education process. Videos have become an important teaching tool in terms of visualizing abstract terms and appealing to multiple senses. Numerous research studies about the effects of using documentaries in teaching NOS, which is a part of science education, are

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encountered in the literature. Seçkin-Kapucu, Cakmakci & Aydoğdu (2015) emphasize that documentaries linked to science content would be fruitful for teaching NOS to secondary school students about specific topics. Moreover, in research about teaching NOS, it is stated that students also want to benefit from videos and activities in lessons (Dereli, 2016).

Science teachers have a significant influence on their students for learning NOS. A science teacher needs to have information about NOS to include activities about NOS in his/her lessons, which means science teachers must have a new and updated point of view about NOS if the opinions of students about NOS are to be improved (Sorensen Newton & McCarthy, 2012). In a study about Science Technology Society course, it is stated that introducing scientific videos to preservice science teachers can be useful especially help them understand that science is affected by the social and cultural values of the society. When the studies regarding this subject are reviewed, it is implied that the interests of students in science and the scientific literacy level of students would be increased if science concepts were taught via science-fiction movies (Efthimiou & Llewellyn, 2007). In a two-week study with 11 teachers that was conducted by Bloom, Binns & Koehler (2015), the effects of documentaries in the subject of teaching NOS were researched and it is stated that these effects are limited. In the suggestions of the same study, it is stated that these effects should be investigated by applying these studies over a more extended period. In this study, documentaries about scientific events and the lives of scientists were watched by preservice science teachers (PST) who attended the NOS course for 12 weeks and the effects of these documentaries on the perceptions of PST were researched.

Research questions; (1.) Is there a statistically significant difference between posttest scores of experimental and control groups on understanding NOS? (2) Is there a statistically significant difference between pretest and posttest scores of the experimental group on understanding NOS?

## 2. METHOD

### 2.1 Research Design

In this research, quasi-experimental design with the pretest-posttest control group was used to determine the effects of documentary films on PST' understanding of NOS as seen in Table 1. This design refers to the application of the experiment and the interpretation of data without random assignment (Cook, Campbell & Shadish, 2002). The independent variable of the study was documentary films as a way of teaching NOS, and the dependent variable is preservice teachers' understanding of NOS.

Before and after the course, VNOS questionnaire was applied to PST, and the effect of the documentaries on the views of PST' NOS understanding was evaluated with a comparison of pre- and post-tests of the experimental and control group.

**Table 1** Design of the research

| Group | Pre-test | Treatment | Post-test |
|---|---|---|---|
| Experimental group | VNOS-C | Documentary films | VNOS-C |
| Experimental group | VNOS-C | Regular content | VNOS-C |

### 2.2 Sample / Participants

This study was conducted in the "Nature of Science and History of Science" course in the 2017-2018 spring term. Participants of this study consisted of third-grade preservice teachers who were studying in the Science Teaching program and taking this course. The preservice teachers had a similar background; they took the same courses in the first two years of the college and had no experience about NOS. Sixty preservice teachers were included in this study who continued to take this course and participate in pre and post-tests. The experimental group consisted of 30 preservice teachers (12 females and 18 males), and the control group consisted of 30 (14 females and 16 males) preservice teachers. The age of the sample was about 20 years old. The experimental group and the control group were chosen randomly.

### 2.3 Intervention

The study was implemented in science teaching program students at a state university in Turkey in the "Nature of Science and History of Science" course in the 2017-2018 spring term. The course was taught for two hours per week and spanned 14 weeks (one semester). Pre and post-tests were applied at the first and the last week of the semester. At the remaining 12 weeks, documentary films were used as a way of teaching NOS at the experimental group, regular content was used for teaching science at the control group. Both groups were taught by the same instructor and held explicit reflective discussions about NOS. All the activities and documentary films were addressed the seven targeted aspects of NOS.

Experimental group. Documentaries about scientific events and the lives of scientists were watched by experimental group and discussions about these documentaries were made via the questions asked by the instructor. Eleven documentaries were chosen carefully by the researcher and instructor which would be suitable to highlight NOS aspects like the characteristics of scientific knowledge, progress and historical periods of science, the science-society relation and the lives of scientists. Table 2 shows the content of documentary films and NOS aspects emphasized within each documentary films. Documentary films have been watched in each lesson, and questions have been directed to pre-service science teachers by pausing the video at the points which gives the possibility to relate aspects of NOS and discussions were provided by specifying the ideas of the pre-service science teachers. For example, before the documentary film about Galileo "Does beliefs and culture of a society affect science?" was asked to PST and they were let to discuss it briefly. At the end of the documentary, the same question was asked and after PST had stated their opinions, the instructor stressed the social and cultural aspect of NOS. The length of each documentary was about 45-60 mins and watching each documentary and the discussion took two lesson hours.

Control group. The control group was received regular content which was determined by the Higher Education

**Table 2** Introduction of documentaries and NOS aspects

| Introduction of Documentaries | NOS Aspects |
| --- | --- |
| **1.Mankind-The Story of All of us: Inventors 1&2:** In this documentary, the adventure of mankind's survival is told. We witness mankind challenging dangers while trying to find new places and resources on earth. This documentary unrolls the story of mankind existing on earth. Beginning with the first man's existence, human beings will continue with the adventure of hunting and gathering, learning about the use of agricultural activities, which is a great revolution, and how to learn to use various tools of human beings and learn to survive by developing them. After that, the first battles emerge as a result of the negative aspects of agricultural activities and the emergence of disputes across borders. When it puts up a fight to survive in its early days, mankind uses his effort to destroy his own kind in time and mankind now consumes the resources on Earth rapidly. | *The development of scientific information, the science-technology interaction, the processes of science history and the interaction of science with the social and cultural environment that it belongs to are mentioned.* |
| **2. Avicenna "The Emperor of Medicine":** The documentary, which takes place in the documentary series named 'The candles of Asia' that highlight scientific works in the Islamic world in the Middle Ages, is about Avicenna's life. This documentary gives information about Avicenna's life as it gives information about his scientific study understanding. Avicenna, a Muslim Persian scientist and philosopher, had a good education from a famous scientist of his age. With the help of his intelligence and strong memory, he reached his teachers' levels and had in-depth knowledge in various subjects like philosophy, literature, mathematics and medicine at the age of 14. He focused on medicine and improved new treatments. He got the 'Doctor' title at the age of 19. Avicenna, who was accepted as one of the best doctors of his age, carried out his work without sleeping at night and revealed many works at a young age. 'Kitabu'ş Şifa', one of the biggest works of Avicenna, is an encyclopedia which gathers the information of his age in areas of Logic, Physics, Geometry, Astronomy, Mathematics, Music and Metaphysics. 'Kanun fi't-Tıbbise, maybe Avicenna's most famous work, has been taught as a textbook in Europe for 600 years and is named as the Bible of Medicine. | *The subjective aspect of science, the characteristics of scientists and their personal lives, and the interaction of science with the social and cultural environment that it belongs to were mentioned.* |
| **3. Al-Farabi "Philosophy Courses in Transoxiana":** The documentary, which handles the famous Islamic philosopher Al-Farabi's scientific works in science, art, and philosophy without isolating them from the cultural, social and political atmosphere of the era, can be interpreted as a productive and extraordinary trip to culture and humanity, as well as being a biographical documentary. Al-Farabi, known as the first Muslim philosopher, produced works about philosophy and walked from city to city by following in Aristotle's footsteps. He made an effort to ensure that philosophy and religion did not interfere with each other. | *In this documentary, the subjective and experimental factors of NOS are mentioned. In addition to this, science and society relation is also mentioned.* |
| **4. The life of Albert Einstein:** The documentary, which starts with Einstein's youth years, mentions Einstein's personal life as well as his academic life. His close relation with theoretical physics started when he moved to Switzerland after quitting his school in Germany because of its education style and family problems. Einstein, who had a lively personal life, started his patent officer job when he broke up with his great love and student Milena Maric. The science environment, which became very political because of the World Wars, deeply affected Einstein's life. Einstein, who was known as anti-war, went to the USA as a refugee after he had certified the theory of relativity and settled there. Einstein, who did not lose his hope and inspiration, said: "The important thing is not to stop questioning; curiosity has its own reason for existing." Einstein, who kept on having relationships in his late years, found himself in a big challenge. | *In this documentary, the relation of science with the society that it is produced in, the place of imagination in science, and the relation of scientific theory and law are mentioned. In addition to this, the subjectivity of scientific information and the private lives and characteristics of scientists are also mentioned.* |

*continued*

**Table 2** Introduction of documentaries and NOS aspects (*continued*)

| Introduction of Documentaries | NOS Aspects |
|---|---|
| **5. Who is Galileo Galilei? What contribution has he made to science and technology?:** Galileo, who shook the understanding of science in the Medieval Age, caused a revolution by questioning the church belief which had the control of the era, and Aristotle's knowledge. Galileo was born in Italy in the 16th century and studied there in areas of medicine, mathematics, and philosophy. Galileo, who had been doing experiments about Physics since his early years, got his professorship at the age of 25. In 1609, he invented a more advanced telescope by examining a telescope, and he had a chance to make observations no one had done before. According to his observations, he suggested the heliocentric model and he published his studies about it. Since he collided with the church which advocated the geocentric model, he was judged more than once by the Vatican. Teaching his theories and publishing his books was banned and he was sentenced to lifetime house confinement. Galileo became a symbol for the science-religion conflict due to his challenge with the church in his lifetime. | *In this documentary, the importance and difference of observation and implication while science is produced, the interaction of science with social and cultural values and especially religion-science are mentioned. In addition to these, the science-technology relation, the experimentality of science, the change of scientific information in time, and the paradigm change in science are also mentioned in this documentary.* |
| **6. Nikola Tesla Documentary:** Nikola Tesla undoubtedly is one of the most distinctive personalities of science history. Trying to understand his ideas took many years. Tesla, who said that his photographic memory and creative genius were a heritage from his mother, started to make inventions in his early years. Despite illnesses and hardships in his childhood, he never quit and made numerous inventions including earthquake machines, death rays, and universal wireless energy. We get closer to the mind and ideas that are behind those strange inventions. | *In this documentary, the subjectivity of science, the place of creativity and imagination in science, and the personal lives of scientists are mentioned.* |
| **7. Thomas Edison Documentary:** In this documentary, which gives us the possibility to know Edison better, we witness Edison, whose life affected our lives. Edison, who was born in 1847 in the USA, started to be interested in science from his early years. He started to do his own experiments at the age of 10 by creating his own lab at home. Edison made many inventions in his life and his patents were accepted in many countries. The inventor, who has many inventions like the gramophone, carbon microphone and the cinema machine, also founded his own company by showing entrepreneurship and he succeeded in making his inventions commercialized. | *In this documentary, the effect of scientific information on the society that it is produced in and the effect of society on science, the place of imagination and creativity in science, the science-technology relation and the importance of experiments in science are mentioned.* |
| **8. Time Bending Beyond the Universe**: A fact which is accepted as stable and accurate anywhere in the universe means it is universal. But according to Albert Einstein's Theory of Relativity, this is not true. This means that time is not the same in all the universe, it changes from observer to observer, and it is relative. As a result of mass which creates warps in space-time, time bends and time flows more slowly from the observer who is at that place to another one. Moreover, time is not universal right there. Let me explain time bending with a more accessible example. Lay a sheet on a bed without leaving wrinkles. Here, the sheet without wrinkles represents two a dimensional space-time plane. When we put an iron marble on this sheet, the marble will sink into the sheet a little bit. Just like in the example, time also can be bent by a mass represented by a marble. When the mass gets bigger, the bending will be greater. If the mass is more than the spaceplane can carry, the space plane will collapse and a black hole will exist. | *In this documentary, the importance of observation and deduction in the production of scientific knowledge, the paradigm change and the scientific laws and the theories that scientific information can change and develop over time are mentioned.* |
| **9. Isaac Newton Documentary:** Isaac Newton, who was born in the UK in 1642, spent most of his childhood with his grandmother because of family problems. Since he was curious about science, he read many books and designed various tool models. He had to work in various jobs besides his education life because of his poor family conditions. He started to study in Cambridge in 1661 but he had to pause because of the plague epidemic. In that period, he moved to a farm and continued to study there. After the epidemic, he came back to Cambridge University and he continued to work there as a mathematics professor. He focused on mechanics and he published an important work named Principia. | *In this documentary, the personal characteristics of scientists, the subjective side of scientific information, the importance of imagination and creativity in science, science-technology and the interaction of science with the society that it is produced in are mentioned.* |
| **10. Encounter with Pluto:** Pluto, which is billions of miles away, is one of the mysterious celestial bodies in our solar system. A space vehicle named New Horizons was taken into service to investigate Pluto more closely and sweep the mysteries away. The space vehicle, whose duty is to study Pluto and its satellites, has been traveling in the solar system since January 2006 in order to reach Pluto. New Horizons, which has been traveling for 10 years to complete its duty, will only have a few minutes to view Pluto. If it ends its duty, we will have the chance to see the deepest parts of the solar system for the first time. | *This documentary emphasizes the importance of science experiments, observations and inferences and changeable scientific knowledge.* |

Council (HEC, 2018). The content was "Philosophy of science (Content and purpose of philosophy, paradigms, philosophical thoughts and its effect on development of science), Nature of knowledge (ontology, epistemology, nature of scientific concepts, scientific knowledge and it's characteristics), History of science, Scientific literacy and NOS aspects , The role of NOS in curriculum and teaching. NOS (Nos teaching approaches and NOS assessment), NOS activities (integrated and non-integrated NOS activities), NOS and science, technology and society relation" according to Science Teaching Undergraduate Program (HEC, 2018). Lessons were taught mostly by powerpoint presentations. Both integrated and non-integrated NOS teaching activities helped PST to learn NOS. For example, for explaining the distinctions between observation and inference, both tricky tracks activity developed by Lederman and Abd-El-Khalick (1998) and atom models were used. After the activities, reflective discussions were guided by the instructor by asking questions about emphasized NOS aspects.

### 2.4 Data Collection Instruments

The questionnaire (VNOS-C), which consists of open-ended questions, was applied twice as pre- and post-application in order to evaluate the effect of the documentaries watched in the "Nature of Science and Science History" course on the views of preservice teachers about NOS. VNOS (Views of Nature of Science) questionnaires, whose most basic form was created by Lederman and O'Malley (1990), were designed to reveal students' thoughts about one or more than one NOS fact and they consist of open-ended questions which give students the chance to state their thoughts without being under the effect of individual options. In their studies about the reliability and validity of VNOS questionnaires, which were conducted in-depth, Lederman, Abd-El-Khalick, Bell, & Schwartz (2002) stated that VNOS had been a valid measuring tool in order to understand the perspectives of students about NOS. In this study, a VNOS-C questionnaire which was suitable for preservice teachers was used and there are different versions that are suitable for different age group levels. The survey, which evaluates the opinions of preservice teachers about NOS, consists of 10 open-ended questions.

### 2.5 Data Analysis

Primarily, the answers which were given to the questions in the VNOS-C questionnaire by preservice teachers were classified as naive, transitional and informed, similar to Khishfe and Lederman's (2006). Each aspect of NOS is not questioned in only one item in this questionnaire which sought the opinions of preservice teachers about the aspects of NOS. So, the answers given to all questions in the questionnaire were examined carefully in order to classify each element of NOS. The answers of preservice teachers were classified as naïve when a preservice teacher didn't demonstrate any meaningful understanding related to the element in question and informed when a preservice teacher provided evidence of meaningful understanding related to the aspect of each question. In addition to this, if a preservice teacher demonstrated a useful understanding of an aspect but also had some misconceptions, the answers were classified as transitional. After this, answers of preservice teachers for each aspect were scored from 0 to 2 for naive, transitional and informed. Some examples of preservice teachers' answers are shown in Table 3.

PST' responses to the VNOS-C were scored by two researchers (one studied NOS on her master degree, the other on his Ph.D.) independently. Then the analyses were compared, and reliability was calculated as %90 (Miles and Huberman, 1994). The inconsistencies between researchers were resolved through discussion. Data which were obtained at the beginning and end of the course were compared with the help of SPSS 16.0 statistical program.

**Table 4** Test of normality

| Measurement | Group | Shapiro-Wilk statistic | df | Sig. | Skewness | Kurtosis |
|---|---|---|---|---|---|---|
| Pre-test | Experimental | ,947 | 30 | ,144 | ,280 | -,684 |
| Post-test | Experimental | ,940 | 30 | ,094 | ,397 | ,427 |
| Pre-test | Control | ,947 | 30 | ,144 | -,002 | -,992 |
| Post-test | Control | ,941 | 30 | ,096 | -,504 | -,459 |

## 3. RESULT AND DISCUSSION

### 3.1 Results

In this study, the VNOS-C questionnaire was applied twice as pre-test and post-test to determine the effect of documentary films on the PST' NOS understandings. Results obtained from the analysis are given below in the tables according to the research questions.

#### Preliminary tests

As a preliminary analysis, all the data obtained was tested for normality in order to decide if the data had parametric value or not as shown in Table 4. Because the sample was less than 50, the Shapiro-Wilk test was applied to determine if the data exhibit a normal distribution (Büyüköztürk, 2011). The test results showed that the data was normally distributed therefore, parametric tests were chosen to analyze the effect of documentary films.

According to the test results given in the table, significance values are higher than 0,05. Furthermore, kurtosis and skewness values are between the range of -1 to +1. These results indicate normal distribution (Hair, Black, Babin & Anderson; 2013). Thus, independent samples t-test was used to compare the group scores, and paired samples t-test was used to determine the effect of the documentary films on understanding NOS of the experimental group.

Before comparing means with independent samples t-test, homogeneity of variance was tested as tabulated in Table 5. The assumption on homogeneity between the control and experimental groups was checked by investigating Levene's Test of Equality of Error Variances.

According to the test results, the significance value is greater than 0,05. Therefore, the homogeneity of regression assumption was met.

**Table 3** Examples of PST' answers

| NOS aspects | Naive views | Transitional views | Informed views |
|---|---|---|---|
| The empirical NOS | *Science is an empirical-based discipline. So scientists conduct experiments on their labs to get solid evidence and without an experiment, you cannot prove your theory.* | *Scientists cannot always perform experiments to proof scientific claims, sometimes their studies are based on observation of the world.* | *Doing an experiment is a way of scientific investigation, but not the only way. You can't always rely on experiments, for instance, Einstein didn't conduct an analysis to explain gravitational waves. Knowledge can be derived from observations, imagination as well as experiments.* |
| The tentative NOS | *Theories can change over time since they are not proven. But once they've proven they become laws and laws are specific and cannot change.* | *Yes, theories can change over time. Finding new evidence can change theories. For example, from Democritus's days till these days, atom theories had changed due to new evidences.* | *Since the scientific information we know about the natural world increases, we develop better tools to understand it or we gain a different perspective on the phenomenon we investigate. Because of that, scientific knowledge can change.* |
| The theory-laden NOS | *Because of the missing evidence, scientists had to guess the missing parts to complete the theories. When the truth comes out, they will reach a consensus on one of the theories.* | *Because of the lack of certain knowledge, it is difficult to explain why and scientists have different opinions because they are different.* | *Even if scientists use the same data, they make different experiments, observations, and they can reach different conclusions. Their imagination, beliefs or their pasts can affect their investigation.* |
| Distinctions between observation and inference | *Scientists are not certain about the atom because they cannot see it and they are still investigating how an atom looks like.* | *The evidence they gathered with the help of electron microscopes and the experiments such as Rutherford's gold foil experiment, scientist have an idea what atom looks like.* | *Even if they cannot directly observe the atom, based on the observations, experiments they conduct and using their creativity they can make a model of an atom that explains to us how an atom supposed to look like.* |
| The creative and imaginative NOS | *No, they don't. Because if they used their imagination then the scientific knowledge they've derived would not be reliable. That's the difference between science and other disciplines.* | *I think scientists use their creativity in their work. They think different than normal people and they are curious about the natural world. So they come up with interesting ideas, questions or inventions by their creative minds.* | *Sometimes phenomenon cannot be observed directly, like atoms, genes etc. Creativity and imagination play a big role in these situations. For example Einstein's thought experiments. He used his imagination at all stages of the experiment.* |
| Distinctions and Relationship between Scientific Theories and Laws | *Theories are like predictions; they haven't been proven by enough data. When they are proven by experiments they become absolute and called laws.* | *The theory is not a certain scientific knowledge that is agreed by all scientists like a law. But they are different kinds of scientific knowledge and can't become one and another.* | *Theories are explanations of natural phenomenon whilst laws are descriptions of the relationships among this phenomenon. Both of them are well supported by evidence. There is no hierarchical relation.* |
| Social and Cultural Influences on Scientific Knowledge | *Science is universal; the rules and facts are valid and same all around the world. Science should not be influenced by cultures and beliefs. Otherwise it wouldn't be certain.* | *Science can be affected by society's ideas or belief yet it still remains universal.* | *Science is influenced by cultural and social values. For example, Galileo's ideas about the solar system were forbidden because it was against the church. This shows us how can scientific progress can be effected easily by beliefs of a society* |

**Table 5** Levene's test for equality of variances

| Details | | Levene's Test for Equality of Variances | |
|---|---|---|---|
| | | F | Sig. |
| Experimental & control group pre-tests | Equal variances assumed | ,652 | ,423 |
| | Equal variances not assumed | | |

## Results and Discussion on Comparison Between the Experimental and Control Groups

For testing the effectiveness of documentary films on PST' NOS understanding, VNOS-C scores were analyzed. The comparison results of understanding of the PST' NOS understandings were presented in Table 6.

As seen in Table 6, the pre-test mean scores of experimental and control groups were 4,13 and 4,27 respectively. After the intervention, the mean scores of the control group were 6,27 while the mean scores of the experimental group which was taught with documentary films were 8,53. The results show that there was an increase in the mean scores of the preservice teachers in both groups. Independent samples t-test was conducted to determine whether the post-test scores showed a significant difference. As a result of the analysis, it was found that the scores between post-tests of experimental and control group differed meaningfully in favor of the experimental group. This means that using documentary films had a significant effect on PST' NOS understandings positively.

**Table 6.** Mean and standard deviation values of the experimental and control groups

| Tests | Groups | N | X | Sd | df | t | P |
|---|---|---|---|---|---|---|---|
| Pre-test | Experi-mental | 30 | 4,13 | 1,852 | 58 | -,260 | 0,796* |
| | Control | 30 | 4,27 | 2,116 | | | |
| Post-test | Experi-mental | 30 | 8,53 | 1,852 | 58 | 3,972 | 0,000* |
| | Control | 30 | 6,27 | 2,518 | | | |

*p<0,05

As VNOS-C scores of experimental and control groups were compared by NOS aspects, it is seen that there was no statistically significant difference between experimental and control groups regarding "Distinctions and Relationship between Scientific Theories and Laws" and "Social and Cultural Influences on Scientific Knowledge" aspects. As it is seen in Table 7, there was a statistically significant difference between experimental and control groups regarding other five aspects which are "The Empirical NOS", "Distinctions between observation and inference", "The tentative NOS", "The Theory-Laden NOS" and "The Creative and Imaginative NOS". Considering mean scores, at all aspects experimental group scores were higher than control group scores. However, according to the independent samples t-test, there was a statistically significant difference between groups in five of the aspects in favor of the experimental group.

### Results and Discussion on Comparison Between the Experimental and Control Groups

Under this title, PST' NOS understandings in the experimental group before and after the intervention are presented. As it is seen in Table 8, majority of the PST' views were transitional in terms of "The Empirical NOS", "Distinctions between observation and inference", "The tentative NOS", "The Theory-Laden NOS" and "The Creative and Imaginative NOS" aspects in the experimental groups before the intervention. In addition to this PST's views regarding "Distinctions and Relationship between Scientific Theories and Laws" and "Social and Cultural Influences on Scientific Knowledge" aspects were naïve at the beginning.

The results presented that after the intervention, the majority of PST's views about "The Empirical NOS" and "The tentative NOS" aspects have changed from transitional to informed and "Distinctions and Relationship between Scientific Theories and Laws" and "Social and Cultural Influences on Scientific Knowledge" aspects have transformed from naïve to transitional. Moreover, only one PST held naïve views on "Distinctions between observation and inference" and "The Creative and Imaginative NOS" aspects and no PST left who held naïve views on "The Theory-Laden NOS" aspect after the intervention.

The results presented in Table 8 have shown that teaching with documentary films is an effective way to enhance understandings of PST on certain NOS aspects. In order to determine whether this increase is statistically meaningful or not, paired-samples t-test was conducted.

According to Table 9, paired-samples t-test results showed that there is a statistically significant difference between the pre-test and post-test. As it is seen in the table, mean scores of the experimental group have increased from 4,13 to 8,53 after the intervention. In order to explain the results more detailed, paired-samples t-test was conducted for each NOS aspect.

Paired samples t-test results of pre-test and post-test scores of PST has shown that there is a statistically significant difference between pre-test and post-test scores of PST on NOS understanding in each aspect except for one; the tentative NOS. Even though there was an increase according to the mean scores, there is no statistically significant difference regarding the tentative NOS aspect. To overall, results of the tests have shown that using documentary films is effective to teach PST NOS.

### 3.2 Discussion

In this study, the effects of documentary films on PST' views about NOS was investigated. According to the table 7, it was found that there was a significant difference

**Table 7.** Mean and standard deviation values of NOS aspects between groups

| NOS aspects | Groups | N | X | Sd | df | t | p |
|---|---|---|---|---|---|---|---|
| The Empirical NOS | Control | 30 | 1,23 | 0,568 | 29 | 2,062 | 0,044 |
| | Experimental | 30 | 1,57 | 0,679 | | | |
| Distinctions between observation and inference | Control | 30 | 0,90 | 0,758 | 29 | 2,443 | 0,018 |
| | Experimental | 30 | 1,33 | 0,607 | | | |
| The tentative NOS | Control | 30 | 0,83 | 0,521 | 29 | 2,723 | 0,009 |
| | Experimental | 30 | 1,27 | 0,699 | | | |
| Distinctions and Relationship between Scientific Theories and Laws | Control | 30 | 0,73 | 0,629 | 29 | 0,894 | 0,375 |
| | Experimental | 30 | 0,87 | 0,521 | | | |
| The Theory-Laden NOS | Control | 30 | 0,93 | 0,466 | 29 | 3,101 | 0,003 |
| | Experimental | 30 | 1,30 | 0,450 | | | |
| The Creative and Imaginative NOS | Control | 30 | 0,77 | 0,365 | 29 | 2,432 | 0,019 |
| | Experimental | 30 | 1,07 | 0,568 | | | |
| Social and Cultural Influences on Scientific Knowledge | Control | 30 | 0,87 | 0,571 | 29 | 1,516 | 0,136 |
| | Experimental | 30 | 1,13 | 0,776 | | | |

**Table 8** Percentages and frequencies of naive, transitional and informed views of NOS aspects of the experimental group before and after the intervention

| NOS aspects | Tests | Naive | | Transitional | | Informed | |
|---|---|---|---|---|---|---|---|
| | | f | % | f | % | f | % |
| The Empirical NOS | Pre-test | 8 | 26 | 21 | 70 | 1 | 3 |
| | Post-test | - | - | 14 | 46 | 16 | 53 |
| Distinctions between observation and inference | Pre-test | 14 | 46 | 15 | 50 | 1 | 3 |
| | Post-test | 1 | 3 | 20 | 66 | 9 | 30 |
| The tentative NOS | Pre-test | 7 | 23 | 16 | 53 | 7 | 23 |
| | Post-test | 5 | 16 | 10 | 33 | 15 | 50 |
| Distinctions and Relationship between Scientific Theories and Laws | Pre-test | 24 | 80 | 6 | 20 | - | - |
| | Post-test | 8 | 26 | 18 | 60 | 4 | 13 |
| The Theory-Laden NOS | Pre-test | 9 | 30 | 20 | 66 | 1 | 3 |
| | Post-test | - | - | 21 | 70 | 9 | 30 |
| The Creative and Imaginative NOS | Pre-test | 14 | 46 | 16 | 53 | - | - |
| | Post-test | 1 | 3 | 26 | 86 | 3 | 10 |
| Social and Cultural Influences on Scientific Knowledge | Pre-test | 20 | 66 | 10 | 33 | - | - |
| | Post-test | 3 | 10 | 20 | 66 | 7 | 23 |

**Table 9** Mean and standard deviation values of the experimental group

| Tests | N | X | Sd | df | t | P |
|---|---|---|---|---|---|---|
| Pre-test | 30 | 4,13 | 1,852 | 29 | - | ,000 |
| Post-test | 30 | 8,53 | 1,852 | | 11,162 | |

between posttest scores of the experimental and control groups in favor of experimental group regarding "Distinctions between observation and inference" and "The Empirical NOS" aspects. In addition to that, there was a significant difference between pretest and posttest scores of the experimental group regarding these aspects (Table 10). As we examine table 8 for the development of PST understandings on these aspects, after the intervention no PST left with naive views on "The Empirical NOS" aspect and only one PST held a naive view on "Distinctions between observation and inference" aspect. These reveal that using documentary films had a positive effect on PST' NOS understandings on "The Empirical NOS" and "Distinctions between observation and inference" aspects. Observations are explanations of natural phenomena which are accessible to senses and can be observed by other individuals. But scientists do not have direct success to the most natural phenomena, they use scientific instruments and conduct experiments to generate empirical evidence and based on observations and experiments, scientists interpret and derive a conclusion which is called inference (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002; Lederman, 2007).

Since engaging students with laboratory activities; try to work as a scientist, conduct scientific investigations and experiments help them to improve their understanding about NOS (Wardani & Winarno, 2017; Prima, Utari, Chandra, Hasanah, & Rusdiana, 2018), watching scientists on work and discussing might have provided a development on PST understanding of NOS. For instance, on the 5. Documentary film Galileo documented the experiments and observations he made and observed the movement of Jupiter's satellites, and was seen to be influenced by the fact that there are objects that do not revolve around the world, and thus there are examples of such things that contradict the idea of the world as the center of the universe. Historical science stories help PST to connect with scientists and have the opportunity to see the examples of how scientific researches are conducted. (Laçin-Şimsek, 2019).

According to the results of the study, a significant difference was found on The Theory-Laden aspect of NOS between posttest scores of the experimental and control groups in favor of the experimental group and between pretest and posttest scores of the experimental group. As science is a human activity, it shouldn't be expected to be objective. Scientists', prior knowledge, philosophical perspectives, training, experiences, backgrounds beliefs, bias, values, and expectations can affect their studies. These may influence scientists' researches; what they observe, how they observe, and how they interpret their investigations. Since scientists aren't objective, their observations cannot be expected to be objective; their views depend on their theoretical perspectives (Lederman, 2007). PST had the chance to look at the lives of scientists like Newton, Teslathe, and Einstein more closely. They could observe that scientists are involved in their work discipline, scientific study and scientific knowledge as well as their personal lives and personal characteristics, and recognize that the prejudices of the scientists, their beliefs and their experiences could affect their decision-making processes and their scientific viewpoints, in the light of this aid to understanding theory-laden aspect of science (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002;

**Table 10** Mean and standard deviation values of NOS aspects before and after the intervention

| Groups | Tests | N | X | Sd | df | t | P |
|---|---|---|---|---|---|---|---|
| The Empirical NOS | Pre-test | 30 | 0,77 | ,092 | 29 | -4,942 | ,000 |
| | Post-test | 30 | 1,57 | ,104 | | | |
| Distinctions between observation and inference | Pre-test | 30 | 0,57 | ,568 | 29 | -5,887 | ,000 |
| | Post-test | 30 | 1,27 | ,521 | | | |
| The tentative NOS | Pre-test | 30 | 1,00 | ,695 | 29 | -1,904 | ,067 |
| | Post-test | 30 | 1,33 | ,758 | | | |
| Distinctions and Relationship between Scientific Theories and Laws | Pre-test | 30 | 0,20 | ,407 | 29 | -5,525 | ,000 |
| | Post-test | 30 | 0,87 | ,629 | | | |
| The Theory-Laden NOS | Pre-test | 30 | 0,73 | ,521 | 29 | -4,958 | ,000 |
| | Post-test | 30 | 1,30 | ,466 | | | |
| The Creative and Imaginative NOS | Pre-test | 30 | 0,53 | ,093 | 29 | -5,757 | ,000 |
| | Post-test | 30 | 1,07 | ,067 | | | |
| Social and Cultural Influences on Scientific Knowledge | Pre-test | 30 | 0,33 | ,479 | 29 | -6,595 | ,000 |
| | Post-test | 30 | 1,13 | ,571 | | | |

Vanderlinden, 2007). Owing to that experiences PST might have developed a better understanding on the tentative aspect of NOS.

The results indicated that on "The Creative and Imaginative NOS" aspect, a significant difference was found between posttest scores of the experimental and control groups in favor of the experimental group and between pretest and posttest scores of the experimental group. Even though science is based on observations of the natural world, creativity and imagination play a significant role in science. Science is not rational and orderly; scientists don't always follow specific method to conduct their researches while generating scientific knowledge, this process contains creativity and scientists can use their imagination to fill the gaps in their studies (Lederman, 2007). With the documentary film of Tesla, the importance of creativity and imagination in science was mentioned by discussing exciting ideas and incomprehensible inventions. It was emphasized that scientists use their imagination and creativity to produce new ideas and that imaginative power occupies an exceptional place beside the methods and rules, showing that science is not only methodological (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). Similarly, it can be said that the emphasis on the imagination that lies behind the theories of Einstein's behavior on macro dimensions influenced the development of the PST' views in this aspect of science.

The results showed that there was no statistically significant difference between experimental and control groups on "Distinctions and Relationship between Scientific Theories and Laws" "Social and Cultural Influences on Scientific Knowledge" aspects. When the literature is examined, studies which have been conducted with samples at every level show that there are many conceptual errors about theory and law concepts, and that there are difficulties in understanding these concepts (McComas, 1998; Buaraphan, 2010; Deng, Chen, Tsai, & Chai, 2011; Göksu Aslan, Murat & Zor, 2016). It is a common misconception of individuals that there is a hierarchical relationship between theories and laws; with more supporting proof, scientific theories become scientific laws. According to this misconception, scientific laws are more secure than scientific methods and have a higher status than scientific methods (Lederman, 2007; McComas 1998). Contrary to this common belief, scientific theories and laws are a different kind of scientific knowledge and don't change one into another. A scientific theory is an explanation of observable phenomena whereas a scientific law is a description of the relationship between observable phenomena (Lederman, 2007).

When the table 10 examined, it was found that there was a significant difference between pretest and posttest scores of the experimental group on "Distinctions and Relationship between Scientific Theories and Laws" aspect. This significant difference can be the effect of the following documentary films. This scientific knowledge were discussed especially in the Time Bending beyond the Universe documentary, paradigms and theories were explained, the points that theories and laws are different and that they will not convert into each other were underlined, in the Newton and Einstein documentaries, Newton's laws and Einstein's theories were explained to describe this scientific knowledge.

As it is mentioned before one of the two aspects that there was no statistically significant difference between experimental and control groups was "Social and Cultural Influences on Scientific Knowledge". According to the literature, these two aspects, the social and cultural influences on scientific knowledge and the distinction between theories and laws, were more challenging to teach to PST than the other five aspects (Bell, Lederman, & Abd-El-Khalick, 2000). When the pretest and post-test scores of the experimental group are compared, there was a statistically significant difference in favor of posttest on "Social and Cultural Influences on Scientific Knowledge" aspect. Contrary to common belief, science affects and is affected by the culture in which it is embedded. Because science is a human enterprise and scientific knowledge is generated by humans; it can affect and be affected by the ethical, social, political, moral and religious aspects of a culture (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). At the intervention the period of the scientists' lives was revealed with the documentary films, making it possible for the PST to become aware of the social and cultural values of the society in which science is produced. For example, the world was at war during the Einstein era, and in the period of Galileo, there was a prohibition of the view of the heliocentric model due to the dominant influence of the church. Besides this, it can be said that one of the factors influencing the change in the opinions of the PST is the mention of religion and science in the Avicenna and Al-Farabi parts, in particular, emphasizing that religious belief made a great contribution to the progress of scientific research at that time. Similar to this study, Ayar (2007) stated that science-technology-society lessons were used to study the influence of science teachers' opinions on the NOS, and it was concluded that the use of film sections and newspaper news in the lessons was successful in the relationship between science and social values.

The results of the study also showed that there is a statistically significant difference was found between posttest scores of the experimental and control groups in favor of experimental group on the aspect of "The Tentative NOS". Even though scientific knowledge is considered as absolute or certain, this knowledge can change through time, by new data or interpreting data with the light of new theoretical ideas (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). Scientists based their growing understanding on empirical data that becomes more extensive with each new wave of technology (Sterling, 2009). Tentative NOS was emphasized by comparing Newton's physics and Einstein's physics and explaining why Pluto wasn't considered a planet anymore. It is also revealed in almost every documentary film that whatever the type of scientific knowledge is, it will not be specific, and that science can change in the light of new findings or reinterpretation of old data.

## 4. CONCLUSION

In this study, the effects of documentary films on PST' views about NOS was investigated. According to the results, there is a statistically significant difference between posttest scores of experimental and control groups (Table 6). Therefore, it can be concluded that teaching NOS with documentary films is an effective way to teach NOS.

When the aspects of the NOS are examined, the fact that the NOS is included in more than one documentary for each aspect, and that the same aspects are spread over a long period by giving the opportunity for them to be discussed through different examples in different weeks, is effective in changing the opinions of PST. According to the literature before the intervention, PST' opinions were resistant to change and therefore, long term applications are needed (Çil, 2010; Mulvey, Chiu, Ghosh & Bell, 2017). The pretest scores of PST showed that they have many misconceptions about NOS. In order to prevent this, education about NOS should begin in students' early years and supporting it with documentary films and sections from science history until undergraduate degree level will help to get rid of misconceptions.

Since NOS is based on different disciplines like science philosophy and science history, lessons at undergraduate level need to be given that is enriched with sections from science history and documentary films which focus on scientific works and scientists instead of theoretical ones. It can be suggested that documentaries and scientific videos like these should be used in not only NOS courses but also science lessons integrated with topics, and they should emphasize NOS in this way.

Presenting science in a way which includes stories, documentary films and the conditions that it has been made in, and criticizing it, will help to improve students' opinions about NOS. Making an effort to help them understand how problems exist instead of how to solve them will increase their curiosity about science, and it will make learning science easier.

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