Analysis of investigative skills based on the use of tracker video analysis for 21th century skill

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ABSTRACT

This study aims to analyze the investigative skills of Junior High School students upon the use of tracker video analysis for 21th century skill.This reasearch was quasy experimental reasearch using non-randomized pretest-posttest control group design. The population was 8th grade of SMP Negeri 4 Depok in academic year of 2018/2019, which consists of 4 classes with a total of 127 students. The samples consist of 30 students of class VIII A and 30 students of class VIII B, which are selected using cluster sampling technique. The Class VIII A was chosen as the control class, which used powerpoint and video, whereas Class VIII B was prepared as the experiment class, which used Tracker Video Analysis. The instruments used were pretest-posttest questions and observation sheet of investigative skill. The data analysis technique used was t-test. The result of this reasearch shows that the analysis through t-test gives a significance level value of investigative skill of 0.024 (Sig. $< \alpha$). This shows that there is an infuence of investigative skill of students upon Tracker Video Analysis.

INTRODUCTION

Science education is directed to inquire and do experiment so that it can help students to gain abstract understanding. Many students who are less interested will have difficulty in learning Natural Sciences. The impact of these difficulties is the presence of the concept directly in front of the class without going through investigative activities. The lack of investigative activities by itself will cause students to be less trained in carrying out the process of scientific investigation and ultimately not accustomed to investigating the phenomena of science.

Based on interviews and observations at SMP N 4 Depok, learning activities on the subject matter of Motion carried out at school so far have only been carried out by giving demonstrations of two-dimensional motion events by teachers and students receive directly without going through a process of experimentation or discovery of results or concepts. The assessment of the experimental activities has not yet fully and specifically touched the students' science process skills (SPS). Assessments for students' SPS are not carried out and indeed are not a priority. So, the learning science carried out is still result-oriented and has not yet touched the process, especially investigative skill.

In the context of science learning, the meaning of investigation refers more to learning activities using practical work. Woolnough (1991, p. 3) argues that scientific investigation is a holistic approach to learning science through practical work. A more detailed explanation was put forward by Millar (2010, p. 49; Osborne & Dillon, 2010) who viewed the investigation as:

> *Practical activity in which students are not given a complete set of instructions to follow (a recipe), but have some freedom to choose the procedures to follow, and to decide how to record, analyze and report the data collected. They may also (though this will not be taken as a defining characteristic) have some freedom to choose the question to be addressed and/or the final conclusion to be drawn. Like experiments, investigations are a sub-set of practical work.*

So, in investigative activities students can determine work procedures, be able to analyze data, and draw conclusions.

Currently, there is Tracker software that can be downloaded for free and allows students to con-

duct comprehensive research in terms of kinematics. This software may be utilized through a video analysis method concerning natural events, especially those related to speed, velocity, acceleration, force, gravitational field, and also energy conversion and conservation. Through this software, students are expected to be able to activate their SPS through observing, measuring, and calibrating into the software, designing experiments in the video analysis, interpreting the data generated in the form of graphs and tables to draw conclusions based on statistical data of the tracking process done by students with the Tracker software.

Based on a research about measuring the moon's gravitational acceleration using a video made by NASA, the researchers think to obtain the value of the Earth's gravitational acceleration. This experiment can be integrated into the two-dimensional motion material in Grade VIII of junior high school. Actually, this experiment is a standard experiment in physics. But by using this software students are expected to be able to optimize the SPS possessed through the video software tracker analysis. In the end, it is hoped that by applying free fall motion material that is integrated into the Tracker software video analysis, SPS especially in the investigative abilities of students will be optimally trained.

Tjandrawinata (2016) argues that technological progress will bring about the possibility of automation occurring in almost all fields. New technologies and approaches that combine physical, digital, and biological worlds will fundamentally change the patterns of life and human interactions. In the 21st century era, graduates need to be competitive, i.e.: not only sufficient with old literacy (reading, writing, and arithmetic) but must apply new literacies, namely data literacy (the ability to read, analyze, and use information in the digital world), technological literacy (understanding how machines work and technology applications), and human literacy (communication, design, and humanities). So, the relevance of the world of education and career needs to be adjusted to the development of the science and technology era while still giving attention to the aspects of humanities (Ahmad, 2018).

The 21st century generation, especially students are required to be able to develop skills in mastering information and communication technology, so that students have the ability to use technology in the learning process aimed at achieving students' thinking and learning abilities. This is reinforced by the statement of the Government through the Ministry of Education and Culture (2013) stating that in the 21st century, education is very important to ensure students have the skills to learn and innovate, the skills of using technology

and information media, and can work and survive by using the skills in life.

Physics as part of science is very closely related to the 21st century era where physics is very instrumental in the progress of technological development in the 21st century. Therefore, learning physics must also spur developments made by utilizing technology. One effort to improve students' technological abilities is through the media used by teachers when learning takes place in class.

The ability of students in investigative skills is a part of the ability of the 21st century that must be possessed by students today. The use of video analysis tracker software is a creative learning method so that it can help students improve their investigative abilities, this is reinforced by Physics (2009) which states that video analysis using a tracker program based on open source in the learning process is a creative method so as to make natural science interesting for students.

Based on the background described above, the researches are interested in conducting research on the analysis of investigative skill improvement through the video tracker analysis, which is related to 21st century skills.

METHOD

This study used quasi-experimental research. The research design used was nonrandomized pretest-posttest control group design. The research design framework can be seen in Table 1.

Table 1. The Research Design

Group	Pretest	Treatment	Posttest
Experiment	Y_1	X_1	Y_2
Control	Y_1	X_2	Y_2

Information: Y_1 = pre-test, X_1 = using Tracker Video Analysis, Y_2 = post-test, and X_2 = using Powerpoint and video

This design compares two groups, namely the experimental and the control classes. The learning in the experimental class was given treatment (X_1) in the form of Video Tracker Analysis, while the control class was given treatment with other media or conventional learning (Powerpoint and video). Both classes were given pretest (Y_1) and posttest (Y_2) with the same test questions, where the pretest was given before learning and posttest was given after the learning process.

This research was conducted at SMP Negeri 4 Depok, Sleman Regency, Special Region of Yogyakarta, and was carried out for 2 weeks in December 2018. The subjects in this study were 30 students of grade VIII A as the control class, and 30 students of grade VIII B as the experimental class. The object in this study is the investigative skills of students. The sampling technique used in this study was cluster sampling, with the selection of two

classes, namely the control and experimental classes. The sample was taken by conducting population homogeneity test with a midterm assessment (PTS) in 2018. The results of the analysis showed that the population of grade VIII in SMP Negeri 4 Depok was homogeneous, so that sample grade VIII B was chosen as the experimental class and grade VIII A as the control class. Both classes are equivalent class groups because they have almost the same average value. Class selection also considers the availability of a laptop that will be used to conduct learning activities using Tracker Video Analysis.

The instruments used were pretest-posttest test questions and observation sheets of investigative skill. The test used was in the form of pretest and postest questions with 20 multiple choice questions. Pretest and posttest questions were used to measure students' investigative skills. This test was carried out before and after the classes were being treated. The value obtained was then processed and analyzed with the normalized n-gain score to see an improvement of the investigative skills of students. The formula used to calculate the normalized gain score (g) according to Hake (1999) is given as follows:

$$(g) = \frac{T_2 - T_1}{I_S - T_1} \tag{1}$$

where T_1 is the pretest value, T_2 is the posttest value, and I_S is the maximum score of pretest or posttest. The normalized gain for each student was calculated on average. Average gain values were then categorized according to Hake (1999). The categorization of student gain is presented in Table 2.

Table 2. Categorization of Student Gain Score

Interval	Category
$(g) \geq 0.7$	High
$0.7 > (g) \geq 0.3$	Medium
$(g) < 0.3$	Low

The hypothesis prerequisite test consisted of normality and homogeneity tests. The hypothesis test was conducted by the t test and the influence test used the effect size. The analysis was performed using SPSS 22 for windows at a significance level (α) of 0.05. The hypothesis proposed in the t test is as follows: First, Ho means that there is no significant influence of the use of video tracker analysis on students' investigative skills. Second, H_1 means that there is a significant influence on the use of Tracker Analysis Video on students' investigative abilities. Next, to calculate the effect size in the t test, Cohen's formula is used as follows:

$$d = \frac{\bar{x}_t - \bar{x}_c}{S_{pooted}} \; x \; 100\% \tag{2}$$

with d is Cohen's d effect size, $\bar{X}_t$ is the mean treatment condition, $\bar{X}_c$ is the mean control condition,

and S_{pooted} is the standard deviation. The criteria for effect size interpretation can be seen in Table 3.

Table 3. Criteria of Effect Size (Becker, 2000, p. 3)

Cohen's Standard	Effect Size	Percentage (%)
High	$0.8 \leq d \leq 2.0$	$79 \leq d \leq 97.7$
Medium	$0.5 \leq d < 0.8$	$69 \leq d < 79$
Low	$0.2 \leq d < 0.5$	$50 \leq d \leq 69$

The observation sheet contained 43 statement items. The data obtained were analyzed into percent implementation using the following equation:

$$\% \text{ implementation} = \frac{\sum ability\ steps\ implemented}{\sum total\ of\ ability\ steps} \; x \; 100\% \tag{3}$$

Then, it was converted to qualitative data with a standardized five-scale value shown in Table 4.

Table 4. A standardized five-scale value

No.	Percentage (%)	Category
1.	86 - 100	Very good
2.	76 - 85	Good
3.	66 - 75	Good enough
4.	55 - 65	Not good enough
5.	≤ 54	Not very good

RESULTS AND DISCUSSION

Results

Before being given treatment, the two groups were given pre-tests to measure the initial conditions of the students' investigative skills with the material of particle moving in a straight line. The experimental group in the learning process was treated using the video tracker analysis. So in the experimental group students were directly involved with the video tracker analysis media. Moreover, the control group used Powerpoint and video. The research data obtained in the form of data were the students' initial investigative skills (pretest), the final investigative skills of the students (posttest), and the value of students' investigative skills. The research data can be described as follows.

Data on the investigative skill was obtained by giving pre- and post-test questions to students in the experimental and control classes. The following pretest-posttest data are presented in Table 5.

Table 5. Data of *Pretest-Postest*

Value	Experiment	Control
Pretest	62,5	52,5
Posttest	72,5	62,5

Table 5 shows that the pre- and posttest scores of the experimental group are higher than the control group with a difference of 10 points. Then the value was processed and analyzed to determine the n-gain score. The following results from the gain scores of investigative skills are presented in Table 6.

Table 6. Gain score of *Pretest-Postest*

Group	Gain Score
Experiment	0.27
Control	0.21

Based on Table 6 it is known that the n-gain score in the experimental class is higher than the control class. In the experimental group the n-gain score was 0.27, while in the control group the n-gain score was 0.21. So, it can be said that the increased of investigative skills of the students in the experimental group is higher than the control group. However, the n-gain scores obtained from the two groups are included in the low category. To make it easier to see the difference in n-gain obtained by the two groups, the data obtained are presented in Figure 1.
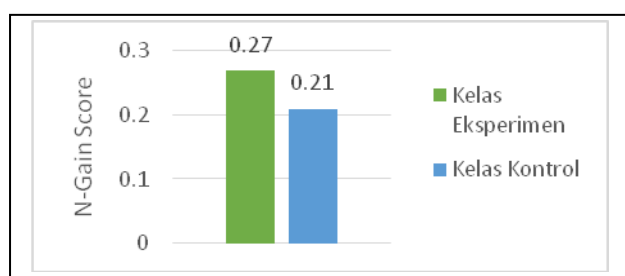

Figure 1. n-Gain Bar Diagram

Data on the results of investigative skills are also obtained through observations made by observers using five aspects, namely observing something of interest, formulating a question that can be answered in a measurable way (asking questions), formulating a hypohesis, setting up an experiment to test the hypothesis (design an experiment to prove the hypothesis), and concluding. The data is taken on average at each meeting in each group. The results of the investigative skills data are presented in Table 7 and Figure 2.

Table 7. Investigative Skill Score based on the Observation Sheet

Group	Score
Experiment	80.6
Control	72.7

Table 7 and Figure 2 show that there is an increase in the investigative skills of students in the experimental and control groups, even though the highest score is obtained by the experimental group.

The statistical test results were carried out with SPSS 22 in the form of normality test, homogeneity test, and t test. The statistical results are presented in Table 8.
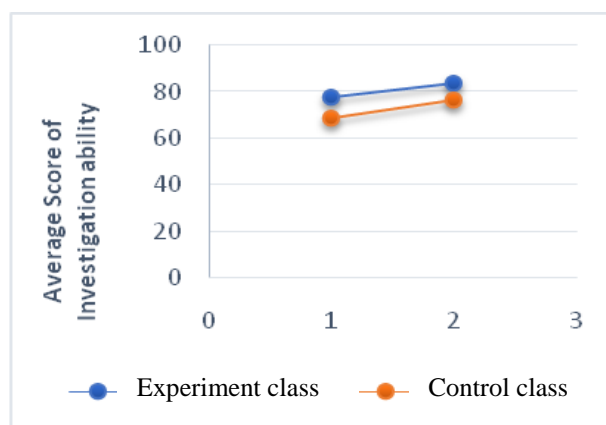

Figure 2. Improvement of investigative skills

Table 8. Results of the Statistical Tests

Statistical Test	Results	Information
Normality test	Sig > .05	Normally distributed
Homogeneity test	Sig > .05	Same variant
t test	.024 < .05	There are significant differences

Table 8 shows that both groups are normally distributed and homogeneous, so that parametric hypothesis testing can be done. The t test results from the research data is significant from the treatment with a score of 0.024 (< 0.05) so that H_o is rejected meaning there is a significant difference from the use of video tracker analysis on investigative skills of students. Then the effect size calculation is performed to find out how much influence the use of video tracker analysis on the investigative skills of the students. From the calculation of the effect size, a score of 0.6 is obtained with a percentage of 73% included in the medium category according to Cohen standard.

Discussion

The implementation of learning in the experimental and the control groups in this study uses a cooperative learning model with the 5M or Curriculum 2013 approach. However, the difference in the learning process is the use of the learning media. In the experimental group, the video tracker analysis media was discussed, while in the control group Powerpoint and video media were used.

Science learning still emphasizes the orientation of the results achieved compared to the SPS so that the presentation of the science concepts is conducted without any investigation activities. The investigation process can be carried out upon natural phenomena, for example motion. The phenomenon of science can be observed directly but not in detail. In schools, usually on the material of objects' motion, students practice using the ticker timer, but the data obtained are incomplete and not detail. So that emerging technology that can be used for analysis on the object's motion by providing more

complete information is video tracker analysis.

Based on the results obtained through the independent t test and effect size test it can be seen that the use of video tracker analysis media can have an influence on the ability of students to investigate the motion of an object with constant acceleration. Video tracker analysis media is able to influence the ability of students' investigations because the tracker software can activate the SPS possessed by the students through observations, measurements, and calibration into the software. Moreover, the process of designing experiments in the video analysis, interpreting the data generated in the form of graphs and data tables to drawing conclusions based on the statistical data are done by students. Using this media science phenomena such as the motion of an object with constant acceleration can be directly observed and analyzed by the presentation of various information such as its initial velocity (v_o), acceleration (a), and others.

As mentioned by Bryan (2004, p. 284) *"inexpensive video analysis technology makes possible the investigation of numerous types of motion with detail and precision that would be incredibly difficult, if not impossible, without the use of this technology"*. Hence, students can easily analyze real-world problems, especially on the topic of motion and optics which are sometimes impossible to do without the help of technology.

The main purpose of this video tracker analysis media is to increase students' investigations. Students are able to make observations, carry out tracking, make measurements, interpret the data generated in the form of graphs and tables, and draw conclusions.

In line with these objectives, the results of the study indicate that the use of the tracker video analysis media can improve the investigative skills of students. The results of enhancing students' investigative skills can be seen in the observation sheet that has been carried out by the observers during the two meetings. The graph of investigative skill improvement can be seen in Figure 2.

The results of the improvement in investigative skills of these students go through several stages according to five aspects of the investigation, namely: **First**, Observe something of interest. Observation is the first step in an investigation. Where can raise questions to be confirmed; **Second**, Formulate a question that can be answered in a measurable way. Asking a question with the words "what", "why", and "how" is a good first step. In addition, questions must also be focused and not too wide, which can make it difficult for the investigation process; **Third**, Formulate a hypothesis. Formulating hypotheses in investigations will help in finding key answers to what is being investigated because there is already a theoretical or model base

on some of the things observed. **Fourth**, Set up an experiment to test the hypothesis. Conducting experiments while paying attention to control variables can help in proving hypotheses in an experiment. **Fifth**, Concluding. Experimental evidence can be in the form of a conclusion that the hypothesis is accepted or rejected. If a hypothesis is supported by convincing evidence or data, then the hypothesis can be accepted as true.

The above is reinforced with a study that has been carried out by Habibbulloh and Madlazim (2014) with the title of Application of Video Analysis Software Tracker Method in Physics Learning Concepts of Free Fall Motion to Improve the Process Skills of Class X Students of SMAN 1 Sooko Mojokerto. The result is an increase in the number of students who have finished working on the SPS problem. There is an increase in the average score of each class at the time of posttest compared to the results of the pretest after applying the tracker software.

Utilization this tracker sharpens the ability of students in creative thinking skill, which is part of the ability of the 21st century that must be possessed by students today. The use of tracker software in learning physics is a creative method in helping students to improve their ability to think creatively as well. This was reinforced by Physics (2009) stating that video analysis using the tracker program (Open Source Physics) in the educational process introduced a new creative method of teaching physics making other natural sciences interesting for students.

The application of 21st century learning in this study includes students apply aspects of 21st century skills namely data literacy needed to improve the ability to process and analyze big data, where students in using video analysis tracker software must be able to analyze and process data they get based on experiments. Second, Technology Literacy which shows the ability to utilize digital technology to process data and information. Students have implemented the literacy where the technology used is clear, namely in the form of a computer and using software in the form of a video analysis tracker in order to process data and information that they can get through experiments that have been carried out. Third, Human Literacy which must be mastered because it shows the element of soft skills or can be done as an individual character development to be able to collaborate, adapt, and become a wise person in the era of technology and information booming. In this case the students work together between group members to solve a problem, and this is where the character's attitude of each student develops.

CONCLUSION

Based on the results of the data analysis and discussions that have been carried out, it can be concluded that there is a significant influence of the use of video tracker analysis on the students' investigative skills. This is indicated by the significance value of the treatment of 0.024 (< 0.05) and the effect size of 0.6. So that the use of Tracker Video Analysis can be used as one of the learning media to improve students' investigative skills. The use of ICT in learning is one of students' skills that must be possessed in the 21st century skills in the form of Technology Literacy.

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