DEVELOPMENT OF TEACHING MATERIALS OF PARABOLA MOTION USING TRACKER SOFTWARE FOR PHYSICS LEARNING DURING THE COVID-19 PANDEMIC

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Abstract

One of the problems in online learning during the COVID-19 pandemic is monotonous learning. This fact requires teachers to be able creating joy learning. Not only focusing on the knowledge aspect, but also the skill aspect through experiment from home by using technology. So that students feel happy and motivated to learn, able to prove the concepts in real-life, so physics can be understood contextually. One of the software that can be used for distance learning based on physics experiment is tracker. According the facts, the researchers try to develop the learning materials topics parabolic motion using tracker. The research method in this research using 4D model (*Define, Design, Development, Disseminate*) *of Thiagarajan. From the results of the research, it can be concluded that, (1) video analysis of parabolic motion using tracker can be getting appropriate results. (2) the results of the design of learning materials for parabolic motion materials include: title, learning instructions, learning objectives, parabolic motion materials, and questions based on critical thinking indicators of interpretation, analysis, evaluation and inference.*

Keywords: *Learning materials, Pandemic era, Parabolic motion, Tracker software*

1. INTRODUCTION

COVID-19 pandemic has caused some fundamental changes in various areas of life. Formal work that is usually in the office has turned into working from home. In education, learning that was originally class-based (classroom learning) turned into learning from home (home learning). Likewise, in teacher professional development activities, such as workshops, training, technical guidance and so on, which are usually carried out with the face-to-face method, have turned into online activities. This requires teachers to change, at least learn to be more familiar with technology. Whatever field of work a person is in, through the use of technology, the work will be time-saving, free from geographical barriers, economical, improving quality, and effectiveness (Catarina, 2015).

Based on researchers' observations conducted in several classes, several obstacles were encountered during online learning and assessment systems, both from teacher and student factors. From the learning factor, most teachers have not been able to integrate technology into learning during the pandemic. This results in the implementation of learning being monotonous. The teacher only touches the knowledge aspect, while the attitude and skill aspects are neglected. In addition, in the learning process, the teacher gives more assignments than carrying out learning that involves the active interaction of students. Teachers tend to give assignments that must be completed by students, for example through the WhatsApp application. This condition results in the child being bored with the tasks that are continuously given by the teacher. Parents also find it difficult to accompany their children when learning from home.

This fact requires teachers to be able to create fun distance learning. Not only focusing on the knowledge aspect, but also the skill aspect through experiments from home by utilizing technology. Thus, students feel happy and motivated to learn, prove the concepts contained in real-life physics events against existing theories so that physics can be understood more contextually (Johnson in Nurhadi et al., 2004).

One of the software that can be used for distance learning based on physics experiments is a software tracker. Tracker is software capable of analyzing and modeling motion and optical phenomena, free of charge, and developed by Open Source Physics (OSP) using the Java framework (Wee and Lee, 2011). Through the tracker, educators and/or students can easily analyze real-world problems, especially on topics of motion and optics which are sometimes impossible without the help of technology.

The most suitable topics for Tracker software are those related to kinematics and motion phenomena in general (Habibbullah and Madlazim, 2014). Tracker software has a calibration facility so that the measurement results obtained are close to reality (Ristanto, 2012). This proves that the tracker software is very good for analyzing videos of physics events.

Video analysis of physics events is an analytical activity carried out on a video of physics events to understand the concepts contained in the video. Several researchers have conducted research on video analysis of physical events, Kinchin (2016) analyzed harmonic motion videos, Wee et al. (2015) analyzed the vertical motion up and down, Habibullah and Madlazim (2014) analyzed the video of free fall motion, and Fadholi, et al. (2018) analyzed momentum and impulse videos. Based on the results of these studies, it can be concluded that video analysis of physics events is useful for proving the concepts contained in real-life physics events against existing theories so that physics can be more easily understood contextually.

Based on the experience of researchers, parabolic motion material is often presented with the lecture method and theoretically so that students are less able to analyze. Students tend to memorize concepts without understanding the concepts being studied. One of the indicators is the results of the analysis of the achievements of the national exam which shows that the student's absorption of parabolic motion material in the last three years is in the very low category. One of the reasons is that it is very difficult to measure the motion of a satellite dish directly, especially if the equipment is not sufficiently complete. Measurements and calculations that are difficult to do in real terms are calculating the speed of objects at a certain height and the highest point. One activity that is relatively easy to do is to measure the furthest distance because it can be measured directly with a measuring instrument.

Seeing the facts described above, researchers are interested in conducting research through the development of teaching materials for parabolic motion materials. using a tracker to support the physics learning process during the Covid-19 pandemic.

2. RESEARCH METHODS

The research method used to develop this teaching material was to use the Research and Development (R&D) research method by following the path of Thiargarajan (1974), namely the 4D development model (Define, Design, Development, Disseminate). This model was chosen because it fitted the development conditions in the field. The stages of 4D development, as follows:

a. Defining Stage (Define)

The define stage was carried out to determine and define the needs in the learning process related to the development of teaching materials for the concept of parabolic motion using tracker software.

b. Planning Stage (Design)

The design stage was carried out by designing teaching materials in the form of student performance sheets of parabolic motion material using tracker software with the following steps:

1) Video capture, the researcher recorded a video of the parabolic motion using a cellphone (mobile phone).
2) Video analysis, at this stage, an analysis of the video was carried out using tracker software.
3) Data analysis, at this stage, an analysis of the data obtained related to the magnitudes of the parabolic motion material was carried out using tracker software.
4) Designing teaching materials in the form of worksheets for video analysis of physical events, parabolic motion material with tracker software.

c. Development Stage

In the development stage, media or products that had been designed were then discussed with three peer physics teachers (School MGMP) through FGD (Focus Group Discussion). Based on suggestions and input from colleagues, improvements were made to teaching materials.

d. Stage of Dissemination (Disseminate)

At this stage, the revised product was then disseminated through teachers who joined the Physics Subject Teacher Conference (MGMP) of Situbondo District High School through MGMP meetings or via video conference using the Webex meeting application.

3. RESULT AND DISCUSSION

a. Define Stage

The define stage is carried out to determine and define the needs in the learning process. In this case, the preliminary process carried out is a study of the concept of parabolic motion material. In addition, the introduction of tools and how to use the tracker software application was also carried out. Researchers also prepared tools and materials, including mobile phones to record motion, ping pong balls, dark background cloth, and tin soldering straws.

b. Design Stage

The design stage is the stage of designing teaching materials carried out through experiments through a tracker. The data obtained then becomes a reference for designing teaching materials. The steps are as follows:

1) Video capture
   Researchers recorded a video of the parabolic motion using a cellphone (mobile phone).
2) Video analysis using tracker software.
   At this stage, the researcher analyzes the videos that have been produced using the tacker software. The steps taken in the process of analyzing parabolic motion videos are as follows:
   Perform a stick calibration. In this study, a stick with a length of 1 meter was used.
   a) Set the coordinates at position (0,0) on the ping pong ball before moving.
   b) tracking the mass point by pressing each point of the ping pong ball that forms a parabolic curve.
3) Data analysis, the data obtained from the experiment is then analyzed, looking for variables or quantities related to parabolic motion. The results of tracking data are shown in Table 1.

T bel 1. Data of tracking result.

No	*t* (sekon)	*x* (m)	*y* (m)
1	0.134	0.119	0.601
2	0.168	0.181	0.800
3	0.201	0.215	0.975
4	0.235	0.261	1.163
5	0.268	0.301	1.293
6	0.302	0.329	1.423
7	0.335	0.357	1.537
8	0.369	0.386	1.650
9	0.402	0.425	1.747
10	0.436	0.465	1.854
11	0.469	0.476	1.928
12	0.503	0.499	1.990
13	0.536	0.527	2.030
14	0.570	0.550	2.075
15	0.603	0.573	2.110
16	0.637	0.595	2.121
17	0.670	0.607	2.138
18	0.704	0.635	2.144
19	0.737	0.663	2.132
20	0.771	0.680	2.115
21	0.804	0.698	2.087
22	0.838	0.732	2.058
23	0.871	0.760	1.985
24	0.905	0.783	1.939
25	0.938	0.805	1.860
26	0.972	0.834	1.775
27	1.005	0.862	1.690
28	1.039	0.890	1.582
29	1.072	0.930	1.469
30	1.106	0.958	1.350
31	1.139	0.992	1.219
32	1.173	1.015	1.077
33	1.206	1.055	0.936
34	1.240	1.094	0.743
35	1.273	1.134	0.561
36	1.307	1.180	0.374
37	1.340	1.202	0.181

From the data above, it can be determined directly the quantities associated with parabolic motion, including:

a) Farthest distance = 1.202 meter (di kolom *x*, baris 37);
b) Time to cover the farthest distance = 1.340 seconds (in column t, row 37);
c) Highest point = 2.144 m (in column y, row 18);
d) Time to reach the highest point = 0.704 seconds (in column t, row 18).

Other physical quantities related to velocity can be determined using graphical analysis. The results obtained are as follows:

Axis direction speed x = 0.86 m/s

Axis direction speed y = 0.86 m/s

c. Development Stage

At this stage, the researchers developed parabolic motion teaching materials. Based on the data obtained from the experimental results, discussion and development are carried out to compare with the theory in parabolic motion. Then a design of teaching materials is drawn up in the form of a parabolic motion material worksheet. The product that has been designed is then discussed with three peer physics teachers (School MGMP) through FGD (Focus Group Discussion) and then revised. The results of the design of the teaching materials are as follows.

1) Title "Lembar Kerja Siswa Materi Gerak Parabola menggunakan Software Tracker",
2) Study Guide,
3) Purpose of Study,
4) The material for parabolic motion is dense and concise,
5) Assignment in the form of video analysis of parabolic motion using tracker software, and
6) Questions based on critical thinking indicators covering aspects of interpretation, analysis, evaluation, and inference. This question is a contextual result of the study of parabolic motion videos with tracker software.

d. Disseminate Stage

At this stage, teaching material products are disseminated through teachers who join the Physics Subject Teacher Conference (MGMP) of Situbondo High School through MGMP meetings or video conferences using the webex meeting application. Dissemination activities include: the use of tracker software in physics learning, especially parabolic motion material and product development of teaching materials in the form of parabolic motion material worksheets. The dissemination activity was carried out on May 20, 2020, with MGMP participants originally visiting 30 teachers from 13 schools, but attending the dissemination activity through vicon which was attended by 25 people.

Constraints when using tracker software and product dissemination. Based on research's experience, some of the obstacles that arise when using the tracker software are:

a. The calibration stick is less precise;
b. coordinate coordinates (0,0) are less precise;
c. ball looks less clear when moving due to confusion with the background;
d. Camera captured images are blurred due to poor camera quality;
e. When the image is blurry, the tracking point mass is inconsistent, for example if it is tracked at the top of the image, then so on it must be consistent at the top. This will affect the displayed data.

In addition, several obstacles encountered by the author when conducting dissemination through the Situbondo District High School Physics MGMP forum via video conference, including:

a. Not all teachers are familiar with video conferencing applications, so at the beginning of the activity, they still had difficulty entering the vicon room, had difficulty playing audio and showing video.
b. The limited time for vicon is only 40 minutes because it uses the free vicon application. resulted in the vicon running less than optimal, especially the limited time for delivering material and discussion.

4. CONCLUSION

Based on the results of the study, it can be said as follows.

a. Video analysis of physical events of parabolic motion material with tracker software can be carried out in learning and get the appropriate results.
b. The results of video analysis of events can be used as a basis for designing teaching materials in the form of parabolic motion material worksheets.

Based on the study results, the researcher gave suggestions for further research that when the initial data related to calibration and coordinates should be carried out more carefully. This needs to be done so that more accurate customs are obtained so that they are more detailed in describing physical events.

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