The Development of Guided Inquiry Student Worksheet using Tracker Video Analysis for Kinematics Motion Topics

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Abstract. This paper aims to describe the development of guided inquiry student worksheets using tracker video analysis for kinematics motion topics. This development is to facilitate students to do straight motion and parabolic practicum using a video analysis tracker with teacher guidance. It uses a six-step guided inquiry approach. The model of the research and development is Analysis, Design, Development, Implementation, and Evaluation (ADDIE). The samples of the implementation stage are 34 students, then grouping into nine groups. The results of the development research obtained worksheets on the material: horizontal motion, vertical upward motion, downward vertical motion, free-fall motion, and parabolic motion. This worksheet was validation by material experts, media experts, and learning experts. The result of validation is the product was very feasible or has fulfilled the requirements to use as learning media.

1. Introduction
Visual information, such as graphs, is a convenient way of displaying large quantities of information in a form that is easy to understand [1]. Graphs are commonly used in many gateway subjects (mathematics and science) to convey vital information [2]. Student understanding of graphs has discussed in many physics education research (PER) studies [3,4]. The first PER studies are how student difficulties in connecting graphs to physical concepts in kinematics and the real world [4]. The graphs in kinematic topics help students to explain the comparison between position, velocity, and acceleration versus the time [4,5]. But in fact, students have difficulties in understanding these graphs [5]. Some students have trouble with motion graphs even when they understand the mathematical concepts [6].

Now is a digital era where technology is at the forefront of our day to day life [7]. This led to teachers and students being provided with new innovative ways to teaching and learning of new concepts like kinematics. One of the ways to teaching kinematics is by using tracker video analysis [8] and worksheet [8, 9].

The tracker video analysis is free software and can be downloaded from the open source physics website [10]. The tracker video analysis has been used by many Physics Education authors such as Fadilah [8, 10]. The benefit of using tracker video analysis is the value deduced from video analysis are consistent with real-world data of gravitational acceleration on the surface of the earth [10].

Worksheet for students contains instruction manuals or the learning process to guides the students. Student worksheets also help students to improve competence to achieve learning objectives [11]. The
learning process systematically listed on student worksheets. Student worksheets include investigation, problem-solving, or conclusions [12]. Student worksheets help teachers to enable students in the learning process, inquiry, and discovery of the concept to achieve a minimum competency [13]. Following the student worksheets function, it can combine with the learning model. One of the learning models that can improve the ability of students to find their answers to a questionable problem is the Guided Inquiry Model [14]. The main principle of Guided Inquiry is to point on student's activity to seek and find their answers to a problem [14]. So, the purpose of this research is to develop a worksheet using tracker video analysis for kinematics motion topics.

2. Method
   The research method used is a Research and Development method. The research model used is the ADDIE research model consists of 5 stages that are analysis, design, development, implement, evaluate [15]. The implementation of ADDIE in this research [16]:
   (1) Analysis needs assessment used to determine the problems in laboratory activities, determine the type of teaching materials to be developed, assess the achievement competence.
   (2) The design stage uses to determine the specification of teaching materials that will produce. The content will be loaded and determine the assessment strategy.
   (3) The development stage contains the process of making a modified guided inquiry-based laboratory worksheet, validation test, review, and revises modified guided inquiry-based laboratory worksheet. A validation test used to see the feasibility of a modified guided inquiry-based laboratory worksheet. The validation tests judged by material, media, and learning experts.
   (4) Implementation stage testing a physics worksheet to 34 senior high school students (nine groups).
   (5) Evaluate stage contains in all stages, analysis, design, development, and implement.

3. Results and Discussion
   The product is a student worksheet in a horizontal motion, vertical upward motion, downward vertical motion, free-fall motion, and parabolic motion using a tracker based on a guided inquiry learning model. The contents of the book consist of covers, table of contents, supporting information, instructions for using the LKPD, tracker usage specifications, practicum rules, minimum competencies, and main competencies. Then there is a practicum activity, which is a straight motion practicum and parabolic practicum. In laboratory activities, adapt from guided inquiry steps with (1) orientation stages, (2) formulating problems, (3) determining hypotheses, (4) collecting the data, (5) testing hypotheses, and (6) drawing conclusions [17]. Compare the final product with research from Fadilah (2019) [8] and Yudha (2019) [9]. Their student worksheet doesn’t mention a laboratory activity adopt by a learning model steps. The difference result from Yanto (2019), He doesn’t explain a learning model not on the worksheet, but in a question on student worksheet [18].

   Figures 1 to 4 show an activity laboratory adopt by guided inquiry steps in the develop student worksheet. Figure 1. Orientation stages on the student worksheet. Figure 2. Formulating problems and determining hypotheses stages on the student worksheet. Figure 3. Collecting data stages on the student worksheet. Figure 4. Testing hypotheses and drawing conclusions stages on the student worksheet.
Figure 1. Orientation stages on the student worksheet

Figure 2. Formulating problems and determining hypotheses stages on the student worksheet
| Step | Aktivitas                                                                                     | Gambaran Aktivitas                                      |
|------|----------------------------------------------------------------------------------------------|---------------------------------------------------------|
| 1.   | Pastikan laptop/ komputer yang digunakan untuk praktikum sudah terinstal aplikasi tracker (cara menginstal tracker bisa dilihat di Petunjuk Penggunaan LKPD). | Tampilan desktop laptop yang sudah terinstal aplikasi Tracker. |
| 2.   | Lalu, pindahkan terlebih dahulu file video rekaman tadi dari kamera handphone ke laptop/ komputer. | Kamere → file Video → Laptop/ komputer                  |
| 9.   | Gunakan alat ukur meteran untuk mengukur ketinggian yang akan ditempuh bola. Setelah itu masukkan angka hasil pengukuran pada calibration stick seperti pada gambar (1). Pastikan kembali calibration stick lurus dengan mengecek sudut dan ketinggian di bagian atas halaman video (2). Jika calibration stick sudah pas, klik kanan di calibration stick, pilih fixed, supaya tidak berubah (3). | Atur jarak/ ketinggiannya rentang 0,5 – 1,25 meter        |

**Figure 3.** Collecting data stages on the student worksheet
The student worksheets activities are used to optimize the implementation of the learning process to maximize the learning outcomes of students in the attitudes, knowledge, and skills competencies [8]. Generally, the material on kinematics include facts, concepts, procedure principles, and cognitive
aspects that students need to master. Table 1 shown the student activity in student worksheets compare with the domain of Anderson taxonomy [19].

Table 2 shows the result of validation to material experts, media experts, and learning experts. The result of learning experts shows that activity laboratory can adopt guided inquiry steps and suitable to student worksheet. A good worksheet has an interesting theme [20]. Based on the result of media expert we know that the theme of developed worksheets shows interesting themes and consistent, so it’s easy to use and make student feel comfort.

Table 1. Student activities and domain of Anderson

| Stages of Guided Inquiry | Students Activity                                                                 | Domain of Anderson |
|-------------------------|----------------------------------------------------------------------------------|--------------------|
| Orientation stages      | 1) Students demonstrate horizontal motion, vertical upward motion, downward vertical motion, free-fall motion, and parabolic motion. 2) Students record with the camera the motion event | 1. Applying 2. Creating |
| Formulating problems    | Students identify as many questions as possible about the recorded phenomena phenomenon. | Analyzing |
| Determining hypotheses  | 1) Students find information as possible in textbooks and the internet to get related theories. 2) Students making hypotheses is the result of agreement from group discussions. | 1. Analyzing 2. Evaluating |
| Collecting data         | Students enter the recorded video results into the tracker application.           | Creating |
| Testing hypotheses      | Students compare hypotheses to the data obtained.                                | Evaluation |
| Drawing conclusions     | Students make conclusions based on theory and data obtained.                     | Creating |

Table 2. Validation results

| Validator              | Aspects                     | Score  | Interpretation |
|------------------------|-----------------------------|--------|----------------|
| 1. Material experts    | Content Feasibility         | 99.65% | Very suitable  |
|                        | Consistency                 | 100%   | Very suitable  |
| Average of all aspects |                             | 99.88% | Very suitable  |
| 2. Media experts       | Students worksheet themes   | 94.28% | Very suitable  |
|                        | Presentation Techniques     | 89.46% | Very suitable  |
|                        | Language                    | 100%   | Very suitable  |
| Average of all aspects |                             | 94.58% | Very suitable  |
| 3. Learning experts    | The stages of guided inquiry learning | 83.61% | Very suitable  |
|                        | Application of inquiry learning model | 80%    | Suitable       |
| Average of all aspects |                             | 81.16% | Very suitable  |
4. Conclusion

The developed result is the student worksheet of linear motion kinematics using video analysis tracker based on guided inquiry learning models. Based on the validation it can be concluded that the product is very feasible or has fulfilled the requirements to be used as learning media.

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