Electronic practicum module based on scientific argumentation as a practicum medium of motion and force in the covid-19 pandemic

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Abstract. The concept of motion and forces needs to be mastered by physics students through theoretical learning and scientific inquiry in the laboratory. The theory of motion and forces can be learned through online lectures and assignments. However, laboratory investigations cannot be conducted due to campus policies to study and work from home. Therefore, this research was conducted to develop practicum modules that can facilitate the practicum of motion and forces remotely. This module features videos containing experimental data and analysis guides with EPUB format to facilitate scientific argumentation ability. This article primarily discusses the content validity of the electronic module and the practicum video. The method used was expert judgment using validation questionnaires by five experts. Validation results are then converted to a five-scale score based on the ideal standard deviation to determine the product eligibility. The calculation results show that practical electronic and video modules have an excellent level of feasibility. Furthermore, the electronic practicum module based on scientific argumentation needs to be tested to determine its level of practicality and effectiveness in facilitating practicum and developing scientific argumentative ability.

1. Introduction

Newton's law of motion is one of the most fundamental laws in physics. In a verse poem, Alexander Pope said, "Nature and Nature's laws lay hid in the night: God said, Let Newton be! and all was light" [1]. The poem implies the significance of Isaac Newton as a genius person and his laws' implications for the world of science. Newton's first law addressed the inertia of objects due to mass influence. The second law discusses the concept of accelerating a mass object influenced by the force that works on it. Because mass objects are part of the concept of inertia, mass also affects acceleration. Newton's third law or reaction action law explains the interaction of similar forces between two objects. These
three laws are interconnected in explaining the phenomenon of motion in the macroscopic, from the fall of an apple on the earth's surface to the earth's revolution surrounding the sun [2].

Physics is a science-based on the minds-on activity to understand the theory and hands-on activity to prove the theory [3]. Both learning activities must be connected because if it relies on theoretical learning only, it will be challenging to overcome the various misconceptions students have [4]. Therefore, students also need to do scientific experiments in the laboratory on the concepts of inertia, the influence of force and mass on acceleration, and the action-reaction forces [5]. Experimental activities need to be appropriately designed so that students can scientifically observe, investigate, and collect data to concluding Newton's laws of motion [6]. Thus, practicum activities can strengthen the concepts that students have while reducing misconceptions, so that learning in the classroom becomes meaningful.

The experiment is an integral activity in studying the concept of physics [7]. However, the laboratory's current experiment cannot be implemented in the Physics Education study program of Palangka Raya University due to work from home policy. The learning process is also transformed into online learning through learning management system programs, social media, and video conferences to prevent viruses. Theoretical learning can still be conducted by this method, where students can be given materials and self-assignment to delve into physics concepts. However, the method cannot be applied to practicum activities because the students do not have the necessary tools and materials at home. If this problem is not addressed immediately, then the skills in observing, retrieving data, measuring, making analysis, and making practicum reports will be reduced to students.

The results of the practical report analysis reveal the lack of students' ability to argue scientifically. Scientific argumentation is the process of linking statements to data through consideration or evaluation of edified knowledge with theoretical or empirical evidence [8]. Ideally, students would represent experimental data to create scientific explanations to match Newton's laws. However, students are not able to do this. The analysis of the student's data is limited to the explanation of how the data obtained and the description of the work steps performed. Therefore, an intervention is required in the experimental process for students to make statements supported by precise data and theories.

The practicum problems need to be solved by developing a new practicum module. The module is expected to remotely facilitate Newton's laws practicum during the COVID-19 pandemic while developing the students' scientific argumentation ability to create experimental reports. The practicum module has many variations, such as an android-based module used as learning media [9], material presenters in the form of video and flash players [10], or modules that can be stored in smartphones [11]. These modules can be used as learning resources anywhere and anytime, so they are considered effective and efficient for self-learning. The appropriate type of practicum module to use in remote practicum is an electronic module. This module can store practicum videos and be sent over the internet so that practicum activities can be conducted even if not in the laboratory.

The ability of scientific argumentation can be developed by providing interventions in learning. Oriented learning in scientific activities is seen as developing scientific argumentation [12]. Practicum activities are learning processes that can facilitate the ability through data retrieval, data analysis, and evaluation of data against scientific laws. Through the practicum, students are invited to prove data and think critically to strengthen assessment and decision making, thereby strengthening arguments [13]. Therefore, it is necessary to intervene in students to use scientific laws to interpret data. Therefore, in the electronic practicum module, an analysis guide is given so that students can make an analysis based on the appropriate data and relevant theories.

This research aims to develop electronic practicum modules based on scientific argumentation to be used as a standalone practicum medium. Electronic practicum modules have been widely developed before. However, this module has a difference because the practicum videos in it simultaneously display measurement data. That way, students can still make observations, analyze data, and make reports even if they do not enter the laboratory. The module also features an analysis guide to guide students to create analysis supported by experimental data and strengthened by Newton's laws. This
characteristic is also a differentiation because no practical module has been created to facilitate the
ability of scientific argumentation until now. Specifically, this article discusses the practicum module
and videos' content validity for motion and forces topics.

2. Method
This research is part of research on the development of electronic practicum modules based on
scientific argumentation. The development model used is the ADDIE model to analyze, design,
develop, implement, and evaluate stages [14]. Various problems and the need for practicum motion
and forces were analyzed to determine the required remote practicum scheme at the analysis stage. At
the design stage, the module was then designed according to the previous problem-solving idea. Then,
the module was assessed for validity by experts at the development stage. The revised results will be
tested at the implementation stage to obtain more intact data on the module's practicality and
effectiveness. The evaluation stage is the final stage aimed at determining the level of product
achievement. This article focuses on the development stages related to e-module and practicum videos
validation conducted by experts.

The validation process was carried out by five experts using expert validation questionnaire
instruments [15]. The experts consist of four lecturers and one high school teacher. All of them have a
master's degree in physics education. The objects that become validation processes are prototype e-
module and practicum videos. Expert validation polls use Likert scales to assess each component of a
statement divided into content, construction, and language aspects. The expert validation instrument
indicators can be seen in Tables 1 and 2 below.

| No | Aspects | Indicators |
|----|---------|------------|
| 1  | Construction | The smooth operation of e-modules on android smartphones |
| 2  | Construction | The completeness of e-module components (cover, table of contents, user manual, practicum topics) |
| 3  | Construction | The clarity of the manual for using the e-module |
| 4  | Construction | The completeness of practicum topic components (title, objectives, tools & materials, experimental steps, analysis guide) |
| 5  | Construction | The order of topic contents (title, objectives, tools & materials, experimental steps, analysis guide) |
| 6  | Construction | The clarity of practicum objectives |
| 7  | Construction | The clarity of tools and materials’ image |
| 8  | Construction | The clarity of observational data tables |
| 9  | Construction | The clarity of analysis guide |
| 10 | Content | The correctness of the physics concepts in module with physics expert |
| 11 | Content | The compatibility of the tools & materials image with the name label |
| 12 | Content | The effectiveness of the steps to achieve experiment objectives |
| 13 | Content | The compatibility of the observation table design with the data from the video |
| 14 | Content | Suitability of the analysis guide with the data in the observation table |
The effectiveness of the analysis guide in aiming student arguments

Language
The correctness of text in the module with an Indonesian spelling system

Clarity of information from the sentences used

Effectivity of the language

The correctness of typing words in the module

### Table 2. Indicators of videos validation instrument

| No | Aspects     | Indicators                                                                 |
|----|-------------|-----------------------------------------------------------------------------|
| 1  | Construction| The smoothness of video playback                                           |
|    |             | The clarity of video display                                               |
| 2  |             | The readability of practicum data                                          |
| 3  |             | The clarity of tools and materials used                                    |
| 4  |             | The clarity of the text stated                                              |
| 5  |             | The clarity of the audio                                                   |
| 7  | Content     | The compatibility of the experimental steps in the video with the scientific work concept according to experts |
| 8  |             | The compatibility of the experimental steps in the video with experiment objectives |
| 9  |             | The order of the experimental video                                       |
| 10 |             | Ease of understanding experiment step video                               |
| 11 |             | The correctness of the data in the experiment step video                   |
| 12 |             | The compatibility of video data with experiment objectives                |

The results of the validation questionnaire by experts need to be converted in advance in the form of a five-scale based on the ideal standard deviation [16]. The number of experts assessing e-modules and videos is five. The e-module assessment criteria and practicum video are shown in Table 3 below.

### Table 3. Five-scale scoring criteria

| Interval Score | Criteria   |
|----------------|------------|
| X > 4,2        | Outstanding|
| 3,4 < X ≤ 4,2  | Good       |
| 2,6 < X ≤ 3,4  | Adequate   |
| 1,8 < X ≤ 2,6  | Bad        |
| 1,8 > X        | Poor       |
3. Result and Discussion

3.1. Result

The analysis of expert validation questionnaires on the electronic module and practicum videos can be seen in figure 1 and figure 2 below. The image shows the validation score for each validation statement item according to Table 1 and Table 2. For e-modules, all category scoring items are excellent, except items 2, 3, and 19. Item 2 relates to the completeness of e-module components, such as cover, table of contents, usage guides, and practicum topics. Validators assess that the e-module guide should be equipped with an example of a temporary report and a final practicum report. The next item is item 3, where this item relates to the clarity of the e-module usage guide. According to the validators, the slope topic module should explain the stopwatch’s use for retrieving trolley travel time in the slope. Then, item 19 relates to a typing error in the e-module, which needs to be corrected to improve its information.

![Figure 1. Graph of e-module validity score](image1)

![Figure 2. Graph of videos validity score](image2)

The validity assessment of practicum videos also shows excellent categories. Of the 12 items, all items have excellent validity, except items 3, 5, and 10. Item 3 relates to the readability of practicum data. Overall, validators can read practicum data, but one section whose data is unreadable, i.e., at the end of the second practicum. In that section, the video ends before the trolley reaches the slope’s base, so the trolley’s travel time cannot be measured. The practicum video will be extended to solve this problem until the trolley reaches the slope’s base. Then, item 5 relates to the clarity of the text listed, where the validators consider the explanatory text using the stopwatch to be corrected sentence. Besides, the countdown display also does not end precisely when the trolley is released from the hand. These things affect the assessment of item 10, which is the ease of understanding the trial steps. Revisions are made to the text section to make it easier to understand. Then, the countdown is also adjusted so that the trolley slides when the countdown ends. That way, the practicum will obtain accurate data related to trolley travel time.

3.2. Discussion

Electronic module based on scientific argumentation were developed using different types of software. Microsoft word and publisher are used as programs to design module formats. For video editing, the programs used are adobe premiere pro and adobe illustrator. Modules and videos are then combined through sigil applications to produce epub-formatted electronic modules. The Reasily reader app is required to install into an android smartphone to read the e-module. The readable e-module view can be seen in figure 3 below.
The electronic module on motion and forces aims to help students understand Newton's Laws concepts through investigations on the slope. Students were invited to investigate the slope's mechanical forces, determine the relationship between force and acceleration, determine the relationship between mass and acceleration in the slope, and analyze the action-reaction force on the trolley. To that end, this module provides instructional use, tools, and materials in the form of images, up to practicum steps in the form of videos. The view of the electronic module of topics of motion and forces can be seen in the following figure 4.

The practicum of motion and forces in this module has two activities. In the first activity, the trolley is placed on a slope with elevation angle changes, while the mass of the trolley is controlled permanently. Then, in the second activity, the trolley mass is manipulated with the addition of load, while the angle of the slope elevation is made fixed. Both activities have the same variable response: the weight force experienced by the trolley and the trolley's time to descend the slope. Trolley mass is measured by digital balance, the arc of degrees measures the angle of slope, a dynamometer measures the weight force on the trolley, and trolley travel time is measured using a stopwatch. These variable data can be directly observed in the test video, as in Figure 5, except for trolley travel time data. The practicum video shows a trolley scene down a slope, and the students will be asked to calculate the time by themselves using a stopwatch at home.
The data obtained from the practicum video must be written to the observation table, as in figure 6. The column of angle, experimental forces, trolley masses, slope length, and trolley travel times are obtained through the measuring instrument. The trolley travel time data and the slope's length are then inserted into the straight motion equation to obtain the experimental acceleration of the trolley. Then, the slope angle data is inserted into the slope equation to get theoretical acceleration and theoretical force. For its analysis, students were asked to compare forces value by dynamometer measurement data to forces value by theoretical calculation, and then experimental acceleration was also compared to theoretical acceleration.

![Figure 5. The practicum video containing measurement data](image)

![Figure 6. Observation table](image)

Not all students can produce an analysis that is as expected. To that point, the module is equipped with an analysis guide that serves to guide students in analyzing the data [17]. Figure 7 shows seven questions that lead students to produce a more proper analysis of data. Students were asked to compare the results of the experiment with the theoretical calculations obtained. If the results are different, students should think more deeply to determine the cause of the difference. The experiment results will be different from theoretical calculations because many theoretical calculations ignore the various variables that affect the movement of the trolley.
Furthermore, students are asked to understand the trolley acceleration pattern when the slope's angle is magnified. When the angle is magnified, the weight force in the slope of the slope will get increased. Based on this, students should be able to associate it with Newton's second law. In B activity, when the trolley's mass is increased, then the weight force also increases, but because the mass slows the trolley's movement, then the addition of the trolley load does not affect whatever. Students will find that trolley travel time on B activity is the same in all experiments. They should analyze the influence of mass on the constant travel time of trolleys under Newton's first law. Also, students are asked to represent vector's diagram of forces when the trolley is in equilibrium. They should make an analysis of which forces include action-reaction pairs. This process will establish the misconceptions students have towards Newton's third law [18].

The experimental activities guided by data and theory implementation can facilitate scientific argumentation [19]. Utilizing technologies such as practicum simulations in experimental videos can support argumentative learning since practices can view data and reason it in different situations [20]. Besides, asking students to make vector representations is also useful because the scientific argument can also be known based on proficiency using multiple representations in expressing an idea or concept [21]. Ultimately, a learning process that involves assessing data, evaluating, and making statements on what is observed will improve students' critical thinking abilities [22].

The epub-formatted electronic modules have been widely developed previously to help students to learn, support practicum activities in the laboratory, and demonstrate abstract concepts [23]–[25]. However, none of the previous studies utilized the video feature as a source of data retrieval for remote practicum, which is owned by this module. With videos containing experimental data, students are expected to conduct the process of observation and retrieval of data, then create advanced analysis and practicum reports to intensify cognitive achievement of scientific process skills during the pandemic. In addition, the development of scientific argument ability so far is only done in classes through writing and dialogue between groups of students [26]–[29]. In fact, practicum activities have the potential to develop these abilities because in the creation of student reports it is required to analyze data, make statements, and associate it with theory. A valid electronic module based on scientific argumentation is expected to facilitate the development of such abilities in students.
4. Conclusion
The expert assessment of prototype electronic practicum modules and practicum video topics of motion and forces show validity with excellent criteria. These practicum module and videos are considered valid in terms of construction, content, and language. In the future, the module needs to be applied on a broader scale to determine its practicality and effectiveness in facilitating scientific argumentation.

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