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Development a practicum tools to measure the speed of the air using Arduino Uno Microcontroller

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Abstract. This study aims to produce practicum tools that can measure the speed of the air. This tool uses the HC-SR04 ultrasonic sensor module as a sound wave transmitter and uses the Arduino UNO as a control system. The research method used is ADDIE. After the product has been developed, it is evaluated by conducting a validation test. Based on validation results, this practicum tool's suitability has also been validated by the media expert. The following is the score achieved from each of the indicators, distance and time measurement score was 75%, appearance of practicum tool data was 100%, and clarify the concept was 75%. Therefore, the practicum tools as learning media to measure the air's speed are fit for use.

1. Introduction

The syllabus topics have been selected to enable the students to acquire the relevant knowledge, skills, and attitudes needed for tertiary level education, apprenticeship, and life [1]. The physics syllabus embodies a wide range of projects, experiments, demonstrations, and scientific inquiry skills [2]. The physics curriculum in schools requires student skills, one of which is achieved through practicum activities. The physics practicum also applies science process skills [3]. Again, the Physics practicum can integrate many attitudes such as objectivity, accuracy, precision, honesty, collaboration, discipline, responsibility, open-mindedness, courage, humility, decision-making, integrity, diligence, persistence, curiosity, etc [4].

There are many physics practicums demanded by the curriculum at the Senior High School (SMA), including taking measurements [5], simple harmonic motion experiments [6, 7], Hooke's Law [8], static fluids [9, 10], etc. However, there are still practicums that are not yet available in schools, one of which is determining airspeed even though airspeed is often discussed in sound wave material such as the organa pipe, Doppler law, and strings [11]. So far, in schools, the value of airspeed has been known from the textbooks used [12]. Not only airspeed, but there are also other quantities whose values are known from books, one of which is the acceleration due to gravity [13]. Even though the gravitational constant in schools can be found using a practicum through simple harmonic motion experiments [14]. Therefore, it is possible to design a practicum used to determine the value of airspeed.

Development research to determine the air speed has been carried out before [15, 16]. Both use the same sound from the loudspeaker, which is then detected using a microphone. But the results of the development of both are not in the form of practicum tools. Therefore, this research will develop a set of practical tools that can measure speed of the air. The measuring instrument developed will use a
microcontroller, because in learning activities, the microcontroller can be used as a learning medium to improve practical skills [17].

2. Method

The development research model developed is ADDIE [18]. The following steps:

2.1. The Analysis
First to do a needs analysis is done to find out and obtain information about high school students' conditions and needs. A needs analysis was performed using a survey method using a questionnaire.

2.2. The Design
The design stage aims to design a set of practicum tools. This stage along with prepare the appropriate tools and materials.

2.3. The Development
The development stage is the stage to produce a development product which is carried out in stage consists of making practicum tools, calibration of practicum tools, validating, and improving according to revisions.

2.4. The Implementation
The implementation stages a field trial is carried out where each student will be given a pre-test and post-test.

2.5. The Evaluation
The evaluation carried out at each stage of Analysis, Design, Development, and Implementation. One of them is an evaluation at the developing stage, namely improving the practicum tools according to the validator's input.

3. Result and Discussion

This practicum tool for measuring the air's speed consists of four main components: an adapter, an electronic box, a barrier board, and a barrier board path. The tool developed uses the Arduino UNO R3 module based on the ATMega 328P microcontroller, which is connected to the HC SR-04 ultrasonic sensor. Figure 1 shown the design of practicum tool. The explanation of the structure of the practicum tool is presented in Table 1.

![Figure 1. The design of practicum tool](image)

The device designed can measure the distance travelled by sound waves and the travel time of sound waves. This practicum tool can work at a sufficient length of 5 cm - 100 cm and measure travel time on the microsecond scale (μs). The product developed utilizes sound waves with frequencies the height generated by the ultrasonic sensor module as a distance gauge substitute a ruler for measuring distances.
Table 1. The structure of the practicum tools

<table>
<thead>
<tr>
<th>No</th>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cable</td>
<td>The connecting cable is functional connect the electronic box to power source.</td>
</tr>
<tr>
<td>2</td>
<td>Electronic box</td>
<td>The electronic box contains a circuit a microcontroller as a control system connected by cable mains connection, sensor ultrasonic, LCD, and switches.</td>
</tr>
<tr>
<td>3</td>
<td>Barrier board</td>
<td>Reflective board measuring 30 x 10 cm, which is placed on the track. Board reflectors can move on the track which exists.</td>
</tr>
<tr>
<td>4</td>
<td>Board trajectories</td>
<td>Reflective board track sized 1 m long and placed on top table. Reflective board trajectory serves as a place puts the reflective board.</td>
</tr>
<tr>
<td>5</td>
<td>Practicum Table</td>
<td>The practicum table functions as a place to put the tool components practice.</td>
</tr>
</tbody>
</table>

Figure 2. The practicum tools

The practicum tool developed to work according to design and following the theory used needs to be done first using existing tools (Figure 2). Calibration is done by comparing the ultrasonic sensor module's distance with the ruler or ruler's measured distance. The distance calibration on the ultrasonic sensor module is done by placing it barrier at a certain length in the range 5 cm - 100 cm as measured using a ruler or ruler's help. Calibration is repeated three times. The calibration results show a relative error of 2.02%. This value is much better than the ultrasonic sensor calibration results carried out before, which has a relative error value of 2.56% and 2.03% [19]. Figure 3 Shown the result of calibration ultrasonic sensor.

After sensors have been calibrated, this sensor can be used to make practicum tools. Based on Figure 4, the speed of sound propagation in the air as measured by the practicum tool tends to be constant and following the fast theory, the sound propagation in the air used is 343 m/s. The practicum tool also has an average relative error of 0.08%, which means that the practicum tool developed has a very high accuracy level. Previous research on measuring the speed of the air gets the value of the air's speed is (349 ± 13) m/s with a relative error of 2.6% [15]. Practical tools developed in this study can measure the average speed of sound propagation in the air of 343.17 m/s with a relative error of 0.08%. Practical tools developed are easier to operate and have a high degree of accuracy than the previous research [15].
The result of calibration ultrasonic sensor

Barriers versus fast air creepage relationship graph relation

The suitability of this practicum tool has also been validated, while the validation results are presented in Table 2.

<table>
<thead>
<tr>
<th>No</th>
<th>Item</th>
<th>Score</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Distance and time measurement</td>
<td>75%</td>
<td>Good</td>
</tr>
<tr>
<td>2.</td>
<td>Appearance of practicum tool data</td>
<td>100%</td>
<td>Very Good</td>
</tr>
<tr>
<td>3.</td>
<td>Clarify the concept</td>
<td>75%</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>83.3%</td>
<td>Very good</td>
</tr>
</tbody>
</table>

The validation assessment results by physics learning media experts were carried out using a Likert scale and obtained the average value of all aspects, an assessment of 83.33%. Based on the interpretation in a Likert scale, tools the practicum developed is categorized as very feasible in the media aspect of physics learning to be used as a medium for learning physics. The suggestions for improvement provided by the expert validator of physics learning media are as follows: given a list of specifications on the practical tool storage box and given code instructions in the form of numbers on the practicum tool following a list of specifications. All suggestions have been done.

4. Conclusion
Based on the validation results, this practicum tool's suitability has also been validated by media experts. The following is the score achieved from each indicator, the distance and time measurement score of 75%, the appearance of the data for the practicum tool at 100%, and the clarification of the concept of 75%. Therefore, the practicum tool as a learning medium for measuring airspeed is feasible.
Because this tool is only at the calibration stage (Figure 3 and 4) and validation of media experts (Table 2), so the suggestion for the next researcher is to conduct field trials and see their effects on the psychomotor, affective, and cognitive aspects of students.

References
[16] Nur I and Yudhiakto P Wahana Fisika 3 pp 11–18