Spring oscillator as case based learning (CBL) device

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Abstract. This research aims to: (1) develop and find out the feasibility of a spring oscillator practicum; and (2) practice the spring oscillator tool developed. The research method was the research & development method with the ADDIE development model. The study was conducted at SMAN 1 Indramayu in July-August 2019. The instrument was developed using a laser distance sensor type VL53LX as a distance gauge, a vibrator made from a coil as a spring and LCD system shaker and a laptop to display the results of the experiment. The control system uses Arduino Nano. The study was conducted in March-May 2019 at the Physics Laboratory, FMIPA, Jakarta State University. The experimental results of measuring the spring constant get an average value of 6.527 N / m. The second experiment obtained an average value of the natural frequency of the system at 1.672 Hz. The third experiment obtained a maximum amplitude value of 4.8 cm and a period of 0.59 s. The results of expert validation from media experts, and material experts were 85.16% and 90.04%, respectively. The trial of practicum tools was carried out at SMAN 1 Indramayu, West Java, as many as 20 students with a percentage of 86.66% achievement. Based on the data it is concluded that the spring oscillator practicum tool developed is suitable for use as a learning medium.

1. Introduction
Physics is a branch of the science that study natural phenomena or non-living system, physics uses a process consisting of observation, measurement, analysis, and conclusion. The conclusion must be based on a scientific attitude, objective, in accordance with the facts, honest, patient, not easily give up, tenacious and meticulous in taking a conclusion[1]. Physics learning is the process of creating conditions and opportunities so that students can construct knowledge, process skills and scientific attitudes and include aspects of knowledge, aspects of the process and aspects of attitude as a whole that can be implemented in the life process as a superior character. In its implementation there are several factors that influence physics learning [2].

Physical material always requires an understanding of the concept which is difficult to do only through imagination as an abstract and sometimes difficult to observe it but it still has to be understood deeply. This is the cause of students not having fun in Physics. Misconception in learning physics is due to many factors, such as lack of practicum, model analogy used, narrow model of demonstration [3]. By using physics learning media can give positive impression to the students, so that students will be motivated in learning and physics learning into lessons that will be interested by students [4]. Practicum tool is one type of learning media for conducting experiments. Through practicum activities give students the opportunity to be able to see and prove the theories they learn, through direct observation
and experimentation, in the end, the students' creativity and skills are improved. Students will be more motivated in assessing a theory, and indirectly the students’ curiosity also develops and is larger. Seventy percent of students said they enjoyed doing physics labs [5].

The high failure rate in physics due to their inability to understand the basic subject matter content, principles of physics in formulas. It leads to lack of remembering problem based equations in physics [6]. High school students have difficulty solving physics problems. This is caused by several factors, including the material they are learning, learning activities in class, and the teacher's teaching style. To overcome this, teachers need to change learning methods so that physics lessons are more fun, make students motivated and students are more active in learning [7].

Case based learning (CBL) is an innovative learning model that can be used as a teacher as a learning method so that the learning atmosphere is more interesting. CBL is often defined as a teaching method that requires students to actively participate in real or hypothetical problem situations, reflecting the types of experiences experienced naturally in the discipline being studied [8] and CBL is an interesting and effective active learning strategy [9].

2. Methods
This type of research is a research development of practical tools by using the ADDIE method [10]. The trial sample of this study was 20 students from Indramayu State High School with a total of 20 students. The spring oscillator practicum tool developed refers to the ADDIE model which consists of 5 main stages, namely: (1) Analyze; (2) Design (Design); (3) Development (Development); (4) Implementation; (5) Evaluation. This research was carried out at the fourth stage or implementation stage.

The first stage is to observe the availability of practical tools at school. The practicum tool found was a spring oscillation practicum tool to determine the spring constant (k) manually. In the second stage, the design of a spring oscillator practicum is used to determine the spring constant with which it can display the measured distance digitally. As for the spring oscillator practicum tools that were developed added 2 quantities that can be determined or practiced by students namely determining the amplitude of the oscillation and the oscillation period according to the graph displayed on laptop software. Three objectives of the developed spring oscillator are: (1) Determine the value of the spring constant; (2) Determine the natural frequency of the spring system; (3) Determine the amplitude and period of the graph due to external forces.

In the first experiment the determination of the spring constant is carried out using different load masses. This experiment is carried out by looking at the length increase value on the LCD and determining the spring constant using the equation:

$$F = -k \Delta x$$  \hspace{1cm} (1)

In the second experiment carried out manually to determine the natural frequency of the spring system using different load masses and using equation:

$$f = \frac{n}{t}$$  \hspace{1cm} (2)

In the third experiment the practicum device was connected to the laptop to see a graph of oscillations due to vibrator motion (external force). In this experiment the vibrator frequency can be adjusted on the rotary button in accordance with the natural frequency of the spring system obtained in the second experiment. F: Restoration style (N); k: (spring constant (N / m); \Delta x: Increase in length (m); f: frequency (Hz); n: number of vibrations (10); and t: time (second)

The design of spring oscillator practicum tool development is shown in Figure 1.
Figure 1. Practicum Tool Design (1) Support boards; (2) supporting poles; (3) Spring; (4) vibrator; (5) load mass (6) proximity laser sensor (7) Panel control box (8) LCD (9) Rotary Button

Figure 1 is a practical tool design that will be developed with 2 main parts, namely the buffer and control panel box. The buffer section consists of a supporting pole that has been affixed to the ruler, springs, vibrators and loads as well as a buffer board section that has a laser sensor as a distance gauge. The control panel box section consists of a 20 x 4 Character LCD with blue backlight and a rotary button.

In the third stage, the development of spring oscillator practicum tools is in accordance with the design of practicum tools. In the fourth stage is the validation carried out by media experts and material experts, where each expert consists of 2 physics lecturers. After being validated, a spring oscillator is tested to Indramayu 2 High School students with a total of 20 students to see the feasibility of the tool being developed.

Data obtained from the results of the validation of media experts and material experts and the spring oscillator media trials were analyzed using equation:

\[ p = \frac{s}{N} \times 100\% \]  

where \( p \) = level of program feasibility (%), \( s \) = total number of scores obtained, \( N \) = maximum total number of scores obtained [11].

3. Result and Discussion

Spring oscillator testing is conducted at the physics learning media laboratory at the State University of Jakarta, so that the practicum tool can function properly by calibrating the sensor using the ruler to see the distance value displayed on the LCD is the same as the value obtained from the ruler measurement. Then compare the results of the calculation of the period in theory with the results of the measurement of the period on the graph displayed. The appearance of the developed spring oscillator is shown in Figure 2.
Figure 2. Figure spring oscillator that has been developed

Figure 2 is the result of practicum tools that have been developed, which consists of two main parts, namely the buffer and control panel box. The developed instrument is used to measure the spring constant, the natural frequency of the spring system and the amplitude of the vibrator that will be seen on a laptop graphic using Microsoft visual studio solution.

The working principle of a spring oscillator practicum is as follows: produces an artificial vibration produced by a vibrator, where the vibrator is connected to a spring with a certain constant then given a certain mass will produce natural frequencies that vary. The frequency of the spring can be determined by scanning or testing the artificial vibration directed to the spring by looking at its effect on the oscillation of the spring and the pendulum which reaches the highest amplitude. When the spring and the load are connected to the vibrator, the system will move in harmony so that it is difficult to see the movement so that an infrared sensor is given that measures the distance from the bottom to the bottom of the load surface. Each change in position will be recorded and displayed on the LCD and on the laptop screen where the laptop can record the oscillation movements that occur when given a system given external force using a vibrator with a certain frequency. The results of the spring oscillator trial data through laboratory tests are as follows:
Table 1. Measurement Results of Spring Constant Experiments

| Trial | Mass (g) | $x_0$ (cm) | $x_t$ (cm) | $\Delta x$ (m) | $k$ (N/m) | $|k - \bar{k}|$ |
|-------|----------|------------|------------|----------------|-----------|----------------|
| 1     | 11.02    | 19.01      | 17.4       | 0.0161         | 6.844     | 0.317          |
| 2     | 21.90    | 19.01      | 15.7       | 0.0331         | 6.616     | 0.089          |
| 3     | 32.51    | 19.01      | 14         | 0.0501         | 6.489     | 0.038          |
| 4     | 42.05    | 19.01      | 12.36      | 0.0665         | 6.323     | 0.204          |
|       |          |            |            |                | $\bar{k} = 6.527$ | $\bar{\varepsilon} = 0.1442$ |

Relative error = $\frac{\varepsilon}{\bar{k}} \times 100\% = 2.2\%$

Based on table 1, the average spring value is 6.527 N/m with a relative error of 2.2%. Thus the accuracy of the spring oscillator practicum tool to calculate the value of the spring constant reaches 97.8%.

Table 2. Different Natural Frequency Experiments for Mass Systems

| Trial | Mass (g) | $n$ | $t$ (s) | $f$ (Hz) | $|f - \bar{f}|$ |
|-------|----------|-----|---------|----------|----------------|
| 1     | 11.02    | 10  | 5.2     | 1.92     | 0.672          |
| 2     | 21.90    | 10  | 5.7     | 1.72     | 0.058          |
| 3     | 32.51    | 10  | 6.0     | 1.66     | 0.012          |
| 4     | 42.05    | 10  | 6.3     | 1.58     | 0.092          |
| 5     | 52.86    | 10  | 6.8     | 1.47     | 0.202          |
|       |          |     |         | $\bar{f} = 1.672$ | $\bar{\varepsilon} = 0.1224$ |

Relative error = $\frac{\varepsilon}{\bar{f}} \times 100\% = 7.3\%$

Based on table 2, the average natural vibration frequency value is 1.672 Hz with a relative error of 7.3%. Thus the accuracy of the spring oscillator practicum tool to calculate the natural frequency reached 92.7%.

Figure 3. Graph display of the relation of spring deviation to time
Figure 3 is a graph of the relationship of deviation (x) to time (t) which can be used to calculate the amount of amplitude that produces objects with a certain mass (40 grams) when exerted external force (vibrator). The vibrator frequency is set close to the natural frequency of the system.

| Trial | Vibrator Frequency (Hz) | Amplitude (cm) | Period (s) |
|-------|-------------------------|----------------|------------|
| 1     | 1.600                   | 1.3            | 0.63       |
| 2     | 1.620                   | 2.4            | 0.62       |
| 3     | 1.630                   | 3.5            | 0.61       |
| 4     | 1.640                   | 3.9            | 0.61       |
| 5     | 1.650                   | 4.4            | 0.61       |
| 6     | 1.660                   | 4.4            | 0.60       |
| 7     | 1.670                   | 4.8            | 0.59       |
| 8     | 1.680                   | 3.4            | 0.6        |
| 9     | 1.690                   | 2.4            | 0.6        |
| 10    | 1.700                   | 1.6            | 0.59       |
| 11    | 1.720                   | 1.2            | 0.58       |

Table 3 shows that the vibrator frequency 1.67 obtained a maximum amplitude of 4.8 cm with a vibration period of 0.59 s. The results of the development of the spring oscillator practicum tool can be seen there is a figure 2.

The feasibility test practicum tool is carried out by the media expert validator in table 4.

| No | Assessment Aspect | Percentage (%) | Interpretation |
|----|-------------------|----------------|----------------|
| 1  | Use               | 100            | Good           |
| 2  | Stability         | 75             | Good enough    |
| 3  | Legibility        | 83.3           | Good           |
| 4  | Effectiveness     | 87.5           | Good           |
| 5  | Design            | 75             | Good enough    |

Average Percentage 85.16 Good

Based on the table of the five aspects of media expert evaluation, each aspect gained 100% usefulness with good interpretation, 75% stability aspect with quite good interpretation, readability aspect 83.3% with good interpretation, effectiveness aspect 87.5% with good interpretation and design aspect 75% with pretty good interpretations.

Table 5. Test results of materials experts trials

| No | Assessment Aspects    | Percentage (%) | Interpretation |
|----|-----------------------|----------------|----------------|
| 1  | Content Suitability   | 93.75          | Good           |
| 2  | Concept Resolution    | 88.8           | Good           |
| 3  | Accuracy              | 91.65          | Good           |

Average Percentage 90.04 Good

Based on the table of the three aspects of material expert judgment, 93.75% of aspects of usefulness were obtained with good interpretation, 88.8% of stability was quite good, interpretation was 91.65% with good interpretation.

4. Conclusion

Conclusion should be written carefully. Based on the results of research and discussion that has been presented, it can be concluded that: (1) the spring oscillator practicum tools developed are suitable for use in learning media; (2). The experimental results of measuring the spring constant get an average...
value of 6.527 N/m. The second experiment obtained an average value of the natural frequency of the system at 1.672 Hz. The third experiment obtained a maximum amplitude value of 4.8 cm and a period of 0.59 s.

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