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Development of Student Worksheet Discovery Model Based on Video Logger Pro Analysis to Improve Problem-Solving Skills of Physics Teacher Candidates

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Abstract: Students are less active in learning, lack motivation, textbooks are full of mathematical equations without detailed explanations, and use conventional methods. LKS can be used as an alternative medium to improve problem-solving skills. This study aims to develop pro video logger-based worksheets based on the guided discovery that is valid and effective to improve problem-solving for prospective physics teachers. The research method used is ADDIE. The research subjects were 36 mechanical engineering students. The research instrument used was a validation sheet and a test instrument for problem-solving skills. LKS is feasible to use if it is valid in the category of high validity and reliability, there are significant differences in the pretest and posttest, and the increase in problem-solving skills in the medium N-gain test category is minimal. The results showed that the LKS is valid with an average validity of 0.88 with a high validity category, the value of $R = 0.752 > 0.70$ means reliable, the Wilcoxon equation. Sig. = 0.000 <0.05, meaning that there is a significant difference pretest and posttest, and the average N-gain = 0.64 in the medium category, minimum and maximum N-gain = 0.087 and 0.640.

Keywords: Physics teacher; Problem-solving; Student worksheet; Video logger pro analysis

Introduction

In the 21st-century, graduates of higher education who can compete in the world of work can think critically, creatively, and innovatively and have problem-solving abilities (Amran et al., 2019). Meanwhile, individual creativity depends on knowledge and problem-solving abilities (Wrahatnolo & Munoto, 2018). The quality of a country's human resources is determined by the community's ability to solve problems (Piwowar-Sulej, 2021). Thus, the ability to solve problems is a determinant of an individual ability to compete in the world of work.

Factors causing low problem-solving abilities include: students are less active in learning (Bahtiar et al., 2022), lack of motivation (Kurniawan et al., 2019), textbooks full of mathematical equations without detailed explanations (Argaw et al., 2017) and conventional methods are used by lecturers in learning (Zakirman et al., 2019).

The findings from observations of physics learning by researchers at the SoE Education Institute are that lecturers still use conventional learning methods, and practicum is used as a means of proving the theory, not as a medium to facilitate students' understanding of theory, students' ability to solve problems is still low. As a result, the goal of learning physics to produce human resources capable of using knowledge and skills to solve complex problems in everyday life has not been optimally achieved (Laila & Asrizal, 2021).

Solutions to increase student-solving skills are carried out with innovative learning methods and media one method is guided discovery. The guided discovery method is proven to improve problem-solving abilities (Hulukati et al., 2018), critical thinking skills, creative thinking skill, video-assisted guided discovery improves problem-solving abilities (Setiyani et al., 2019).

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Technological developments provide various conveniences for integrating video analysis software, for example, tracker and logger pro as media for physics practicum (Kumaş, 2021). Video analysis tracker and logger pro is software used to analyze object motion in real phenomena, presented in the form of images, graphs, and tables. Several studies that have been carried out include determining the acceleration of gravity through the free fall of shoes and coins (Yoshida & Murao, 2022). determining the terminal velocity of objects falling in fluids, determining the acceleration of gravity through parabolic motion analyzing the motion of objects moving in the air, and in fluids (Yuningsih & Sardjito, 2021).

Video analysis is effectively used in learning to improve student competence. For example, the use of a video analysis tracker improves the 21st-century skills of junior high school students (Artiningsih & Nurohman, 2020) and stimulates students' curiosity. Implementation of video analysis-based learning gets a positive response from students because it stimulates activity and increases the ability of students to think (Lestari et al., 2021). Based on the above studies, this study aims to produce guided discovery model student worksheets based on video analysis to improve students' problem-solving skills in physics education, which has not been done before.

Method

The research method used is the ADDIE model (Analysis, Design, Development, Implementation, Evaluation) (Almomen et al., 2016) mode research and development method. At the analysis stage, an analysis of student characteristics and an analysis of the curriculum needed in the preparation of student worksheets were carried out. In the design phase, a worksheet design was carried out using the guided discovery model based on video tracker analysis. The development stage is carried out by product validation of student worksheets. The student worksheet validators consisted of 2 media and material expert lecturers from Semarang State University. The validation is the content and construct validity of student worksheets. At the implementation stage, a test was carried out to determine the effectiveness of student worksheets to improve problem-solving skills. The research design at the implementation stage is a one-group pretest-posttest design. At the evaluation stage, an evaluation was carried out on the results of the pretest and posttest as well as student responses to the use of student worksheets. Student response data is intended to determine the practicality of using student worksheets.

The instruments used in this study were validation sheets, student response sheets, and problem-solving questions (Salsabila & Suyono, 2021). Data analysis on student characteristics and curriculum analysis with qualitative descriptive. Analysis of the validation results used a formula 1.

$$V = \frac{\sum s}{n(c-1)} \tag{1}$$

V = rater agreement index.
s = the score assigned by each rater minus the lowest score in the category.
n = a number of raters.
c = the number of categories chosen by the expert.

Interpretation of validation data, namely low validity (< 0.40), moderate validity (0.40 – 0.80), and high validity (0.80) (Chu et al., 2015). The reliability of learning devices is based on the percentage of agreement by experts using the formula 2:

$$R = \left[1 - \frac{A-B}{A+B}\right] x\ 100\% \tag{2}$$

Information:
A = The aspect frequency observed by the observer giving the highest frequency.
B = The aspect frequency observed by the observer giving the lowest frequency.

The results of instrument validation are said to be reliable if R ≥ 75% (Taherdoost, 2016). Data analysis on improving problem-solving skills used parametric statistical tests paired with sample t-tests if the normality conditions were met (Lespita et al., 2023). If not used a nonparametric statistical test Wilcoxon test. The purpose of this data analysis is to find out whether there are significant differences in problem-solving skills before and after the implementation of student worksheets. The problem-solving skills improvement test uses the normalized n-gain test with the formula 3:

$$n - gain = \frac{< Spost > - < Spre >}{100 - < Spre >} \tag{3}$$

Categories of increasing problem-solving skills are low (< 0.30), moderate (0.3 < n-gain < 0.70), and high (> 0.70). Analysis of student response data used the formula 4.

$$p = \frac{gain\ score}{maximum\ score} x\ 100\% \tag{4}$$

p = percentage response

Interpretation of student responses to find out practicality, namely less practical (< 40%), moderate (40%-80%), and very practical (> 80%). Criteria for drawing conclusions about the effectiveness of worksheets to improve problem-solving skills, namely worksheets declared valid in the category of high and reliable validity, there are significant differences in pretest and posttest, as well as an increase in problem-solving skills at least in the medium category.

Result and Discussion

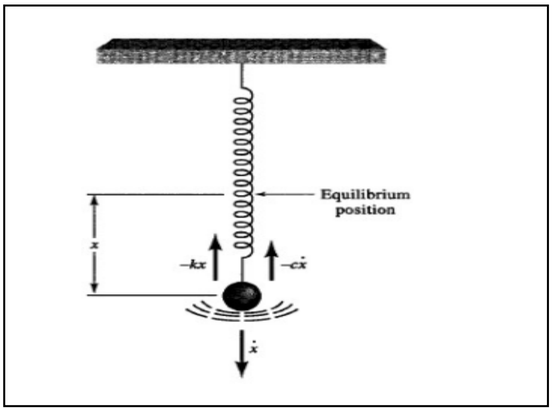
The results of the initial analysis of the implementation of learning in the physics education study program found that there was no availability of learning media, students had difficulty solving physics questions, semester exam results were still low, did not achieve course learning outcomes, laboratory equipment was still minimal, the utilization of computer equipment, the software had not been optimal. in supporting the implementation of learning. Based on this initial analysis, one practicum has been identified, namely simple harmonic vibration and damped vibration using video logger pro analysis software. Student worksheets have been designed to facilitate learning on the simple harmonic vibration material of mass-spring systems and damped vibrations. Figure 1 shows an example of the contents of a student worksheet that has been developed.

EXPERIMENT 2
VIBRATION AND DAMAGE

Experiment Objectives
-Shows the decrease in amplitude over time as an exponential function
-Determine the damping coefficient
-Determining the fractional energy dissipation as an indicator of the quality of damped vibrations

Figure 1. Experiment title and purpose

A. Basic Theory
In all actual oscillatory motion sthere is mechanical energy dissipated due to the influence of frictional forces. Example: a spring that stops oscillating under the influence of damping. So, if there is oscillatory motion energy decreases with time it is called damped. Look at Figure 1.



The damped oscillator

In a damped oscillator the damping force is less proportional to the speed of the object but in the opposite direction. The damping force equation is:

Fd = -bv

b is a constant which states the amount of damping, Fd is the damping force which is always opposite to the direction of movement. So, the work given is not always conservative so that the mechanical energy of the system is reduced.

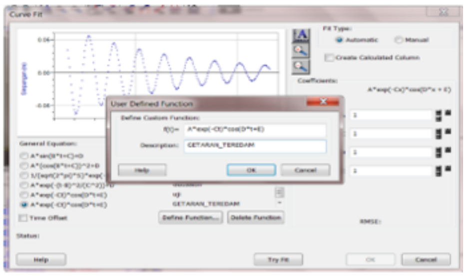
Figure 2. Basic theory

B. Tools and materials used
1) Digital balance: 1 unit
2) Spiral spring 15 cm: 1 unit
3) Mass load: 250 grams
4) Statif wood: 1 unit
5) Measuring Cup 500 ml: 1 unit
6) Water: 500 ml
7) Laptop with LOGGER PRO@ software installed: 1 unit
8) Canon ixus digital camera: 1 unit

C. Work procedures
1) Arrange the equipment as shown in Figure 3.
2) Fill the measuring cup with 500 ml of water.
3) Hang the load on the spring and then swing it above the surface of the water and release it without initial speed.
4) Record the vibrations simultaneously using the camera's video facility until the vibrations stop.
5) Copy of recorded results in Laptop for analysis.

Figure 3. Tools and Work Procedures

D. Video analysis techniques and LOGGER Pro@
1) Open the LOGGER Pro@ program
2) Open the video file using the LOGGER Pro@ software, click insert-select movie-select the video to be analyzed-click Open
3) Start the analysis using the video analysis steps and LOGGER Pro@.
4) To do data fitting, click curve fit-make a definition using the following steps: click curve fit – select define function-input defines function A*exp(Ct)*cos (D*t+E)-OK-try fit-OK



5) Draw a graph of energy loss as a function of time: Click data, select new calculated column, fill in the dialog box.

Figure 4. Data analysis technique

The results of material and media expert validation of student worksheets are shown in table 1.

Table 1. Media validation results

Rated Aspect	Validator		V	Conclusion
	1	2		
Instruction	5	4	0.88	HT
Content	4.5	5	0.94	HT
Language	4	5	0.88	HT

VT = High Validity

Table 1 shows the results of the validator's assessment on the aspect of the instructions stated at 0.88 in the high validity category, meaning that the instructions on the student worksheet are clear. In the content aspect, it is stated that 0.94 is in the high validity category, meaning that the worksheet is in accordance with the learning objectives, the time allocation is in accordance with the demands of the task, the student worksheet encourages students to master the concepts of simple harmonic vibrations and damped vibrations and the sheet is suitable for improving problem-solving skills, aspects language stated 0.88 categories of high validity means that the language used according to enhanced spelling, easy to understand organized and systematic. Thus, the average validity of student worksheets is 0.90 in the high validity category. The reliability of student worksheets based on the percentage of agreement is 0.752, meaning that student worksheets are reliable. Thus, the developed student worksheets are valid and reliable.

The problem-solving test instrument was tried out on 25 students, not research subjects. The test results obtained 9 numbers of problem-solving questions obtained 7 valid question numbers with a validity value of > 0.70, and the reliability value with the Cronbach alpha test of 0.825 was declared reliable. The discriminating power is 7 items of good problem solving with a level of difficulty of 2 easy item numbers, 3 medium item numbers, and 2 difficult item numbers. At the implementation stage, students learn to use student worksheets. Before the implementation of learning students are given a pretest, after learning using worksheets students are given a posttest. The results of the pretest and posttest analysis are presented in Table 2.

Table 2. Descriptive test pretest and posttest

	Mean	N	Standard deviation
Pretest	8.1667	36	3.59762
Posttest	66.8611	36	20.92866

Table 3. Normality test

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
'retest	0.185	36	0.003	0.930	36	0.024
'ostest	0.182	36	0.004	0.940	36	0.050

a. Lilliefors significance correction

Based on Table 2, the sig. pretest = 0.024 < 0.05 and sig. posttest = 0.05 = 0.05, which means the pretest and posttest data are not normally distributed. This means that the parametric statistical test is not used. The nonparametric statistical test used is the Wilcoxon test.

Table 4. Wilcoxon test ranks

		N	Mean Rank	Sum of Ranks
Postest-Pretest	Negative Ranks	0[a]	0.00	0.00
	Positive Ranks	36[b]	18.50	666.00
	Ties	0[c]		
	Total	36		

a. Postest < Pretest
b. Postest > Pretest
c. Postest = Pretest

Based on Table 4, Negative ranks at N = 0, Mean rank = 0.00, Sumn of rank = 0.00 means that there is no sample data that there is a decrease from pretest to posttest Positive ranks at N = 36, meaning that from 36 data samples, there was an increase from pretest to posttest with an average increase of 18.50 and a positive sum rank = 666.000. Ties at N = 0 mean that there is no same value between the pretest and posttest.

Table 5. Wicoxon test

	Postest - Pretest
Z	-5.233[b]
Asymp. Sig. (2-tailed)	.000

b. Based on negative ranks

Based on Table 5, Asymp. Sig. (2-tailed) = 0.000 < 0.05 means that there is a significant difference in problem-solving skills between the pretest and posttest. This means that there is an influence of the guided discovery model assisted by video logger pro analysis on increasing the problem-solving abilities of physical teacher candidates.

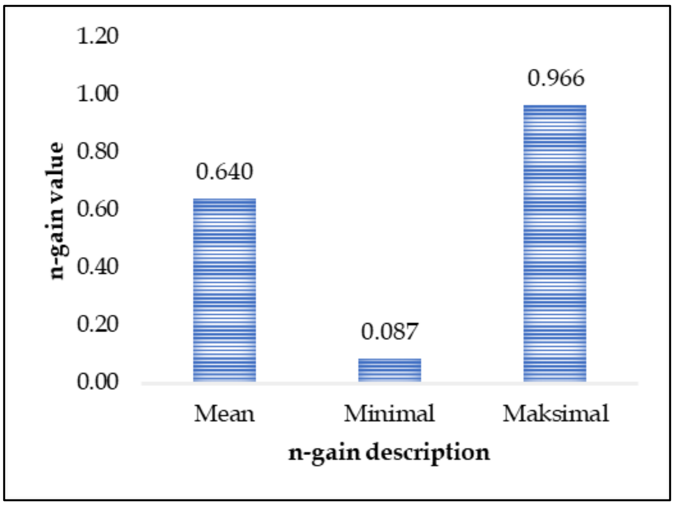


Figure 5. N-gain chart

Based on Figure 5, the increase in student problem solving skills with an average N-gain = 0.64, in the medium category with a minimum N-gain = 0.087 and a maximum N-gain of 0.966. The guided discovery learning model based on video analysis is effective in increasing the problem-solving abilities of prospective physics teacher students. This is because students are faced with real problems that make them curious and think about solving problems. In this model, students are given the opportunity to interact and collaborate with fellow students and lecturers during the experimental process (Tong et al., 2022). Student worksheets with the guided discovery learning model help students to remember formulas and their applications for solving simple harmonic vibration problems and damped vibrations (Windari et al., 2018).

The student worksheet contains the theoretical basis to help students to do data fitting on the pro logger based on video analysis of real phenomena of spring-mass system vibrations in air and spring-mass system vibrations in the water (Bakri et al., 2020). Students are motivated to identify variables, collect data, analyze data, and conclude. Providing a stimulus in the form of a real phenomenon that is deliberately engineered by the lecturer increases students' motivation to think creatively to find solutions to the problems posed (Safira et al., 2021), learning through the process of discovery increases reasoning, independent thinking and cognitive abilities needed in problem-solving (Darling-Hammond et al., 2020).

Conclusion

Based on the results of the study it was concluded that the guided discovery model student worksheets based on video logger pro analysis were stated to be valid and reliable, effectively increasing the problem-solving abilities of prospective physics teacher students. therefore, it is suggested that this student worksheet can be used as an alternative medium to improve problem solving abilities. Further research is needed to assess the effectiveness of this student worksheet with a wider sample.

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