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Effectiveness of Physics Mobile Learning Media to Improve Higher Order Thinking Skills of Students in Thermodynamics

S Agustihana[1] and Suparno[2]

[1]Postgraduates Student of Physics Education, Yogyakarta State University, Indonesia
[2]Department of Physics, Yogyakarta State University, Indonesia

[1]Corresponding author's email: seftyanestmoa1@gmail.com

Abstract. This study aims to produce Physics Mobile Learning Media (PMLM) in thermodynamics, and know the effectiveness of PMLM to improve HOTS. The development of PMLM is based on modified Borg and Gall models. The effect of using PMLM is known by examining experiment and control classes. Based on the results of the research, it was found that PMLM developed feasible to be used with the average score of 3.66 from the experts and 3.24 of the students' response, with very good category. The effect of implementation based on gain score for HOTS, it was found that experimental class 0.53 with medium category and control class 0.35 with medium category. ANOVA test showed that the data came from normally distributed and homogeneous populations, and there was a difference in effectiveness on the average HOTS between students taught with PMLM thermodynamic material and students taught as usual, with sig. (2-tailed) 0.00 <0.05. The results of this study, then used as a reference for teachers, to implement learning with technology-based media structured to improve HOTS of students.

1. Introduction

Physics is the basic science for technology development [1]. Therefore, physics learning is pivotal and requires Higher Order Thinking Skills (HOTS), an ability to analyse, evaluate, and create [2]. In school practice, the physics learning focuses on cognitive competence that encompasses analysing the concepts, principles, laws, and application of metacognition for problem solving, as well as attitude and psychomotor competence [3]. This cognitive competence of physics learning is in line with the nature HOTS so that it is inferred that the physics learning in school is an avenue to increase the students' HOTS. It is because less developed HOTS in learning can affect all aspects of knowledge.

High-level thinking associated with the process includes conceptual understanding, systematic thinking, problem solving, and critical thinking [4]. These processes are formed on an ongoing basis, ultimately to achieve HOTS in the individual. Therefore, HOTS must be trained against the learners [5]. Teachers can therefore train the HOTS to learners using appropriate media, methods, and approaches in learning [6] [7].

Over time, the learning media continues to grow not only print media, but also digital media. The use of digital media in learning called as digital learning. Implementation of the digital learning becomes a source of knowledge information that is structured [8]. Digital learning carries out mobile-based learning [9]. Mobile learning has the accessibility and portability that can support the learning process of learners [10] [11]. Mobile learning can increase learning motivation, reduce misconception and accelerate the learning process, because it is interactive [12] [13].

Mobile has several types, both computer and smartphone. In Indonesia, the use of computer as a medium in the implementation of national examination is being intensively implemented. It is therefore a student is required to have hard skill and soft skills and thus the application of the digital learning is one way to train the soft skills to students. The application of computer-based modules developed based on the concept of scaffolding improves learning satisfaction and learning achievement of learners [14]. The use of computers in learning will help learners not to stutter in the face of computer-based exams.

The media developed by researcher is Physics Mobile Learning Media (PMLM). The PMLM is accessed using computer and offline. The PMLM takes the topic of thermodynamic. In learning thermodynamics, learners must be able to build their own knowledge through exploration, concept recognition, and concept applications. This material is chosen because there has not been much educational research focusing on the laws of thermodynamics and the conception of low-learner in this material [15].

PMLM is developed based on an interactive concept of physics that includes material, exercise, and evaluation questions, which will be implemented using a scaffolding approach. In the material section, it will be explained the contents of the material either through pictures, graphics, animation or verbal explanation. In addition, it is equipped with applications in everyday life and the application of concepts in mathematical calculations. Problem exercises consist of increasing cognitive domains ranging from analysing, evaluating, and creating (students learn from friends as well as from other references, without teacher guidance). The quiz also covers the HOTS cognitive domain, in the form of a closed-ended, dual-choice option where students work independently. Learning is emphasized on the psychomotor, affective, and cognitive aspects that focus on increasing HOTS high school students.

2. Research Methods

This study was conducted on the even semester of the academic year of 2017/2018 on thermodynamic material. The product of this study was in the form of interactive media to increase HOTS of learners. PMLM was accessed offline using a computer, as a result of a first year research. The development model used was a modified development model of Borg and Gall. The twelve stages used was, (1) gathering information, (2) designing the research, (3) developing the initial product form (initial PMLM draft), (4) validating the product by the expert, (5) revising the main product (revision 1), (6) performing the limited trial, (7) revision 2, (8) performing the operational trial, (9) revision 3, (10) final product finalization of PMLM, (11) product and publication reviews, (12) disseminate the product.

The design used in the research is one group pretest-posttest design for limited test, and control group pretest-posttest design for wide test. In this study involves two variables, namely independent variables, and dependent variables. The independent variable of this research is instructional media, while the dependent variable is high-order thinking / HOTS. HOTS students in this study include the ability to analyze, evaluate, and create.

Population in this research is all student of class XI-Science Senior High School (SHS) in Nganjuk district, in even semester of academic year 2017/2018. The sample was determined by simple random sampling. A limited trial was conducted at Senior State High School 1 Rejoso with 34 students of grade XI Science-4. Extensive trials were conducted on XI Science student in three schools, including Senior State High School 1 Pace, Senior State High School 2 Nganjuk, and Senior State High School 3 Nganjuk. The sample research is assumed if students have the same cognitive abilities based on the physics values obtained previously.

Instruments used in the research are PMLM and the question to measure HOTS students. The PMLM is composed of thermodynamics material. The content of PMLM is an explanation of concepts, simulations, sample questions, problem exercises, and evaluations. The question to measure students HOTS in the form of multiple choices is groundless, which have of 20 questions. The questions using the cognitive domain of analyzing, evaluating, and creating. In addition, the process of learning is observed by using the observation sheet of the implementation of learning. Students respond the PMLM by through a student response questionnaire. The instrument has passed the validation by the expert (3 lecturers and 4 physics teachers).

Expert validation results determined the average score, and then converted qualitatively. Instruments named valid and viable if at least good category. The empirical test result of HOTS is processed by using Quest program to determine validity and reliability. The result of the questionnaire of student response to PMLM scaffolding approach and learning is determined by the average score which then converted qualitatively. Increased HOTS of students is determined by Gain score adapted [16]. Here is a formulation to determine the Gain Score (Equation 1). With S_{post} is the posttest score, S_{pre} is the pretest score, and S_{max} is the maximum score of 80.

$$N - gain = \frac{S_{post} - S_{pre}}{S_{max} - S_{pre}} \quad (1)$$

The classification of students' HOTS results is interpreted from the N-gain results obtained by categories such as Table 1.

Table 1. Classification of gain score

Interval	Category
(g) ≥ 0,7	High
0,3 ≥ (g) <0,7	Medium
(g) < 0,3	Low

Data analysis used in this research is the descriptive statistic and inferential statistic. Descriptive statistics were determined by calculating the highest score, the lowest score, the average score, the standard deviation and the average N-gain. The type of statistics inferential statistics used is parametric. Therefore conducted a test of the hypothesis. Test hypotheses in ANOVA test research. Before the test the hypothesis, the test specified prerequisites i.e. the test of normality (the data come from a population that is Gaussian if sig. > 0.05) and test its homogeneity (the data come from a homogeneous population if sig. > 0.05). ANOVA hypothesis test determined the next, which is the utilization of PMLM influence on the increase of students on the material thermodynamics HOTS if Sig. < 0.05.

3. Results and discussion

The instrument used in the study has passed the expert validation stage and is declared eligible for research use. Expert validation consists of 3 lecturers and 4 physics teachers. The PMLM expert's validation results with an average score of 3.66 and a matter of HOTS with an average score of 3.61 is valid (Table 2).

Table 2. Expert's validation results

Instrument	Average Score	Category
PMLM	3.66	Valid
Question of HOTS	3.61	Valid

The empirical test result of HOTS is processed by using Quest program. Problems tested there are two types of types A and B. Each type consists of 20 questions. All tested questions are valid with INFIT MNSQ 0.77-1.33 (Table 3), so it can be used for research. In addition to validity, reliability results indicate that the problem is very reliable, and the personal reliability of the category is quite reliable (Table 4).

Table 3. Empirical Validation Results

Item	Type A			Type B		
	INFIT MNSQ	**Interpretation**	**Result**	**INFIT MNSQ**	**Interpretation**	**Result**
1	1.07	Fit	Valid	1.11	Fit	Valid
2	0.99	Fit	Valid	0.92	Fit	Valid
3	0.96	Fit	Valid	1.00	Fit	Valid
4	1.06	Fit	Valid	1.04	Fit	Valid
5	0.85	Fit	Valid	1.00	Fit	Valid
6	1.10	Fit	Valid	1.00	Fit	Valid
7	0.96	Fit	Valid	0.98	Fit	Valid
8	0.87	Fit	Valid	0.98	Fit	Valid
9	1.03	Fit	Valid	0.93	Fit	Valid
10	1.03	Fit	Valid	1.06	Fit	Valid
11	0.96	Fit	Valid	0.85	Fit	Valid
12	1.06	Fit	Valid	1.10	Fit	Valid
13	1.11	Fit	Valid	0.96	Fit	Valid
14	0.92	Fit	Valid	0.87	Fit	Valid
15	1.00	Fit	Valid	1.07	Fit	Valid
16	1.04	Fit	Valid	0.99	Fit	Valid
17	1.00	Fit	Valid	0.96	Fit	Valid
18	0.98	Fit	Valid	0.92	Fit	Valid
19	0.98	Fit	Valid	1.00	Fit	Valid
20	0.93	Fit	Valid	1.04	Fit	Valid

Table 4. Empirical Reliability Results

Type	**Reliability**	**Result**	**Category**
A	Item	0.89	Very reliable
	Person	0.56	Quite reliable
B	Item	0.85	Very reliable
	Person	0.48	Quite reliable

The feasibility of the PMLM developed, aside from the expert is also known based on the student's response in the experimental class, as a class imposed by PMLM in learning. The responded PMLM aspects include the use of letters, constructs, languages, and drawings (Table 5). The display of same page PMLM is showed by Figure 1.

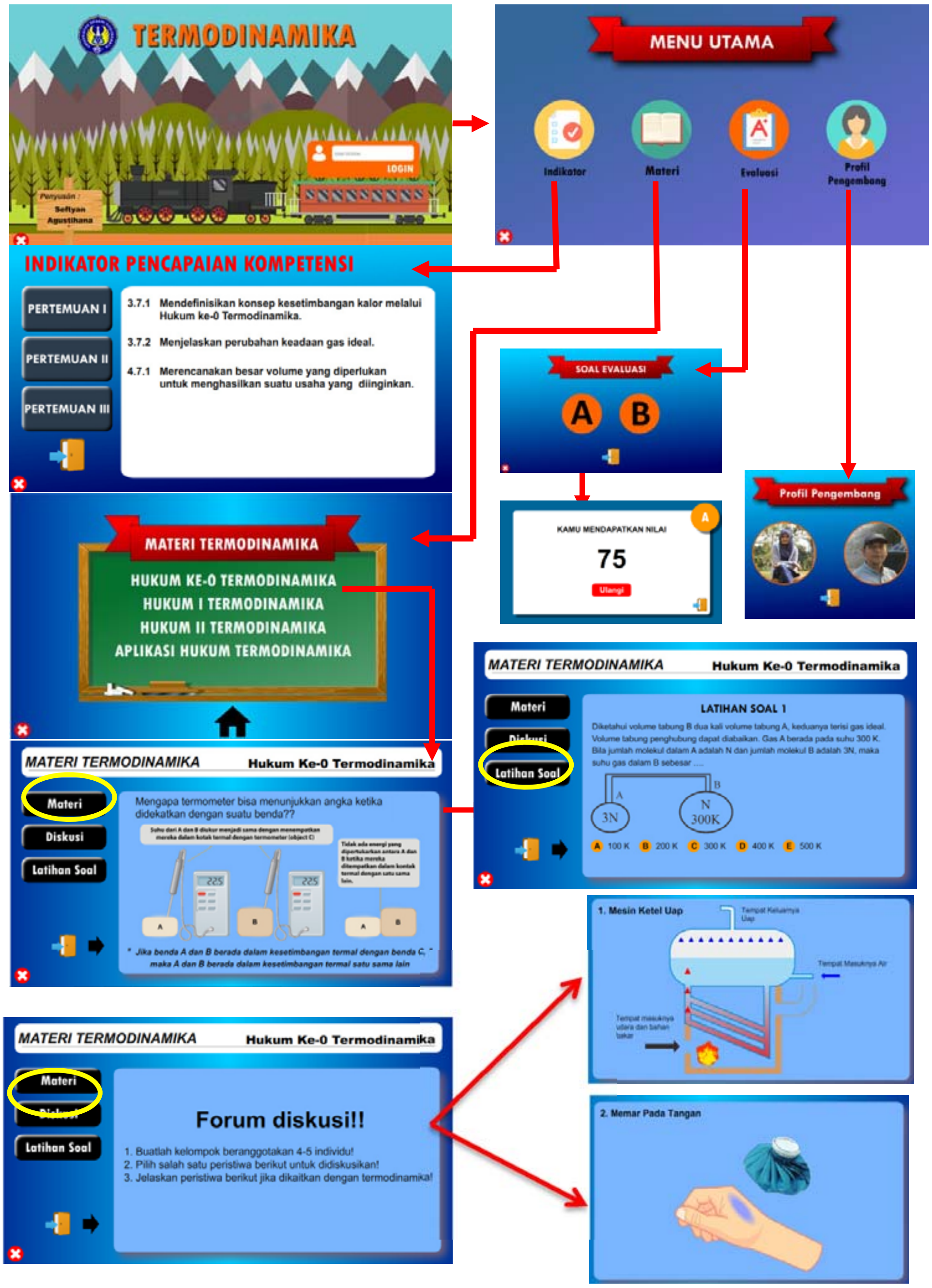

Figure 1. The display of same page PMLM

The developed PMLM is declared feasible if it meets the minimum category either. The assessed aspects of PMLM include the use of letters, constructs, languages, and images. The use of letters relates to the media display. Non-boring media can motivate student learning [12]. Media construction is related to the menu or submenu of the material, and ease of operation. Media is said to be good if its constructs are structured [8]. Language is related to the communicative formulation of sentences in the media. Communicative language becomes the basis for the media to be interactive

[17]. Images not only transform the media into interactive but are able to provide more understanding to the students.

Table 5. Student's response results

Aspect	Average Score	Category
Letters	3,20	Good
Constructs	3,28	Good
Languages	3,17	Good
Drawings	3,32	Good

Eligibility is obtained from media experts, then from students as PMLM user respondents. The average score of experts of 3.66, including valid category (Table 2). Student response to PMLM provides an excellent assessment of all aspects (Table 5). Aspects of the use of letters include the suitability of letter use, letter size, and legibility in the sentence got the average score of 3.20 (Table 5). This indicates that the media display is well read by the students. Aspects of construction include the suitability of the menu with the content, background with writing, the completeness of the menu button, and ease of operation got the average score of 3.28. Aspects of language include language, communicative, and easy to understand comprehension got the average score of 3.17. Aspects of the image include the suitability of the image with the concept, interesting, increase curiosity, and in accordance with life got the average score of 3.32. Based on the assessment by the expert as well as the student response, it provides an excellent rating category on all aspects of PMLM. Therefore, the PMLM of thermodynamic material is feasible to use with an average score of experts and a student response of 3.24.

HOTS data is obtained from the activity pretest-posttest. Pretest-posttest data HOTS experiment class and control classes are then processed to getting n-gain. Description the pretest-posttest results are presented in Table 6. Average descriptions n-gain of experiment class and control class in the form of bar charts are presented in Figure 1.

Table 6. A Summary of HOTS pretest and posttest values

Class		Highest Score	Lowest Score	Average Score	Standard Deviation	Average n-gain
Experiment	Pretest	46.00	28.00	33.23	0.81	0.53
	Posttest	65.00	48.00	55.60		
Control	Pretest	46.00	29.00	33.66	0.89	0.35
	Posttest	67.00	37.00	50.44		

Furthermore, for HOTS increase is calculated using Gain score. HOTS increments in experimental and control class are different. There is an increase in HOTS in each lesson, both in the control class and the experimental class. The Gain score on the control class is 0.35 and the experimental class is 0.53 (Figure 2). Gain scores in both classes are moderate. However, for the experimental class, it gives a larger score than the control class. This indicates that the use of PMLM scaffolding approach has a significant effect on students' HOTS improvement. An interactive media can improve learning motivation, and this affects the students' cognitive abilities [18]. Cognitive ability, in this case, is HOTS. In addition, the use of media combined with the appropriate approach becomes one way to achieve the learning objectives [19]. The PMLM combined with the scaffolding approach becomes an appropriate blend to improve HOTS, as one of the learning abilities developed in the 21st century.

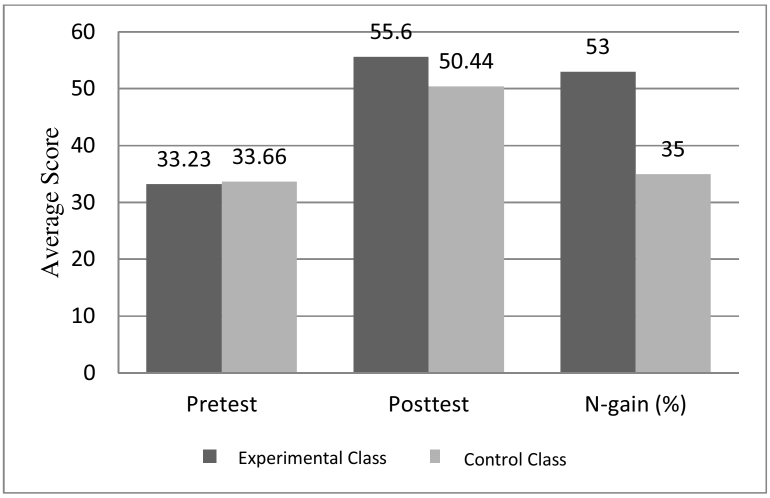

Figure 2. Gain Score from Experimental and Control Class

The prerequisite analysis test is performed against the n-gain value to know normality and homogeneity of data used before the test hypothesis. Normality test using test Kolmogorov-Smirnov, while homogeneity test use Levene test with data processing program. Summary of results the normality test is presented in Table 7. Based on normality test results, n-gain data from each of the three schools meet the normal distribution criteria so the homogeneity assumption test is continued. A summary of homogeneity test results is presented in Table 8.

Table 7. Normality test results

Class	Sig. Value	Decision
Experiment	.200	Normal distribution
Control	.200	Normal distribution

Table 8. Homogeneity Test Results

Levene Statistic	Sig. Value	Decision
0,269	0,605	Homogeny

The summary of hypothesis test results is presented in Table 9. Based on Table 9, it can be seen that different test results in all sample schools have a significance value smaller than α. Therefore, Ho is rejected. The condition means that by using α of 0.05, it can be concluded, the achievement of HOTS of students who received learning of thermodynamic material by using PMLM was significantly higher than that of students who received thermodynamic learning with print media.

Table 9. Hypothesis test results

F Value	Sig. Value	Decision
0,209	0,000	Different

HOTS differences between the experimental and control groups indicate that HOTS improvements can be made using PMLM. Coaching HOTS students in learning will familiarize students in using his reasoning to get used to analyzing, evaluating, and creating. This condition is in accordance with previous research, which states that there is an influence of learning habits of learning outcomes [20]. The learning outcomes show how much students' ability t solve the problem, which indicates the student's HOTS level [21]. Train deep HOTS this study is a treatment given to the experimental class.

4. Conclusion

Based on the results of research and discussion, it can be concluded the feasibility and effectiveness of PMLM material thermodynamics are able to increase HOTS of high school students. The developed PMLM is feasible to be used with a 3.66 average score of experts and 3.24 of the students' responses, in "good" category. Besides, the effectiveness of HOTS, it is found that experimental class gains 0.53 meaning "medium" category while control class obtains 0.35 meaning "medium" category. ANOVA test shows that the data is normal in sig. (2-tailed) > 0.05 and homogeneous, and there is a difference in effectiveness HOTS of between students taught using PMLM thermodynamic material and students taught as usual, shown by sig. (2-tailed) 0.00 <0.05.

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