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Research Article

Development of Android-Based Interactive Physics Mobile Learning Media (IPMLM) with Scaffolding Learning Approach to Improve HOTS of High School Students[1]

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Abstract

The objectives of this study are to: a) Produce an Android-based Interactive Physics Mobile Learning Media (IPMLM) that is eligible for improving Higher-order Thinking Skills (HOTS) of high school students; b) Determine the effectiveness of the use of Android-based interactive physics mobile learning media with a scaffolding learning approach in improving Higher-order Thinking Skills (HOTS) for high school students. The research subjects were 1070 high school students in five regencies/cities. The technique of analyzing the data of empirical test questions used item response theory analysis by looking at the compatibility of items with the model based on the INFIT MNSQ (infit mean square) value. Extensive test data were analyzed with descriptive statistics and inferential statistics. Inferential statistics were performed using the ANOVA mixed design test with a significance level of $\alpha = 0.05$. The results show that a) Android-based interactive physics mobile learning media applications and learning devices are appropriate to be used to improve higher-order thinking skills; b) the use of android-based interactive physics mobile learning media (IPMLM) with an effective scaffolding learning approach in improving higher-order thinking skills. The effective contribution of the experimental group in increasing the ability of HOTS is 84.80%. The effective contribution of the control group that uses learning tools with the direct learning assisted by Physics textbooks in increasing HOTS ability is 55.50%.

Keywords:

android-based interactive physics mobile learning media (IPMLM), higher order thinking skills, scaffolding learning approach

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Introduction

The 21st-century learning paradigm demands some skills that must be owned by students to work and live successfully. The skills are learning and innovation skills, information skills, media, and technology as well as life and career skills. Learning and innovation skills include critical thinking skills, problem-solving skills, communication, collaboration skills (Trilling & Fadel, 2009, p.49; Saputri & Wilujeng, 2017, p.730). The new world of work demands a higher level of thinking and complex communication. The competencies are basic competency that a gifted young scientist has. Gifted students are individuals who can utilize their higher order thinking skills at a highly capable level (Schreglmann & Kanatlı Öztürk, 2018, p.2).

The 2013 curriculum has tried to answer the demands of 21st-century competence. The competencies demanded the 2013 Curriculum are stated in Minister of Education and Culture Regulation Republic of Indonesia No 21 of 2016 concerning basic and secondary education content standards. The ministerial regulation states that through Physics learning, high school students must be able to analyze concepts, design or modify projects, create simple products, design experiments, carry out experiments, present experimental results in the form of tables and graphs, concluding, and reporting the results of experiments. These competencies are included in the high-level cognitive domain. Besides the learning domain, the ability to use information, media and technology is also one of the core tools in the 21st-century skill theme. Thus, to meet these demands Physics learning also needs to be integrated with media and technology.

Physics is one branch of science that is classified as the most fundamental physical knowledge and it is related to the basic principles of the universe (Serway, 2004, p.1). Therefore, learning Physics requires direct contact with what you want to learn (Suparno, 2007, p.12). Experience or direct observation with the five senses makes it easy for students to learn. These experiences will develop the ability of students gradually to understand abstract concepts of Physics, think logically, and even make generalizations (Mundilarto, 2002).

Gedgrave (2009, p.5) states that learning Physics must facilitate students to build their knowledge and thinking skills. The development of thinking skills occurs because Physics students find a large number of problems that allow them to think. These thinking skills will be used by students to solve physics problems. Thus, learning Physics must facilitate students to acquire these skills. But in reality, learning physics does not facilitate students to improve their thinking skills (Rofiah, Aminah, & Ekawati, 2013, p.17). The physics learning process is still centered on the teacher (Rusnayati & Prima, 2011, p. 331; Suryani, Harahap, and Sinulingga, 2017, p.88). Teachers are not creative enough and can not develop learning media based on specific instructional goals that are varied and fun for students (Mardiana & Kuswanto, 2017, p.2). Most teachers only inform how to solve physics problems using existing equations (Suryani, Harahap and Sinulingga, 2017, p.88). Informative learning models will be difficult to improve thinking skills, especially higher order thinkings of students (Mundilarto, 2007). This is proven by Trends International Mathematics and Science Study (TIMSS) research data which shows that the physics reasoning ability of Indonesian students is ranked 40 out of 42 countries studied (TIMSS & PIRLS International Study Center, 2012, p.48).

Uçar, Uçar and Çalışkan (2017, p.11) found that inadequate education systems can decrease an individual's ability to solve problems. Research conducted by Faizaha, Suparmi, and Aminah (2018, p.52) showed that students' HOTS in 11th grade of Chemistry in Sragen Regency was still in the very low category with the percentage of students who answered correctly was 19.01%. The results of the study at Madrasah Aliyah Negeri 3 Yogyakarta showed that students' critical thinking skills reached the low category (Khasanah and Prasetyo, 2018, p.447). The analysis showed that in the aspect of basic clarification there were 37.50% of students included in the low category. There were 46.88% of students reaching only very low categories in aspects of building basic skills, 56.25% reaching very low categories in aspects of advanced clarification, and 34.38% of students reaching low categories in aspects of managing strategy and tactics (Khasanah and Prasetyo, 2018, p .447). The data that have been described show that the HOTS of Indonesian students is still low and needs to be improved through suitable media, methods, and learning approaches.

The concept of physics is physical knowledge so that its learning can be supported with the help of the media. Teachers, laboratory equipment, textbooks, student worksheets are not enough to reach the skills and learning styles of each student (Collete & Chiappetta, 1994, p.288). Computer and electronic technology can involve students in various forms of science learning models that will help them process information and develop cognitive skills in a more individual way than conventional learning models (Collete & Chiappetta, 1994, p.287; Sung, Chang, & Liu, 2016, p.259). Technology media can also help students visualize abstract concepts and principles of physics (Collete & Chiappetta, 1994: 288). Other research shows that the use of smartphones can improve learners' persistence in learning, and enable students to engage in content creation and communication. By using social media (Goksu & Atici, 2013, p.692; Ahmed & Parsons, 2013, p.68). Applications on smartphones enable students to more actively discussing content with classmates and teachers, as well as allow them to collaborate (Hamdani, 2013, p.673). Media in the form of smartphone applications can also improve students' scientific characters such as curious, creative and conscientious (Fatima & Mufti, 2014, p.63). The character of science is one of the characteristics of higher-order thinking skills. The results of research that have been done show that smartphones are proven to provide students the opportunity to be active in learning.

Hamdani (2013, p.673) states that the constructivism learning approach along with the use of technology can improve higher-order thinking skills. The constructivism approach applied in research is the scaffolding approach. The scaffolding approach was developed from the Bandura modeling technique where at the beginning of learning the teacher models the skills being taught, then slowly reduces assistance as learners' skills improve (Scunk, 2012, p.246; Slavin, 2017, p.249). Research conducted by Sari, Sunyono, and Rosilawati (2017, p.31) proves that the scaffolding approach can significantly improve student learning results. Learning with an effective scaffolding approach to improve critical thinking habits, improve problem-solving skills, curiosity, and mastery of students' concepts (Susilowati, Rusdiana & Kaniawati, 2017, p.70; Amanah, Harjono, & Gunada, 2017, p.88; Saputri & Wilujeng, 2017, p.741; Chen, 2014, p.351). Even with scaffolding, participants can examine and correct misconceptions (Lin, 2015, p.17). Furthermore, scaffolding by peers can help clarify the meaning and monitor the learning process of students (Kim & Hannafin, 2011, p.272). Students can also solve quantitative problems that involve alternative concepts and can identify relevant concepts involved in problem-solving (Lin, 2015, p.17). The results of the study indicate that the scaffolding learning approach can improve students' cognitive abilities effectively. Based on empirical and theoretical studies that have been conducted before, a technology-based media was developed that can have a positive influence on learning science especially Physics and also develop children's thinking skills in accordance with the nature of Physics itself.

In accordance with the nature of physics learning and the demands of 21st-century learning, an Android-based Interactive Physics Mobile Learning Media was developed with a scaffolding learning approach to improve the HOTS of high school students.

Method

Research Model

This research was a type of Research and Development (R & D). The product developed was an android application on five subjects, they are Newton's Law of motion, work and energy, impulse and momentum, thermodynamics, and characteristics of mechanical wave. The development procedure was adapted from the 4D development model (Defining, Designing, Developing, and Disseminating) (Thiagarajan, Semmel and Semmel, 1974, p.5). The first stage of defining, it consisted of a preliminary study in the form of field observations and literature review. The second stage of designing was designing an IPMLM application. The third stage of developing was application development which consists of several steps. The initial step was the eligibility assessment of Draft 1 (initial product) by media experts and material experts. The assessment results were used to improve the application. The improvement results in the form of Draft II were then used in a limited test. Limited test results were used to improve the application and produced Draft III. Draft III was then used in learning at the broad test stage. The research design used in extensive trials was the Pretest-Posttest Control Group Design. The last stage was disseminating, the dissemination of applications and research results.

Participants

The subjects of the trial were students of X grade and XI grade of Science Program in five regencies/cities in Indonesia. The trials were conducted in the 2018/2019 academic year. Trial subjects for each regency/city are shown in Table 1.

Table 1.
Research Subject

Regencies/cities	Learning Topics	Amount of student		
		Readability of IPMLM	Empiric test of HOTS instrument	Extensive trial
Sleman, Yogyakarta	Newton's laws of motion	30	344	185 (93 of control group, 92 of experimental group)
Bengkulu	Work and energy	30	300	180 (90 of control group, 90 of experimental group)
Pontianak, Kalimantan Timur	Impulse and momentum	13	272	145 (81 of control group, 64 of experimental group)
Kupang, NTT	Thermodynamics	32	323	210 (104 of control group, 106 of experimental group)
Bima, NTB	Characteristics of mechanical wave	54	544	181 (86 of control group, 95 of experimental group)

Students in the experimental group conducted learning activities with a scaffolding approach assisted by the IPMLM application. Meanwhile, students in the control group conducted learning activities by using the direct learning assisted by the Physics textbook.

Data Collection

Data collection techniques used were test and non-test techniques. The test technique was carried out to measure the students' HOTS. The test instrument was in the form of multiple-choice questions. Non-test techniques were used to validate HOTS questions and assessed the eligibility of the media and get a response to IPMLM by students. HOTS question validation, media eligibility assessment, and student responses were obtained through questionnaires with a rating scale of 1-4.

Data Analysis

Data from the eligibility assessment results were analyzed using descriptive analysis. The average score on each aspect of the assessment of the eligibility of learning instruments was converted to a scale of 5 according to Sukardjo (2012, p .92). The mean score of each aspect of the evaluation was converted to a score with criteria as shown in Table 2.

Table 2.
Assessment Criteria

Respondent Score	Criteria	Categories
$X \geq X_i + 1.8\ SB_i$	$X \geq 85$	Very high
$X_i + 0.6\ SB_i < X \leq X_i + 1.8\ SBi$	$70 < X \leq 85$	High
$X_i - 0.6\ SB_i < X \leq X_i + 0.6\ SB_i$	$55 < X \leq 70$	Sufficient
$X_i - 1.8\ SB_i < X \leq X_i - 0.6\ SB_i$	$40 < X \leq 55$	Low
$X \leq X_i - 1.8\ SB_i$	$X \leq 40$	Very low

Sukardjo (2012, p.92)

- Evaluation questions were validated by 7 experts. The assessment results were then analyzed by using Aiken's coefficient validity (V). The Aiken's coefficient validity for n rater was calculated by the following equation (Aiken, 1985: 133).

$$V = \frac{\Sigma S}{[n\ (c-1)]} \qquad (1)$$

S = r-lo; lo = lowest validity rating score; r = score given by an assessor; c = highest validity rating score.

The calculated Aiken coefficient was then compared with the Aiken table. The item was valid if the Aiken coefficient value was higher or equal to the minimum score listed in the Aiken table.

- The validity and reliability of the empirical question were known by the results of the analysis using the parameter MNSQ INFIT value (infit mean square) and summary of item estimates. HOTS capability data was in the form of politomus data. Items with the form of politomus data were stated valid if they are compatible with the partial credit model (Sumintono & Widhiarso, 2015, p.89). Item fit with the model if it met the acceptance area of $0.77 \leq$ INFIT MNSQ ≤ 1.30 (Adam & Kho, 1996, p.30). Meanwhile, the criteria for item reliability were shown in Table 3.

Table 3.
The Criteria of Item Reliability

Range of item reliability	Criteria
< 0,67	Weak
0,67-0,80	Enough
0,81-0,90	Good
0,91-0,94	Very Good
> 0,94	Excellent

(Sumintono & Widhiarso, 2015, p.85)

- The effectiveness of using IPMLM with the scaffolding learning approach towards HOTS was known by analyzing HOTS data using inferential statistics. The statistical analysis used was ANOVA mixed design. Before being tested by using ANOVA mixed design, HOTS data must meet the prerequisite tests namely variance homogeneity test and normality test. The test criteria used to determine homogeneity were rejecting H0 if the significance value was sig. (two-tailed)> α (0.05), where, H0 was an inhomogeneous data variant. Test criteria for normality test were normally distributed data if the value is more than 50%, the data formed a plot in the form of linear lines. ANOVA mixed design analysis results were used to test the hypothesis (H_1), which was a significant difference in the HOTS of students in the experimental group and the control group. Another hypothesis (H_1) tested was that there was an improvement in the pretest-post-test score of HOTS. The criteria used in testing both hypotheses were H_1 accepted if the significance value was sig. (two-tailed) $<\alpha$ (0.05). The results of ANOVA mixed design analysis were also used to determine the effective contribution of IPMLM to the HOTS of students.

Results

IPMLM is developed through several stages. Development begins with the creation of content that is applied to the application. The content developed is material consisting of experimental videos, animated videos, illustrations, images, and text. Besides, HOTS measurement instruments are also developed in the form of reasonable multiple-choice questions divided into two question packages. The results of the development are described as follows.

Eligibility Assessment Learning Instrument

The learning instrument, the lesson plan and students' worksheet are assessed as feasible by physics teachers and expert lecturers. The developed lesson plan refers to Regulation of the Minister of Education and Culture No. 22 of 2016 concerning the standard processes of primary and secondary education and the syllabus of the 2013 curriculum which is in accordance with the scaffolding levels and the syntax of the guided inquiry model. Students' worksheet is prepared by referring to the Ministry of National Education (2008) regarding guidelines for the development of teaching materials. Aspects of the learning Instruments assessed are content, presentation, graphics, and language. Figure 1 shows the results of the eligibility assessment of the lesson plan and students' worksheet for each subject.

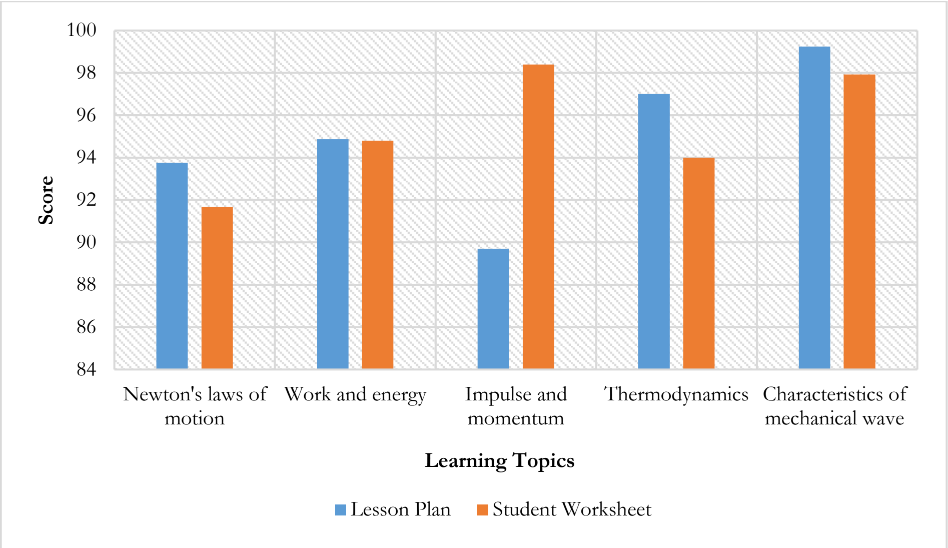

Figure 1.
The Result of Assessment Eligibility of Lesson Plan and Students' Worksheet

Figure 1 shows that the lesson plan and students' worksheet meet the criteria for achieving X ≥ 85 with a very appropriate category according to Sukardjo (2012, p.92). So, it can be concluded that the lesson plan and Students' Worksheet are suitable for use in learning physics.

HOTS Measurement Instrument Validation Results

HOTS measurement instrument in the form of reasoned multiple-choice questions consisting of five answer choices and five choice reasons. Table 4 shows an example of the HOTS problem that is developed

Table 4.
Example of HOTS Measurement Instrument

<table>
<tr><th>Item indicators</th><th>Questions</th></tr>
<tr><td>Conclude the amount of work on a gas undergoing an adiabatic process based on experimental data</td><td>800 grams of oxygen are processed in an adiabatic process, undergoing a change in initial temperature (T_1) to final temperature (T_2). Changes were observed five times, as show in the following table.
<table>
<tr><td>Adiabatic process</td><td>T1 (°C)</td><td>T2 (°C)</td></tr>
<tr><td>1</td><td>25</td><td>46</td></tr>
<tr><td>2</td><td>27</td><td>47</td></tr>
<tr><td>3</td><td>28</td><td>50</td></tr>
<tr><td>4</td><td>28</td><td>49</td></tr>
<tr><td>5</td><td>32</td><td>48</td></tr>
</table>
Based on the data on the table, the biggest work occurs in the data to
A. 1 B. 2 C. 3 D. 4 E. 5
Reason:
A. Efforts are inversely proportional to temperature changes</td></tr>
</table>

Item indicators	Questions
	B. Effort equals temperature change C. Efforts are directly proportional to temperature changes D. Efforts in the adiabatic process are always zero E. Effort is not affected by temperature
Describe the physical concept of elevator motion.	What can a person feel when he is in a moving elevator? A. When the elevator is accelerated upward, the body feels heavier. B. He feels lighter when the elevator has an upward acceleration. C. Person's weight in the elevator is the same as the weight when he is outside the elevator. D. When the elevator is accelerated downward, the body feels heavier. E. His weight is accelerated when the elevator is moving downward. **Reason:** A. When the person is in the elevator, the value of weight equals to the value of normal force. B. Normal force equals to the sum of weight and the force which gives rise to the acceleration of elevator. C. Weight and and the force which gives rise to the acceleration of elevator have a same value. D. Acceleration of the elevator is in the direction of gravitational acceleration. E. Normal force is in the direction of the force which gives rise to the acceleration of elevator.

The HOTS measurement instrument is rated by seven raters. The results of the assessment by 7 raters are then analyzed to find out the coefficient validity for each item. Validated questions are then empirically tested in schools. Table 5 shows the results of the content validation and the results of the empirical validation questions.

Table 5.

The Validity and Reliability of HOTS Measurement Instrument

Topics	Aiken's coefficient validity (V)	Summary of item estimates	Item fit	Information
Newton's laws of motion	0.86-1.00	0.80	All items fit to partial credit model	Valid dan fair reliable
Work and energy	0.86-1.00	0.84	All items fit to partial credit model	Valid dan reliable
Impulse and momentum	0.86-1.00	0.86	All items fit to partial credit model	Valid dan reliable
Thermodynamics	0.90-1.00	0.72	All items fit to partial credit model	Valid dan Valid dan fair reliable
Characteristics of mechanical wave	0.86-1.00	0,60	All items fit to partial credit model	Valid dan less reliable

It is accepted with an error of 1% is 0.86 (Aiken, 1985, p.133). Thus, it can be concluded that all HOTS items are valid in terms of content. Empirical test results indicate that the HOTS instrument is valid and reliable for measuring students' higher-order thinking skills.

Media Eligibility Assessment Results

IPMLM application is an android application that is equipped with several menus and features. The main menus contained in the IPMLM are Competence, Materials, Students' worksheet, Practice Questions, Evaluation, and Developer Profile. The IPMLM application is also equipped with a chat feature that allows students to discuss with the teacher. Figure 2, Figure 3, Figure 4 and Figure 5 show the examples display of the IPMLM application.

Figure 2.
Display of Main Menus

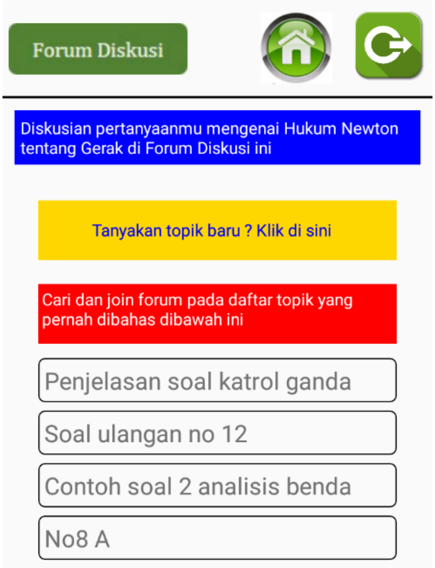

Figure 3.
Display of Chatroom

Figure 4.
Video Display on IPMLM

Figure 5.
Example of Illustration on IPMLM

The eligibility of IPMLM is assessed by material expert lecturers and media experts. The aspects assessed by media experts are aspects of software engineering, ease, and flexibility in accessing, presenting, interacting, and visual communication. Aspects assessed by material experts are material aspects and learning aspects. The results of the assessment by media experts and material experts are shown in Figure 6.

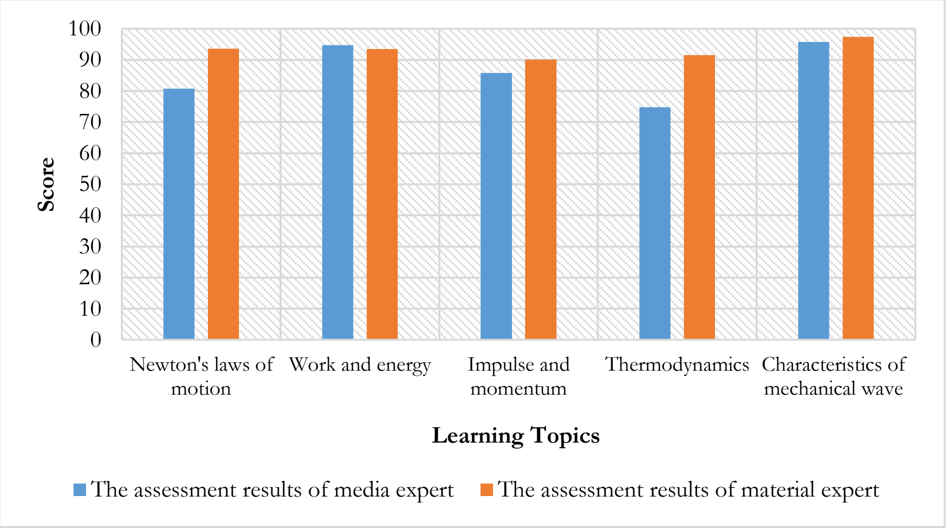

Figure 6.
The Results of Media Eligibility Assessment by Experts

Figure 6 shows that the results of the assessment by media experts on IPMLM for thermodynamic learning materials and Newton's Law meet the criteria of 70 <X ≤ 85 high categories according to Sukardjo (2012, p.92). Meanwhile, IPMLM for other learning materials meets the criteria X ≥ 85 with a very high category according to Sukardjo (2012, p.92). Furthermore, Figure 6 also shows that the results of the assessment by material experts on IPMLM meet the criteria X ≥ 85 with a very high category according to Sukardjo (2012, p.92). So it can be concluded that IPMLM is eligible to use in learning physics in the classroom.

Design Prerequisite Test Results

The normality of data for both groups is known by using plot graphs, it shows the distribution of data. The normality test results for the experimental group are shown in Figure 7 and the normality test results for the control group are shown in Figure 8.

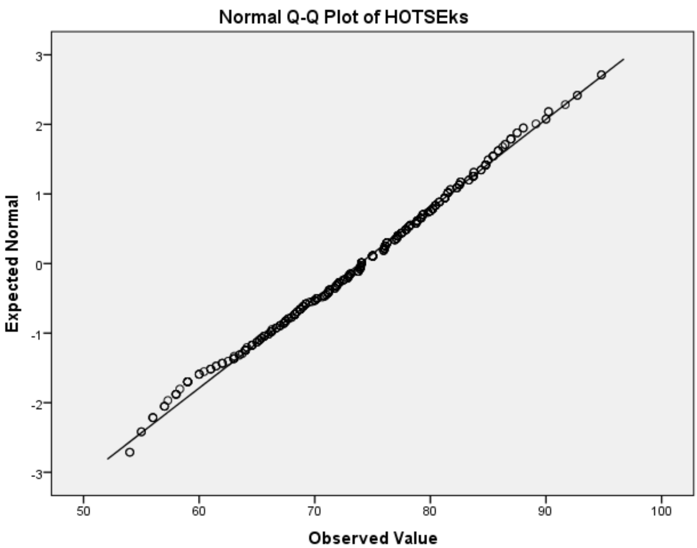

Figure 7.
Data Plot of Experimental Group

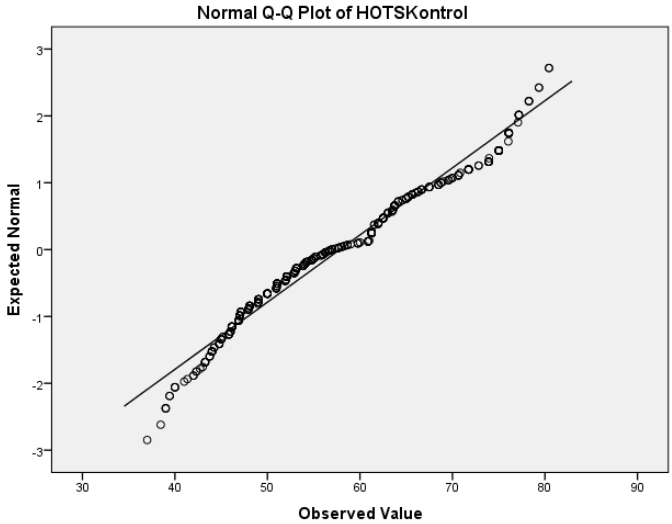

Figure 8.
Data Plot of Control Group

Figure 7 and Figure 8 show that more than 50% of the data plot forms a linear line. Thus it can be concluded that the data in both groups are normally distributed.

Besides the normality test, a variant homogeneity test is also carried out. Homogeneity test results are shown in Table 6.

Table 6.
Levene's Test of Equality of Error Variances

F	df1	df2	Sig.
.032	1	899	.857

Table 6 shows that the significance value of two- tailed HOTS sig. 0.857> α = 0.05. These results indicate that H0 is accepted, which means that the variable data variants are bound to the control group and experimental group is homogeneous. The prerequisite test results indicate that the data meet the requirements to be continued with the ANAVA mixed design test.

Effectiveness Test Results

The effectiveness of the use of IPMLM with the scaffolding learning approach is known by looking at differences in their ability and the improvement of HOTS of students in the experimental group and the control group. Prerequisite tests or basic assumptions that are met indicate that the data can be analyzed with the ANOVA mixed design test. The results of the ANOVA mixed design test are shown in Table 7.

Table 7.
Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Intercept	2643829.071	1	2643829.071	49028.631	.000
Group	13100.151	1	13100.151	242.936	.000
Error	48477.844	899	53.924		

Table 7 shows that the HOTS difference test between the two groups produced a significance of 0,000 <α = 0.05. The significance value shows that H0 is rejected, which means there are differences in HOTS of students in the experimental group using IPMLM with the scaffolding approach and students in the control group who is taught by using the direct learning assisted by the Physics textbook.

The improvement of students' HOTS can be known by looking at the significance of the results of the hypothesis test. Table 8 shows the results of pairwise comparisons for students' HOTS.

Table 8.
Pairwise Comparison

Group	(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.
Experimental	Pretest	Posttest	-31.830	0.449	0.000
Control	Pretest	Posttest	-14.936	0.446	0.000

Table 8 shows that the improvement in the pretest-posttest of HOTS in the experimental group and control group, it is obtained a significance of 0,000 <α (0.05) which means that H1 is accepted. This shows that there is a significant improvement between the pretest-posttest score of HOTS in both groups. Table 8 also shows the mean difference (MD) value for the experimental group of MD = -31,830 and the control group of MD = -14,936. The mean difference shows that the pretest score minus the posttest score is negative for each group. This explains that the post-test score is higher than the pretest score. The mean difference (MD) also shows an improvement in the pretest-posttest score of HOTS in the experimental group higher than the control group.

The use of IPMLM with the scaffolding learning approach contributes effectively to the HOTS of students. Table 9 shows the results of the multivariate test type Hotelling's Trace which shows the amount of effective contribution of the learning process in each group.

Table 9.
Multivariate Test Tipe Hotelling's Trace

Group	F	Sig.	Partial Eta Squared
Experimental	2036.320	0.000	0.848
Control	508.835	0.000	0.555

Table 9 shows that the effective contribution of the experimental group by using IPMLM with the scaffolding learning approach in improving HOTS is 84.80%. High contribution to the control group that is taught by learning instruments with the direct learning assisted by Physics textbooks in increasing HOTS is 55.50%. This is shown by the graph in Figure 9.

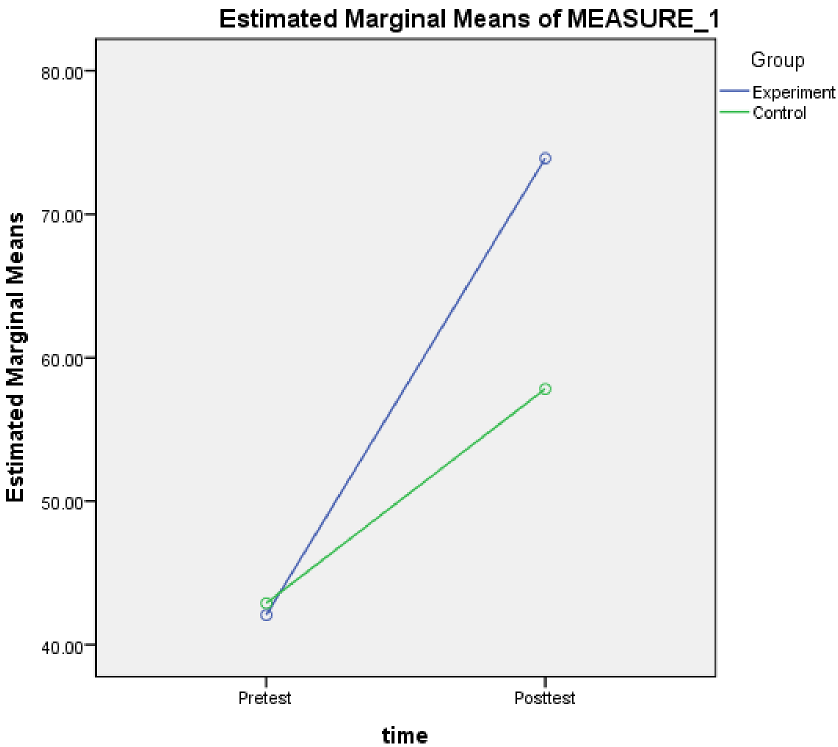

Figure 9.
Graph of Estimated Marginal Means

The effectiveness indicates that the use of the scaffolding learning approach assisted by the application of IPMLM provides a higher effective contribution in improving the students' HOTS compared to the direct learning assisted by the Physics textbook package.

Students' Response

Students' response data collection needs to be conducted to determine students' assessment toward the IPMLM media and learning that use IPMLM with a scaffolding approach. Figure 10 shows students' responses towards IPMLM and learning process.

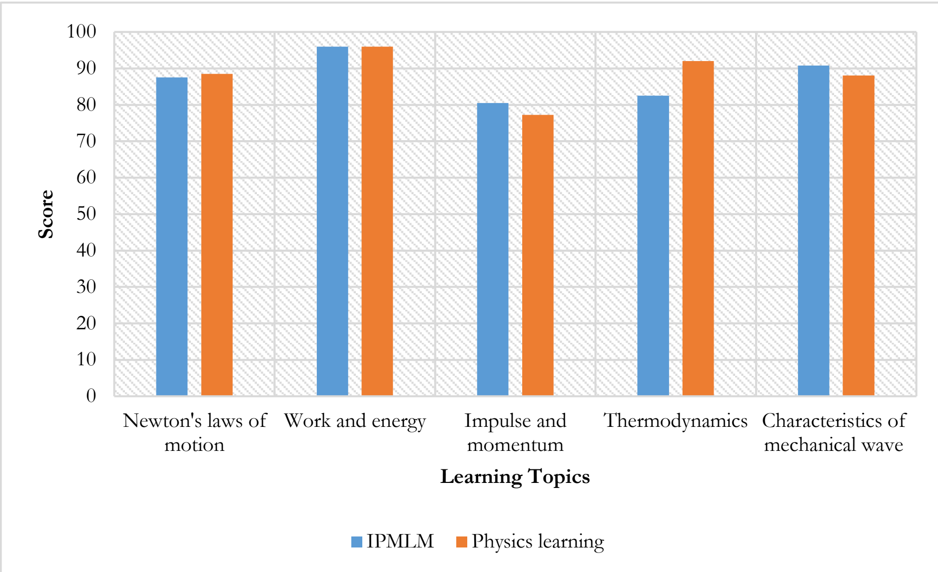

Figure 10.
Student Assessment Results towards Media and Learning Process

The results of the assessment of students in Figure 10 indicate that the average results of the assessment by students meet the achievement criteria of 70 <X ≤ 85 with a good category (Sukardjo, 2012, p.92). So, IPMLM media is good to be used as learning media in the classroom.

The learning process by using IPMLM which is applied with a scaffolding approach allows the creation of a fun physics learning process. This is proven when students are asked to respond to media and learning. Some students stated that the learning process with IPMLM is very interesting and not boring. Such conditions help students to stay focused and also improve motivation to learn the material. Figure 11, Figure 12, and Figure 13 show examples of student responses towards IPMLM media and learning.

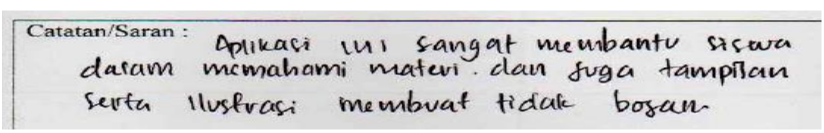
Catatan/Saran : Aplikasi ini sangat membantu siswa dalam memahami materi. dan juga tampilan serta ilustrasi membuat tidak bosan.

Figure 11.
Response of Student A

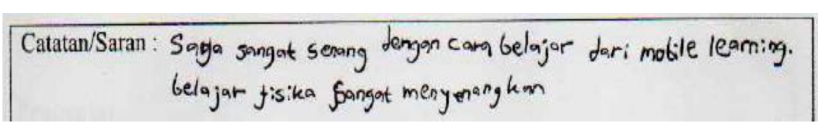
Catatan/Saran : Saya sangat senang dengan cara belajar dari mobile learning. belajar fisika sangat menyenangkan

Figure 12.
Response of Student B

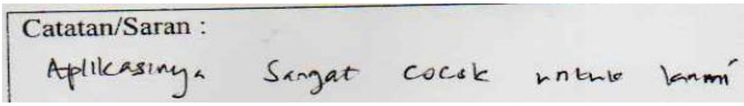

Figure 13.
Response of Student C

Student A is shown to Figure 11 stated "*this application is very helpful for students in understanding the material. The appearance and illustrations make me not feel bored* ". Student B shown to Figure 12 stated *"I am very happy to take part in mobile learning. Learning Physics is very fun"*. Student C shown to Figure 13 stated "*This application is perfect for us*".

Discussion

The findings show that the learning instruments and IPMLM media are suitable for use in learning Physics on Newton's law material about motion, effort and energy, impulse and momentum, thermodynamics, and mechanical wave characteristics. Furthermore, it is found that the use of IPMLM with the scaffolding learning approach has a positive influence on students' higher-order thinking skills.

The results of the study are relevant to the research development of Physics Mobile Learning Media (PMLM) conducted by Agustihana and Suparno (2018, pp.8). The research proves that the PMLM application is better in improving students' HOTS than the control group that does not use the application. If high-level thinking skills are improved during the learning process, students will get used to using their reasoning to analyze, evaluate, and even create (Agustihana & Suparno, 2018, pp. 7). In addition, Ahmed and Parson (2013, p.68) also conducted a similar study of learning using *ThinknLearn* applications. The application contains instructions in the process of learning abductive inquiry on the subject of energy transfer. Middle school students who use the *ThinknLearn* application experience significantly increased knowledge and show more critical thinking compared to the control group who do not use the *ThinknLearn* app. The results of further tests show that students who use the *ThinknLearn* application retain information/material better than students who do not use the *ThinknLearn* application (Ahmed & Parsons, 2013, p.69). Other research conducted by Srisawasdi and Prapaporn (2014) also states that students' conceptual understanding can be improved and maintained up to two months after learning through open inquiry-based mobile learning simulation.

Learning using mobile devices provides benefits for students and also helps teachers in learning. The developed IPMLM is equipped with images that represent the concepts of Physics. This facility helps understanding Physics concepts using images that are familiar with students (Ekanayake & Wishart, 2014, p.237). The cognitive process that occurs is that students connect physical concepts with the environment or familiar situations. The process can develop students' scientific understanding. Developing students' scientific understanding is one way to improve higher-order thinking skills (Madhuri, Kantamreddi & Goteti, 2012, p.122).

Besides images, the IPMLM application is equipped with video. For example, the IPMLM application has presented a video of the process of thermodynamics and experimental video to prove Law I of Thermodynamics. Video facilities in the application help students to develop scientific skills, students' understanding of a process (Ekanayake & Wishart, 2014, p.244). These skills are the characteristics of higher-order thinking skills (Brookhart & Nitko, 2011). In addition, the video presentation can also attract the attention and interest of students (Ekanayake & Wishart, 2014, p.244). It also helps the teacher in managing classroom conditions.

The IPMLM application is also equipped with chat and evaluation features. Evaluation menus can help students to improve cognitive skills by examining their evaluation results as found by Zhu, Au, and Yates (2016, p.56). The chat feature can be used by students to discuss physics learning topics. In addition, the chat feature allows teachers to provide feedback to students.

HOTS achievement of students in the experimental group is inseparable from the teacher's help. Assistance provided by teachers through scaffolding interactions also develops students' thinking skills. The combination of teacher assistance with technology-based learning instruments is a synergistic scaffolding system to support science learning (Lin, Hsu, Lin, Changlai, Yang & Lai, 2012). The results of this study support other research that has been carried out before that teacher assistance can improve problem-solving skill (Amanah et al., 2017) and students' critical thinking skills (Susilowati et al., 2017). For example, the learning process in the experimental group, through prompting and probing interactions (the teacher asks questions that encourage and investigate) encourages students to think independently (Slavin, 2017, p.45). Another example, the teacher gives a problem from the simplest problem to a complex problem. This interaction can improve the problem-solving skill which is also one aspect of HOTS (Brookhart & Nitko, 2011). In the last stage of scaffolding, students independently develop conceptual thinking by linking material and information that has been learned with phenomena or instruments in their daily lives.

The IPMLM application is complemented by trial students' worksheet and discussion. Students conduct experiments and discussion activities in groups using the students' worksheet that is developed to answer the hypotheses formulated by students. Students are trained to think scientifically and systematically through experiments to prove theories or concepts in Physics. The HOTS that is improved in this process is the skill to organize (C4). Students are trained in identifying relationships between physical quantities. Through the process of testing the hypothesis to the conclusion, the skill to evaluate students is also improved. The students determine whether the conclusions are drawn in accordance with the data observed or not (the skill to check). In addition, students also determine the procedure, method, or solution that is most suitable for answering hypotheses (the skill to criticize or C5). This has been proven in the results of research showing that the HOTS of the experimental group is better than the control group. These results are in line with the results of Madhuri, Kantamreddi, and Goteti (2012, p.122) research that students' HOTS can be developed through scientific processes. IPMLM in this process helps to present pictures and illustrations related to experiments that can stimulate students' curiosity.

The results of this study are supported by other relevant studies indicate that IPMLM with the scaffolding learning approach is a unity that can positively improve the students' HOTS. Through the IPMLM application, the teacher can provide constructive feedback, therefore, he/she can help students evaluate and reflect on their learning. Furthermore, the results of student responses also show that the learning process using IPMLM with scaffolding learning approach is very enjoyable. Students also state that IPMLM helped them in understanding the concepts of Physics.

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