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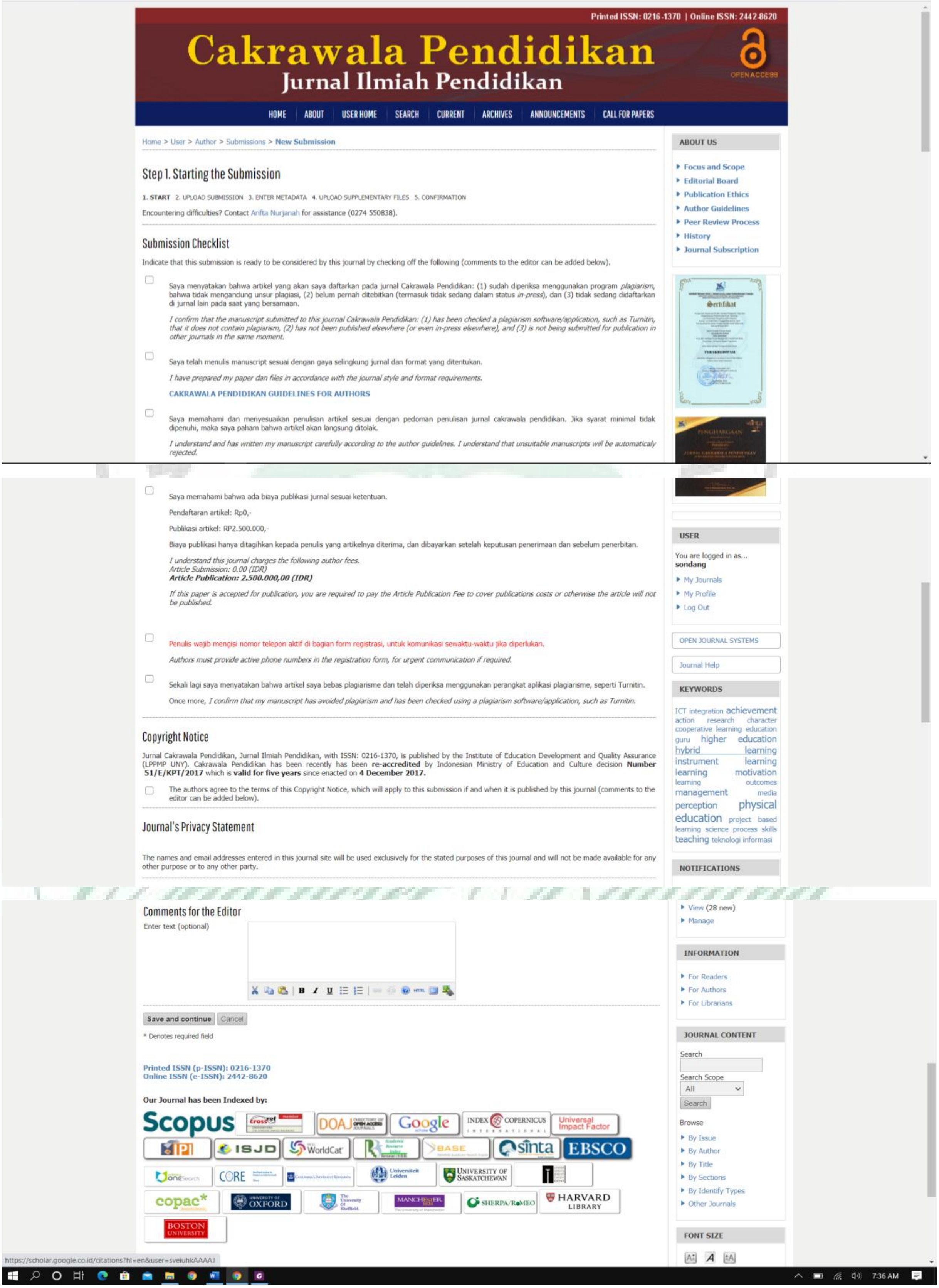

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IMPROVING STUDENTS' THINKING ABILITY IN PHYSICS USING INTERACTIVE MULTIMEDIA-BASED-PROBLEM-SOLVING" (MMI-PS)

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Abstract

The purpose of this research is to see that improving student learning outcomes is influenced by 2 values, namely the quality of teaching and the teaching methods of teachers. Furthermore, this study aims to analyze the problem solving abilities of students in physics education programs after they have been exposed to interactive multimedia-based problem solving methods. This research seeks to produce knowledge that can serve as a basis for further large-scale studies and interventions and informing policy makers and developers of problem solving learning programs and implementing teacher perspectives about the quality of assistance they need and, thereby, stimulating reflection about possible ways to overcome existing obstacles. The research type is quasi-experiment. Data were analyzed using ANOVA. The test of science process skills in the form of formal descriptions as well as reasoning tests in the form of descriptions were used as instruments for this study. The results show that the problem solving ability of students who study physics using interactive multi-media based problem solving is better than students who learn through conventional methods.

Keywords: Thinking Ability; Physic; Interactive Multimedia; Problem Solving

INTRODUCTION

Physics is one of the science that underlies the development of technology, so students need to learn it in the form of general physics (Halliday et al, 2011). As prospective lecturers, students majoring in physics education are expected to have high thinking ability. The improvement of lecturers' competence has not been successfully conducted by the training institute for education practitioners (Lembaga Pendidikan Tenaga Kependidikan Or LPTK Or Training Institute For Education Practitioners). A study by Manurung (2013) at one of LPTK in Medan shows that the teaching of physics is still overly teacher-centred. University teachers tend to learn through lectures, questions and answers. The implementation of the general physics course still the validity of existing theories, carried out by strictly following a set of provided procedures, instead of encouraging students to develop their thinking through experiment.

In addition, it was also found that: (a) methods used in these general physics lectures are downright boring as students are required to listen to their lecturer in long hours; the learning is aimed simply students to the theories; and problems presented tends to be academic (book oriented), (b) students lack of experience to be able to solve problems; problems given are rarely relevant to contextual issues in everyday lives of student, so thus learning becomes less meaningful to students. Those evidents arise from low participation in teaching and learning activities and their relatively low achievement. Furthermore, a number of problems in the teaching of general physics have been identified: (a) the learning process does not present relevant phenomenon, (b) lack of discovery process, (c) lack of learning media, and (d) weak understanding of the concepts. these problems cause difficulties for students to understand the concepts of general physics graphics presented in learning physics.

One of the important factors that influence the low performance of science lecturers is the lack of effective pre-service teacher education (Fhaeizdhyall et al,2018). Teachers' quality is a major factor in increasing teaching and learning quality. Thus, there is a vital need to improve professionalism in the field of education (Depdiknas, 2010). A sustainable and effective teacher education to improve teachers' quality is crucial. Equipping with knowledge and hands-on experience in doing physics experiments that involve abstract physics concepts interactive multimedia is relevant because not all experiments can be done directly in laboratory. Most students experience difficulties in solving physics problems neither do they have a deep understanding of the fundamental concepts in the problem. To overcome this situation, we propose a computer-assisted learning tool known as the adaptive learning environment for problem solving (ALEPS) based on "Polya stages of problem solving" that consists of 1) understanding; 2) planning; 3) applying, and 4) checking (Bimba et al, 2013). Thinking and problem-solving skills as well as speed in problem solving are only developed through practice and feedback. testing students on skills they have not had an opportunity to practice is unfair (Heller & Heller, 2010., Gorghiu, et al 2015).

Fenelon (2012) designed a thinking model and laboratory content on the web-based basic physics lecture, and found that long-distance students' as those with direct interaction. And virtual for various concepts of basic algebra-based physics through project phet (physics education technology) are reported by Habibi & Habibi(2015) to cope with the large number of participants course in universities. Furthermore Habibi & Habibi(2015)., Chetty (2015) stated that computers can be used to support the implementation of practical physics for gathering, presenting, and manipulating data. Kapi et al (2018) also argue that a number of forms of interaction may be presented through the of computer serving as practices and exercises, tutorials, games, simulation, discovery, and thinking. According to Erfan & Sulistyani, 2014., De sousa, 2017 the utilization of multimedia in learning encourages students to the process of invention (discovery learning process) and can solve ill structured problems (Cunningham,2009). Kapin (2018) said that interactive multimedia as audio-visual media can show phenomena in physics in a more real manner. A more real visualization strongly supports c in the learning process. in addition, students get in their learning process. thus, students' skill will increase, which in turn will hopefully encourage the emergence of students' creativity.

Thinking is a complex process and is important in the everyday of learning physics. problem-solving tests focus at the end of result or the middle of the process of learning, rather than on the quality of the procedures and the reasoning that leads to results. Thinking skills developed in general physics present a situation where certain information is given, more often as numerical values for the variables in those situations, so that the value of other variables can be determined. So, problem tends to be well-defined. Meanwhile, life physical problems or those faced by physicist are mostly ill-structured problems, a problem that must be solved through innovative physics (Cunningham, 2009). Lawson (2010) states that the ability to think is a person's ability to solve problems, to think and devise solutions with a logical sequence (sense), as well as career and work. Thinking ability make problem solving important to get the work.

Thinking ability shows that a person has formal reasoning. according to Piaget, (1964)., Haryanto (2006) there are five aspects of the operation of formal reasoning, namely: proportional reasoning, control variables, proportional reasoning, correlational reasoning, and combinatorial reasoning. According to (Arends, 2012), problem solving based learning can improve thinking ability.

Based on the description above, this article will explain the improvement of thinking ability in physiscs through an interactive multimedia-based learning problem solving (MMI-PS), because this model can improve thinking ability and skills in solving ill-structured problems (Byun et al, 2014; Manurung & Panggabean, 2017; De Sousa, 2017)

METHODS

The research method adopted in this study is experiment (Fraenkel et al , 2011) by testing the model in a limited class with pre-test–post-test control group design. This research involves two classes that were treated differently. Each of the two classes was assigned into experimental and control groups. The experimental class taught using the interactive multimedia-based learning containing problem solving (IMM-PS) while the control group taught using conventional learning method. The research sample consist of 35 students per class, i.e. second years physics education students. Second year students get a wave electric magnetic subjects, each number 35 persons per class. We performed two (2) studies. Study 1 is implementation of IMM-PS on experimental group that is consists of 35 students. Study 2 Is performing teaching using conventional learning method to control group that is consists of 35 students as well. Both studies follow 6 steps as shown on Fig. 1 and 2.

Starting with the provision of pre-tests in both groups, then given treatment that is giving MMI-PS in the experimental group, conventional treatment in the control group. after that the test post is given shown in Table 1

Tabel .1 : Research Design (*Pretest – Postest Gruop Design)*

Group	Pretest	Treatment	Postest
Experiment	T_1	X_1	T_2
Control	T_1	X_2	T_2

T_1 = Pretest

T_2 = Postest

X_1 = Treatment With Model

X_2 = Treatment With Convensional Model

In the experimental group the steps were carried out as shown in figure 1. in the beginning with a briefing for branstorming steps is called is brainstorming activities is briefing activity.

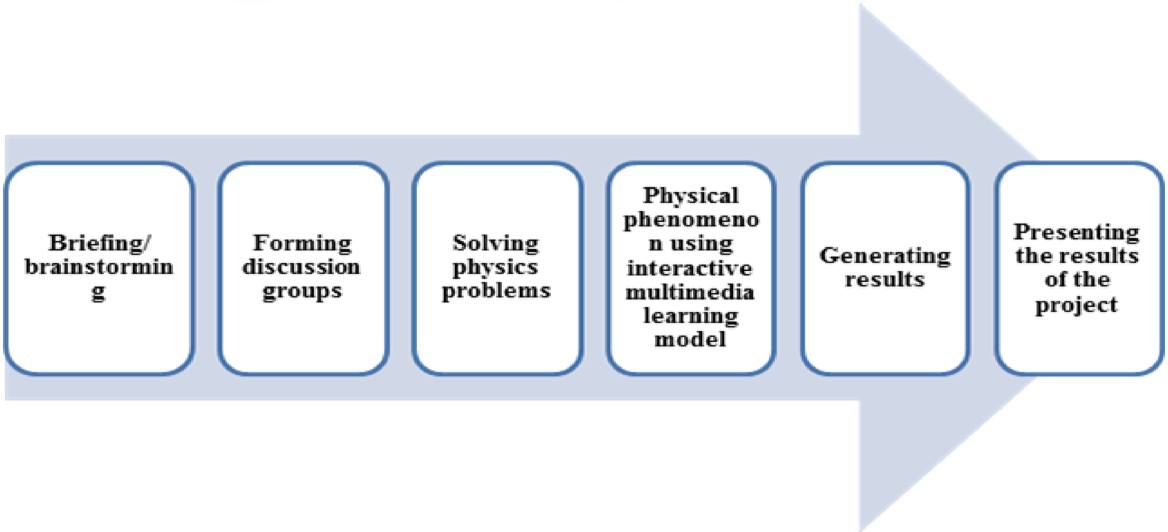

Figure 1. Steps In The Interactive Multimedia Based On Learning Model Containing Problem Solving

In the learning instruction there are discussion groups, to discuss physics problems. the third step is to solve the problems.And problem-solving techniques will be made in the meeting, where group problem-solving involves the spontaneous contribution of ideas by all members of the group, also in order to compile or find a work around. the fourth step is to look at physical phenomena to invesigate of physical phenomena by using problem-solving interactive multimedia and discussion. Thinking-laden interactive multimedia helps students investigate physical phenomenon while solving problems in a group. problem based learning (PBL) is a learning approach that uses real-world problems as a context for students to learn critical thinking and problem-solving skills, as well as to acquire mastery of the knowledge and essential concepts of the subject matter (Sudarman, 2007). PBL challenges students to find solutions to existing problems in the real-world through group work. the fifth step is to find the findings of physical symptoms. finally, the sixth step presented the findings

The research instrument is a thinking ability test is test of logic thinking (TOLT) , TOLT consisting of 10 multiple choice questions which instrument validity and reliability have been ensured. This instrument developed by Tobin and Capie (1981). The value of the validity and reliability of the instrument TOLT is 0.67 and 0.80. Instrument translated into the english language (Tobin & Capie, 1982). The research sample consisted of 35 students per class, i.e. second semester physics education students. The research carried at a LPTK in Medan, as a research and problem solving learning effectivity test site.

Anova is used to find out wheter interactive multimedia-based learning containing problem solving (IMM-PS) can improve students' thinking. Based on the analysis of preliminary study needs, it was found that students and professors of the multimedia program in learning were activated and followed by analyzing interactive multimedia. With a controller that can be operated by user, so thus user can select what is desired for the next process. Examples of interactive multimedia include: multimedia interactive learning games, applications, etc. of multimedia-based learning is shown in Figure 2.

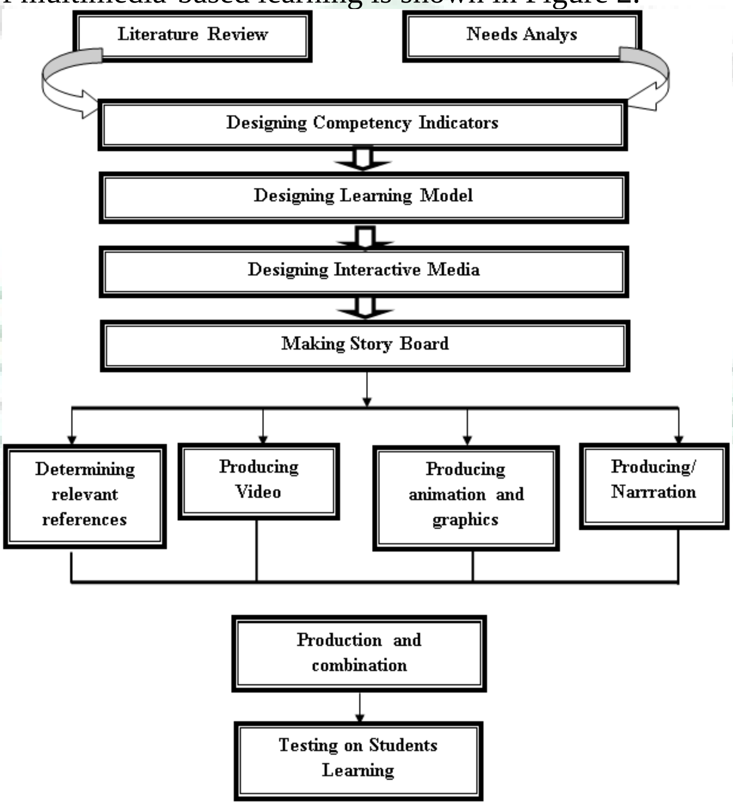

Figure 2. Paradigm Of The Based On The Phylosophy

Figure 2 Describes the preliminary stage of the study namely the literature review and needs analysis required for the formulation of competency indicators to determine the learning, multimedia and story board designs, features , which finally tested on students and discussed with an expert. Interactive multimedia allows the user to realise potential no longer passive reader, but rather as a co-author, as they determine the sequences of their reading experience potential, will have the ability to rearrange their knowledge with respect to the condition of complex knowledge.

Examples of interactive multimedia shown on Figure 3. The movement of the pendulum harmonic phenomena is often considered simple, but in fact, since a number of representations: (1) from the object of the phenomenon, (2) representation of measurement, such as the position of the pendulum in a particular cycle of oscillation, (3) representation of the pendulum phenomenon graphic according to time and speed. Designation of pendulum symptoms in interactive multimedia

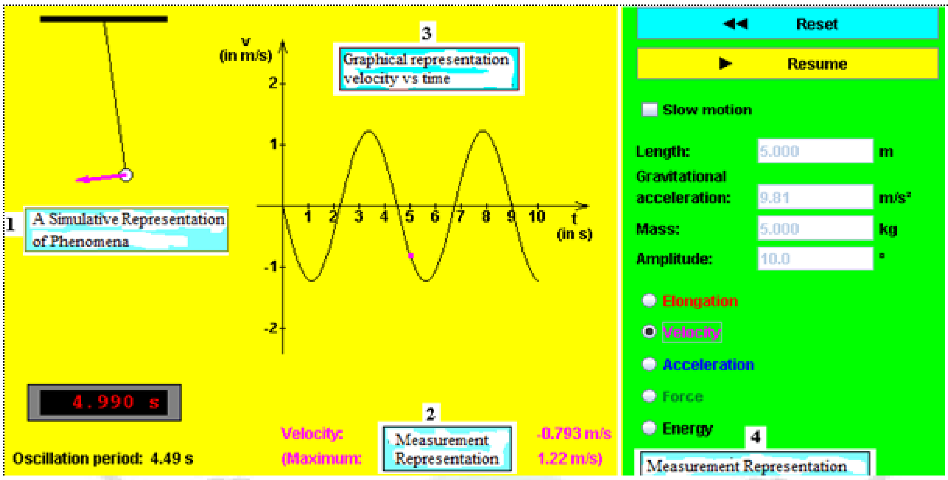

Figure 3. The Pendulum Symptom, According To The Knowledge Representative Constructs Basic Knowledge About Pendulum.

Figure 3 shows the process of building knowledge according to the complexity of symptoms that can be done according to user's navigation,the simulation allows user to reconstruct the needs to improve the substantiation and transfer capabilities a complex concept which refers to advanced knowledge obtained (Nickel, 2014). Through research simulation. According to Heller & Heller (2010) the strategies of problem-based learning consisted of five steps, : (a) the problem (the focus of the problem), (b) the concept in (describe the physics), (c) planning solutions (plan the solution), (d) out the plan (execute the plan), and (e) an evaluation the solution (evaluate the solution).

FINDINGS AND DISCUSSION

Findings

In the beginning of the study, students in both classes were given a pre-test (initial competency test) that aimed to find out whether their thinking ability was on the same level. The results of the experimental class and control class ranged from 0 to10. Based on the pre-test results of the experimental class, the lowest score was 4 (1 person), while the highest score was 10 (1 person) (Figure 4). The average score was 6.86 and the standard deviation was 1.3. Whereas, in the control class the lowest score was 4 (2 people), and the highest score was 10 (1 person) (Figure 4). The average score was 6.94 and the standard deviation was 1.43

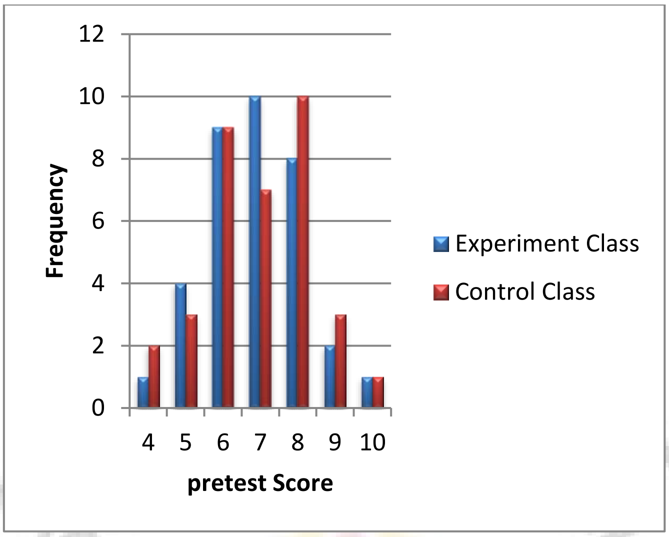

Figure 4. Pretest Scores Of The Experiment Classes And Control Classes

The pre-test scores of the experimental and control classes–were not significantly different ($p<0.05$), meaning that both classes the same initial capabilities and acquisition value. Data of pretes and postest in experiment group is shwon in Table 2

Table 2. . Data Of Pretest Scores And Posttest Score In Experiment Group

No	Pretest Value					Score	Postes Value			
	Scores	F	$\bar{x}$	S^2	S		F	$\bar{x}$	S^2	S
1.	4	1	6,86	1,71	1,31					
2.	5	4				5	-			
3.	6	9				6	1			
4.	7	10				7	6	8,43	1,08	1,04
5.	8	8				8	10			
6.	9	2				9	13			
7.	10	1				10	5			
Total		35				35				

Information: F = Frequency; $\bar{x}$ = Average; S^2 = Variance; S = Standard Deviation,

As the post test result, the lowest score increased from 4 to 6 (1 person) in the experimental class (table 2). the number of students who the highest score, 10, also increased to people (5). in addition, the class score average improved from 6,86 to 8.43 with a standard deviation from 1,31 to 1.04. In the control class, the lowest score 5 (3 people), and the highest score 10 (4 people) with an average of 7.49 and a standard deviation of 1.46. there also a great difference the number of students who achieved a score of 9 (13 students from the experiment class as opposed to only 4 students the control class) (Table 3).

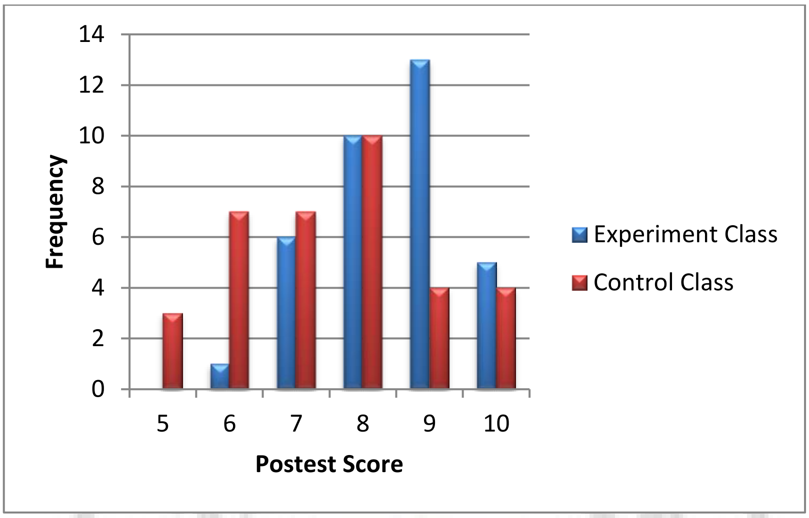

Figure 5. Posttest Scores Of The Experiment Classes And Control Classes

Table 3. Comparison of score averages in pre-test and post-tests of thinking abilities by the experimental and control groups

Group	N	X	Sd	Df	T_{sum}	T_{table}
Experimental	35	8,43	1,04	68	2,876	1,669
Control	35	7,49	1.46	68		

Significant At P<0,05

The statistical analysis (1) indicates that there is a significant difference –(p < 0.05), between the average score of the experiment and control group where the group experiment is influenced experimentation imm-ps, conventional teaching method, as conducted in the control group, did not result in significant difference between the students' achievement before and after treatment (p<0.05) (Table 4).

Table 4. Comparison Of Control Group's Average Scores Before And After Treatment

Group	N	X	Sd	Df	T_{sum}
Control Group Before Treatment	35	6,94	1,43	68	0,12*
Control Group After Treatment	35	7,49	1,46	68	

*Not Significant At P<0,05

Discussion

Abungu et al (2014) states that the ability of computer-assisted formal reasoning and learning deals with logical thinking ability of chemistry (chemistry student). the results of this study is in line with research by Manurung (2012), which stated that using a problem-solving model, especially on dynamic fluid materials, resulted in a very good average scores and moderately increased students' ability to think. Kharida et al (2009) states in his research that there is an increase in the average thinking ability of students taught with problem based learning model. According to Arends (2012), a problem based learning approach to learning, in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher as a facilitator then student must be persistent in solving the problems presented, then all the characters of the students will show themselves and students can develop independence and confidence so that the ability to think can be achieved.

Based on this study, the test results average of students from the experiment class increased from 6.86 to 8.43, while in the control class, it increased from 6.94 to 7.49. The statistical analysis showed that students from the experiment class attained significantly higher post test average compared to students from the control class ($p<0.05$). In addition, the average N-Gain value of students taught using problem based learning model is 0.5 or 50%, with a moderate level improvement in logical thinking competence. Meanwhile, the average n-gain value of students taught using the conventional approach is 0.2 or 20%. This means that the improvement of students' logical thinking ability in the experimental class is greater than in the control class. Thus, we can conclude that student's ability to think logically were enhanced due to the influence of the problem-based learning model on kinematic physics education. Similar result was obtained by Islam, et al (2014) who stated that the use of multimedia animation as teaching media improved students' thinking process; in which students in experiment class obtained 0.682 improvement, while students in control class only 0.326 improvement. It can be inferred from his results, as well as ours, that there exists a difference in logical thinking abilities between the two student classes. This is because learning that uses multimedia encourages students to be actively engaged in the thinking process with regards to the material and linking learning to real-life situations. Thereby, students are motivated to remember and apply the knowledge in everyday life situations. In other words, students are not just passively accepting material from a lecturer but are actively solving problems.

Similar results were also obtained by Ibrahim (2012), Arends (2012) and Adeyemo (2010). Ibrahim (2012) states that there is an increase in average cognitive logic thinking ability of students taught using the problem-based learning model. Therefore, by applying this model, students can acquire knowledge and skills more effectively, as supported by Arends (2012) who states that a problem-based approach to learning in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher acts as a facilitator requires that students be persistent in solving the problems presented. He also states that during the problem-solving process, the problem of the character of the students themselves will be apparent so that students can develop self-reliance and confident in achieving logical thinking abilities. Adeyemo (2010) also states that there is an increase in cognitive ability among students who are positively affected when problem-solving tasks in physics are discussed.

Also De Sousa et al (2017) state that when using various multimedia combinations, the unique nature of social sciences can be addressed effectively. This result, as well as ours, inferred that there exist a difference in logical thinking ability between the two classes. this is because, learning using multimedia helps encourage students to be actively engaged in the process of thinking with regard to the material and link it to real situation (Erceg, 2011). Thereby, they are encouraged to be able to remember and apply the knowledge in everyday life. In this case, students are not just passively accepting material from lecturer but also actively solve problems. Arends (2012) who states that a problem based learning approach to learning in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher as a facilitator then students must be persistent in solving the problems presented, during the solve the problem of unwitting students, then all the characters themselves will appear that students can develop self-reliance , and confidence so that logical thinking ability can be achieved (Özreçberoğlu and Çağanağa, 2018).

In contrast to interactive multimedia based learning given in the experiment class, teaching activities conducted in the control class failed to improved students' score ($p<0.05$) (Jarosievitz, 2015) . This shows that the method used in the control class was not effective in improving logical reasoning. This finding is also supported by Lawson (2010), who argues that certain learning approaches, such as lectures, are not effective in improving logical reasoning.

Bello (2014) said that the experimental group exposed to the process skill instruction approach performed significant better to improve formal thinking ability than the control group expose to the traditional instruction. Erceg et a l (2011) stated in their work that the students were assigned to solve one part special issue to investigate their problem-solving strategies. Lawson (2010) showed that students' score in 'lawson classroom test of formal reasoning was correlated with their achievement in school subjects i.e. social studies, science and mathematics. this finding has provided concrete evidence that formal reasoning abilities can be related to students' general performance, not only to science and mathematics. Manurung (2014) studied that in identifying elementary school students' thinking skills, they do logical thinking tasks. Subali et al (2013) said that descriptively the most mpk-gi group (empowerment conseptual model empowerment) excel in achieving critical thinking skills.

The results showed, to answer the question of physics, students must use the laws of physics to calculate the requested physical quantity, in accordance with the steps to solve the problem. They also have to calculate the quantity of answers from physics problems in everyday conditions. Tasks like these can help different concepts and techniques of problem solving are accepted, and train students and teachers to solve problems in everyday life using physical principles and assumptions.

In conclusion, learning media in the form of interactive multimedia tools is reasonably capable of providing learning experiences that correspond to the level of cognitive development of students. Barsalo (2014) classifies learning experience of children ranging from things that most concrete up to things that are considered the most abstract. The classification of such experiences is widely followed by the educational circles in deciding what tools should be appropriate to the particular learning experienc*e (*Mukherjee, 2013. One of them is interactive multimedia to enhance learning motivation and learning students who have lost interest in the course, may be because of the abstract nature of the subject (Adeyemo, 2010. Siddiquah & Salim (2017) said that students spend more time on computers for recreational and other purposes than for academic purpose (Cakiroglu & Yilmaz, 2017; Kainz et al, 2013; Adlim, 2018). They believe that the use of information and communication technology (ICT) supports their learning our results provide proof that is indeed an effective mode students' thinking. Masino & Nin˜o-Zarazu (2016) stated that our findings suggest that interventions are more effective at improving student performance and learning when social norms and intertemporal choices are factored in the design of education policies, and when two or more drivers of change are combined. Manurung (2012) stated that argumentation is thinking ability that can occur in students who carry out discussions and debates to solve assigned problems. building knowledge based on epistemic aspects requires a dialogical approach with evaluation of evidence and rational reasons in scientific ideas.

CONCLUSION

In conclusion, learning media in the form of interactive multimedia tools is reasonably capable of providing learning experiences that correspond to the level of cognitive development of students. Edgar Dale classifies learning experience of children ranging from things that most concrete up to things that are considered the most abstract. The classification of such experiences is widely followed by the educational circles in deciding what tools should be appropriate to the particular learning experience (Arsyad, 2009), one of them is interactive multimedia to enhance students' skills in generic science class (Cronje., J.S & Fouche, 2008). Our results provide proof that is indeed an effective mode students' thinking

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3. Email konfirmasi dari Editor in Chief setelah proses submit selesai

Gmail

Sondang Manurung <sondangrina@gmail.com>

[CP] Submission Acknowledgement

2 pesan

Prof. Dr. Burhan Nurgiyantoro <cakrawala@uny.ac.id> 19 November 2019 10.01
Kepada: Ms Sondang R Manurung <sondangrina@gmail.com>

Dear Ms Sondang R Manurung,

Thank you for submitting the manuscript, "IMPROVING STUDENTS' THINKING ABILITY IN PHYSICS USING INTERACTIVE MULTIMEDIA-BASED-PROBLEM-SOLVING" (MMI-PS)" to Jurnal Cakrawala Pendidikan. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

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https://journal.uny.ac.id/index.php/cp/author/submission/28205
Username: sondang

If you have any questions, please contact me. Thank you for considering this journal as a venue for your work.

Sincerely,

Prof. Dr. Burhan Nurgiyantoro
Jurnal Cakrawala Pendidikan

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4. **Tampilan OJS “Submission – Summary”**

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#28205 Summary

SUMMARY REVIEW EDITING

Submission

Authors	Sondang R Manurung, Deo Demonta Panggabean
Title	IMPROVING STUDENTS’ THINKING ABILITY IN PHYSICS USING INTERACTIVE MULTIMEDIA BASED PROBLEM SOLVING
Original file	28205-72134-1-SM.DOC 2019-11-19
Supp. files	None
Submitter	Ms Sondang R Manurung
Date submitted	November 19, 2019 - 10:01 AM
Section	Articles
Editor	Endah Retnowati, Ph.D
Abstract Views	0

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5. **Tanggal 19 Juni 2020 Proses Review Tahap I (Komentar Reviewer A dan Reviewer B) melalui email oleh Editor Ibu Endah Retnowati, Ph.D**

Gmail **Sondang Manurung <sondangrina@gmail.com>**

[CP] Editor Decision (revision required)
1 pesan

Endah Retnowati, Ph.D <e.retno@uny.ac.id> 19 Juni 2020 01.50
Kepada: Ms Sondang R Manurung <sondangrina@gmail.com>

Dear Ms Sondang R Manurung,

We have reached a decision regarding your submission to Jurnal Cakrawala Pendidikan, "IMPROVING STUDENTS’ THINKING ABILITY IN PHYSICS USING INTERACTIVE MULTIMEDIA-BASED-PROBLEM-SOLVING” (MMI-PS)".

We require you to revise your manuscript. Please see notes from the reviewer, and also the comments in the soft-copy of your article. You can download these from your dashboard account.

You must see the author guidelines to revise your manuscript. Additionally, you must add title, abstract, and keywords in Bahasa Indonesia too.

Revision deadline: 24 June 2020; to be considered to publish in the current issue, all comments from the reviewers must be accommodated.

On behalf of the editorial board,
Endah Retnowati, Ph.D
Department of Mathematics Education,
Universitas Negeri Yogyakarta
(Scopus ID: 36006825500)
e.retno@uny.ac.id
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Reviewer A:

1. Ikuti pedoman penulisan artikel.

2. References: gunakan APA style dan jurnal CP.

Reviewer B:

Artikel ini masih perlu banyak revisi untuk dapat dipublikasikan, antara lain:

1. Di abstrak tertulis quasi-eksperimen; di method tertulis eksperimen. Mana yang benar?

2. Perjelas variabel bebas dan variabel terikat yang tertulis di abstrak dan method harus sama

3. Tuliskan hipotesis penelitian di paragraf akhir intriduction

4. Berapa lama alokasi waktu pembelajaran? Tulis di bagian method

5. Di bagian method tertulis teknik analisis dengan Anova; di bagian finding tertulis dengan t-test. Mana yang benar?

6. Di bagian findings, figure 2 nampak bahwa data postes tdk mendekati kurva normal. Kok tidak ada penjelasan tentang asumsi normalitas/homogenitas sebagai syarat analisis?

7. Tabel 2 tidak ada gunanya karena "redundant" dengan yang sudah dijelaskan di teks dan di figure

8. Table 4 ini kok aneh. Mengapa membandingkan sebelum-sesudah kelas kontrol? Untuk apa? Jika memang perlu, mana pembandingan untuk kelas eksperimen?

9. Discussion: sebaiknya diawali dengan paragraf yang menjelaskan ulang tujuan/hipotesis penelitian.

10. bagian discussion ini kurang mendalam. Sebetulnya mudah sekali diduga konvensional tidak lebih efektif. Namun, pembelajaran interaktif juga tidak selalu mudah diikuti siswa. Coba tambah lagi penjelasan, kelebihan dan kekurangan masing-masin gmetode.

11. Di bagian method, tambah topik pembelajarannya. Di bagian discussion, bahas apa kesulitan memelajari topik ini sehingga metode interaktif bisa mendukung.

12. Banyak sekali typo/salah ketik. Bahasa Inggrisnya juga belum di proofreading-kan

13. Penulisa daftar pustaka masih banyak yang salah. Harus mengusahakan ada doi untuk jurnal yg memang ada doi-nya dan tulis sesuai panduan.

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Komentar Reviewer A dan B	Keteraran/ Hasil Revisi
Ikuti pedoman penulisan artikel.	Sudah disesuaikan dengan pedoman penulisan artikel
References: gunakan APA style dan jurnal CP. Penulisan daftar pustaka masih banyak yang salah. Harus mengusahakan ada doi untuk jurnal yg memang ada doi-nya dan tulis sesuai panduan.	Abungu, H. E., Okere, M. I., & Wachanga, S. W. (2014). The effect of science process skills teaching approach on secondary school students' achievement in chemistry in Nyando District, Kenya. Journal of Educational and Social Research, 4(6), 359. doi: 10.5901/jesr.2014.v4n6p359 Adeyemo, S.A (2010). Students' Ability Level And Their Competence In Problem-Solving Task In Physics. International Journal Of Education Research And Technology. 1(2), 35- 47. ADLIM, M., NUZULIA, R., & NURMALIAH, C. (2018). The Effect of Conventional Laboratory Practical Manuals on Pre-Service Teachers' Integrated Science Process Skills. Journal of Turkish Science Education, 15(4), 116-129. doi: 10.12973/tused.10250a Arends, R. I., (2012), Learning To Teach Ninth Edition, New York, Mcgraw Hill. Arsyad, S. (2019, March). Struggling for International Publication: The Potential Rhetorical Problems for Indonesian Scholars in Social Sciences and Humanities when Writing in English. In Seventh International Conference on Languages and Arts (ICLA 2018). Atlantis Press. doi : 10.2991/icla-18.2019.77 Barsalou, L. W. (2012). The human conceptual system. In M. J. Spivey, K. McRae, & M. F. Joanisse (Eds.), Cambridge handbooks in psychology. The Cambridge handbook of psycholinguistics (p. 239–258). Cambridge University Press. doi : 10.1017/CBO9781139029377.017 Bhat, M. A. (2016). The predictive power of reasoning ability on academic achievement. International Journal of Learning, Teaching and Educational Research, 15(1). doi : 10.15373/2249555X/August2014/195. Bello, A. (2014). The acquisition of the six formal reasoning abilities by students in Kaduna state, Nigeria. International Journal of Education and Research, 2(60), 613-628. doi : http://dx.doi.org/10.2139/ssrn.1947369 Bimba, A., Idris, N, Mahmud, R. Abdullah, R., Abdul-Rahman, S-S., Bong, C. H. (2013). Problem Representation For Understanding Physics Problem. Research Notes In

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<tr><td></td><td>Spiro, R. J. (1988). Cognitive flexibility theory: Advanced knowledge acquisition in ill-structured domains. Center for the Study of Reading Technical Report; no. 441.

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Ungaretti, T., Thompson, K. R., Miller, A., & Peterson, T. O. (2015). Problem-based learning: Lessons from medical education and challenges for management education. Academy of Management Learning & Education, 14(2), 173-186. doi : https://doi.org/10.5465/amle.2013.0245

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Tobin, K. G., & Capie, W. (1981). The development and validation of a group test of logical thinking. Educational and Psychological measurement, 41(2), 413-423. doi : https://doi.org/10.1177/001316448104100220</td></tr>
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<tr><td></td><td>used and students are divided into two sample groups, i.e. the experimental and control groups. Data were analyzed using analysis of t-tes. The test of science process skills in the form of formal descriptions as well as reasoning tests in the form of descriptions was used as instruments for this study. The results showed that the problem-solving ability of students who studied physics using interactive multi-media based problem solving was better than students who learn through conventional methods.</td></tr>
<tr><td>Tuliskan hipotesis penelitian di paragraf akhir intriduction</td><td>Based on the study discussed above, this current study will evaluate the improvement of thinking ability in physics through an interactive multimedia-based learning problem solving (MMI-PS). We hypothesize this model can improve thinking ability and skills in solving ill-structured problems (Byun et al., 2014; Manurung and Panggabean, 2017; De Sousa, 2017). The hypothesis of this study is: “Learning by using interactive multimedia based on problem solving (MMI-PS) can improve students' thinking abilities”</td></tr>
<tr><td>Berapa lama alokasi waktu pembelajaran? Tulis di bagian method</td><td>The research method adopted in this study was an experiment (Fraenkel et al., 2011) by testing the model in a limited class with pre-test–post-test control group design. Time Allocation of time is 2 months.</td></tr>
<tr><td>Di bagian method tertulis teknik analisis dengan Anova; di bagian finding tertulis dengan t-test. Mana yang benar?</td><td>Statistic analysis is t-test was used to find out whether interactive multimedia-based learning containing problem-solving (IMM-PS) can improve students' thinking. Based on the analysis of preliminary study needs, it is found that students and professors of the multimedia program in learning were activated and followed by analyzing interactive multimedia.</td></tr>
<tr><td>Di bagian findings, figure 2 nampak bahwa data postes tdk mendekati kurva normal. Kok tidak ada penjelasan tentang asumsi normalitas/homogenitas sebagai syarat analisis?</td><td>Test normality of the pretest and posttest data of the experimental class and the control class is used to determine whether the pretest and posttest data are normally distributed. Normality test is done by using Liliefors test.
Homogeneity test is performed to determine whether the sample taken is variant homogeneous or not. Homogeneity test of the experimental class pretest and the control class using the two variance similarity test.</td></tr>
<tr><td>Tabel 2 tidak ada gunanya karena "redundant" dengan yang sudah dijelaskan
di teks dan di figure</td><td>Sudah dihilangkan</td></tr>
<tr><td>Table 4 ini kok aneh. Mengapa membandingkan sebelum-sesudah kelas kontrol? Untuk apa? Jika memang perlu, mana pembandingan untuk kelas eksperimen?</td><td>Diganti menjadi Tabel 3
Table 3. Normality Test
<table>
<tr><th rowspan="2" colspan="2">Group</th><th colspan="2">Data</th><th rowspan="2">CONCLUSION</th></tr>
<tr><th>L_{count}</th><th>L_{tablel}</th></tr>
<tr><td rowspan="2">Pretest</td><td>Experiment</td><td>0,1454</td><td>0,1498</td><td rowspan="2">Normal</td></tr>
<tr><td>Control</td><td>0,1454</td><td>0,1498</td></tr>
<tr><td rowspan="2">Postest</td><td>Exsperiment</td><td>0,1483</td><td>0,1498</td><td rowspan="2">Normal</td></tr>
<tr><td>Control</td><td>0,1346</td><td>0,1498</td></tr>
</table></td></tr>
</table>

Discussion: sebaiknya diawali dengan paragraf yang menjelaskan ulang tujuan/hipotesis penelitian.	The results of this study that using a problemsolving model, especially on dynamic fluid materials, resulted in a very good average scores and moderately increased students' ability to think
Bagian discussion ini kurang mendalam. Sebetulnya mudah sekali diduga konvensional tidak lebih efektif. Namun, pembelajaran interaktif juga tidak selalu mudah diikuti siswa. Coba tambah lagi penjelasan, kelebihan dan kekurangan masing-masin metode.	According to Arends (2012), a problem based learning approach to learning, in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher as a facilitator then student must be persistent in solving the problems presented, then all the characters of the students will show themselves and students can develop independence and confidence so that the ability to think can be achieved.
Banyak sekali typo/salah ketik. Bahasa Inggrisnya juga belum di proofreading-kan	Sudah diperbaiki

6. **Tanggal 24 Juni 2020 Seselai memperbaiki artikel sesuai komentar reviewer**

IMPROVING STUDENTS' THINKING ABILITY IN PHYSICS USING INTERACTIVE MULTIMEDIA-BASED-PROBLEM-SOLVING" (MMI-PS)

Sondang R. Manurung[1*] & Deo Demonta Panggabean[1]
[1]Universitas Negeri Medan, Indonesia
[*] e-mail : sondangrina@gmail.com

Abstract : The purpose of this paper is to evaluate factors affect student learning outcomes. The independent variable is a teaching method in the form of interactive multi media based on problem solving (MMI-PS) and the dependent variable is students' thinking ability in physics. To answer this goal, a quasi-experimental method was used. Study groups were drawn from the "Educational Personnel Educational Institutions" (LPTK) (training institutions for education practitioners) in Medan, Indonesia. Random cluster samples were used and students are divided into two sample groups, i.e. the experimental and control groups. Data were analyzed using analysis of t-tes. The test of science process skills in the form of formal descriptions as well as reasoning tests in the form of descriptions was used as instruments for this study. The results showed that the problem-solving ability of students who studied physics using interactive multi-media based problem solving was better than students who learn through conventional methods.

Keywords: thinking ability, physics, interactive multimedia, problem solving.

INTRODUCTION

Teacher education institutions recognize the power of establishing competent, unconstrained, and adaptive classroom teachers who can reckon with the progressively complex demands of learning. The problems school teachers deal with are mainly real-world, ill-structured problems and are thus extremely emergent and interdisciplinary in nature (Jonassen, 2011). Physics is one of the sciences that underlie the development of technology, hence students need to learn it in the form of general physics (Halliday et al, 2011).

As prospective lecturers, students majoring in physics education are expected to have high thinking ability. The training institute for education practitioners (Lembaga Pendidikan Tenaga Kependidikan or LPTK - Training Institute for Education Practitioners) has not been successfully conducted to the improvement of lecturers' competence. A study by Manurung (2013) at one of LPTK in Medan shows that the teaching of physics is still overly teacher-centered. University teachers tend to learn through lectures, questions, and answers, which we called as the conventional method. The learning system adopted in teaching general physics course still the validity of existing theories carried out by strictly following a set of provided procedures.

The conventional system produced several facts that need to be concerned by a respected authority. The conventional learning system is downright boring as students are required to listen to their lecturer in long hours. The learning is aimed at simply students memorize the theories. As a result, students frequently possess a deficiency of credence, weak competence to work as part of a team, possess weak written and oral communication, etc. (Chen et al., 2013).

Another fact in conventional learning physic was students' lack of experience to be able to solve problems. Problems given are rarely relevant to contextual issues in the everyday lives of students, so this learning becomes less meaningful to students. Those shreds of evidence arise from low participation in teaching and learning activities and their relatively low achievement.

Furthermore, many problems in the teaching of general physics have been identified: (a) the learning process does not present relevant phenomenon, (b) lack of discovery process, (c) lack of learning media, and (d) weak understanding of the concepts. These problems cause difficulties for students to understand the concepts of general physics graphics presented in learning physics.

One of the important factors that influence the low performance of science lecturers is the lack of effective pre-service teacher education (Fhaeizdhyall et al., 2018). Teachers' quality is a major factor in increasing teaching and learning quality. Thus, there is a vital need to improve professionalism in the field of education (Depdiknas, 2010).

A sustainable and effective teacher education to improve teachers' quality is crucial. Equipping with knowledge and hands-on experience in doing physics experiments that involve abstract physics concepts interactive multimedia is relevant because not all experiments can be done directly in the laboratory. Most students experience difficulties in solving physics problems neither do they have a deep understanding of the fundamental concepts in the problem.

To overcome this situation, we propose a computer-assisted learning tool (Bimba et al., 2013) known as the adaptive learning environment for problem-solving (ALEPS). ALEPS is based on "Polya stages of problem-solving" that consists of 1) understanding; 2) planning; 3) applying, and 4) checking. Thinking and problem-solving skills as well as speed in problem solving are only developed through practice and feedback. Testing students on skills they have not had an opportunity to practice is unfair (Heller and Heller, 2010; Gorghiu et al., 2015).

Fenelon (2012) designed a thinking model and laboratory content on the web-based basic physics lecture and found that long-distance students' as those with direct interaction. A virtual for various concepts of basic algebra-based physics through project PHET (physics education technology) is reported by Habibi and Habibi (2015) to cope with a large number of participants course in universities.

Since the advanced of internet technology, computer, and related technology have been studied extensively in its role in learning outcomes (such as Karimova and Zhetpeisova, 2020; Kapi et al., 2018; De Sousa, 2017; Habibi and Habibi, 2015; Chetty, 2015). Habibi and Habibi (2015) and Chetty (2015) revealed that computers can be used to support the implementation of practical physics for gathering, presenting, and manipulating data. Kapi et al (2018) also argue that many forms of interaction may be presented through the computer serving as practices and exercises, tutorials, games, simulation, discovery, and thinking.

The role of multimedia technology in the learning process has been proposed by many scholars (such as Karimova and Zhetpeisova, 2020; Kapin, 2018; De Sousa, 2017; Cunningham, 2009). Karimova and Zhetpeisova (2020) posited that multimedia technology represents one of the most promising areas of computerization of the educational process. The utilization of multimedia in learning encourages students to the process of the invention (discovery learning process) (De Sousa, 2017) and can solve ill-structured problems (Cunningham, 2009).

Kapin (2018) posited interactive multimedia as audio-visual media can show phenomena in physics in a more realistic manner. More real visualization strongly supports the learning process. In addition, students involved in the learning process. As such, students' skills will increase, which in turn will hopefully encourage the emerges of students' creativity.

Thinking is a complex process and is important in every day of learning physics. Problem-solving tests focus at the end of the result or the middle of the process of learning, rather than on the quality of the procedures and the reasoning that leads to results. Thinking skills developed in general physics present a situation where certain information is given, more often as numerical values for the variables in those situations, so that the value of other variables can be determined. So, the problem tends to be well-defined.

Meanwhile, life physical problems or those faced by physicists are mostly ill-structured problems, a problem that must be solved through innovative physics (Cunningham, 2009). Lawson (2010) states that the ability to think is a person's ability to solve problems, to think and devise solutions with a logical sequence (sense), as well as career and work. Thinking ability make problem-solving important to get the work.

Thinking ability shows that a person has formal reasoning. According to Piaget (1964) there are five aspects of the operation of formal reasoning, namely: proportional reasoning, control variables, proportional reasoning, correlational reasoning, and combinatorial reasoning. According to Arends (2012), problem-solving based learning can improve thinking ability.

Based on the study discussed above, this current study will evaluate the improvement of thinking ability in physics through an interactive multimedia-based learning problem solving (MMI-PS). We hypothesize this model can improve thinking ability and skills in solving ill-structured problems (Byun et al., 2014; Manurung and Panggabean, 2017; De Sousa, 2017). The hypothesis of this study is: "Learning by using interactive multimedia based on problem solving (MMI-PS) can improve students' thinking abilities"

METHODS

The research method adopted in this study was an experiment (Fraenkel et al., 2011) by testing the model in a limited class with pre-test–post-test control group design. Time Allocation of time is 2 months. This research involves two classes that were treated differently. Each of the two classes was assigned to experimental and control groups. The experimental class taught using interactive multimedia-based learning containing problem-solving (IMM-PS) while the control group taught using the conventional learning method. The research sample consists of 35 students per class, i.e. second years of physics education students. Second-year students get a general physics, each number 35 persons per class. We performed two (2) studies. Study 1 was the implementation of IMM-PS on an experimental group that was consists of 35 students. Study 2 was performing teaching using a conventional learning method to control group that was consists of 35 students as well. Both studies followed 6 steps as shown in Fig. 1 and 2.

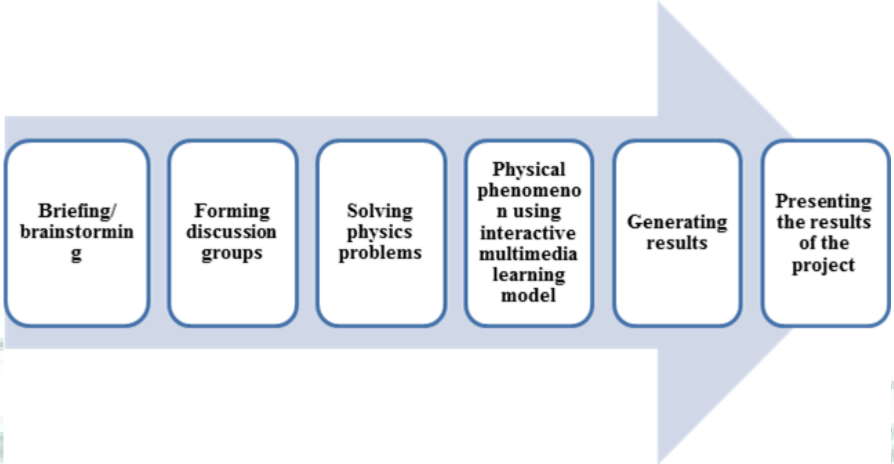

Figure 1. Steps in the interactive multimedia based on learning model containing problem solving.

The study was started with the provision of pre-tests in both groups. Having completed the pre-test, treatment of MMI-PS was implemented in the experimental group. While in the control group was implemented conventional treatment. In the experimental group, the steps were carried out as shown in Figure 1. At the beginning with a briefing for brainstorming steps was called is brainstorming activities is briefing activity.

In the learning instruction, there were discussion groups, to discuss physics problems. The third step was to solve the problems. Problem-solving techniques were deployed in the meeting, where group problem-solving involved the spontaneous contribution of ideas by all members of the group, also in order to compile or find a workaround. The fourth step was to look at physical phenomena to investigate physical phenomena by using problem-solving interactive multimedia and discussion as seen in Figure 2.

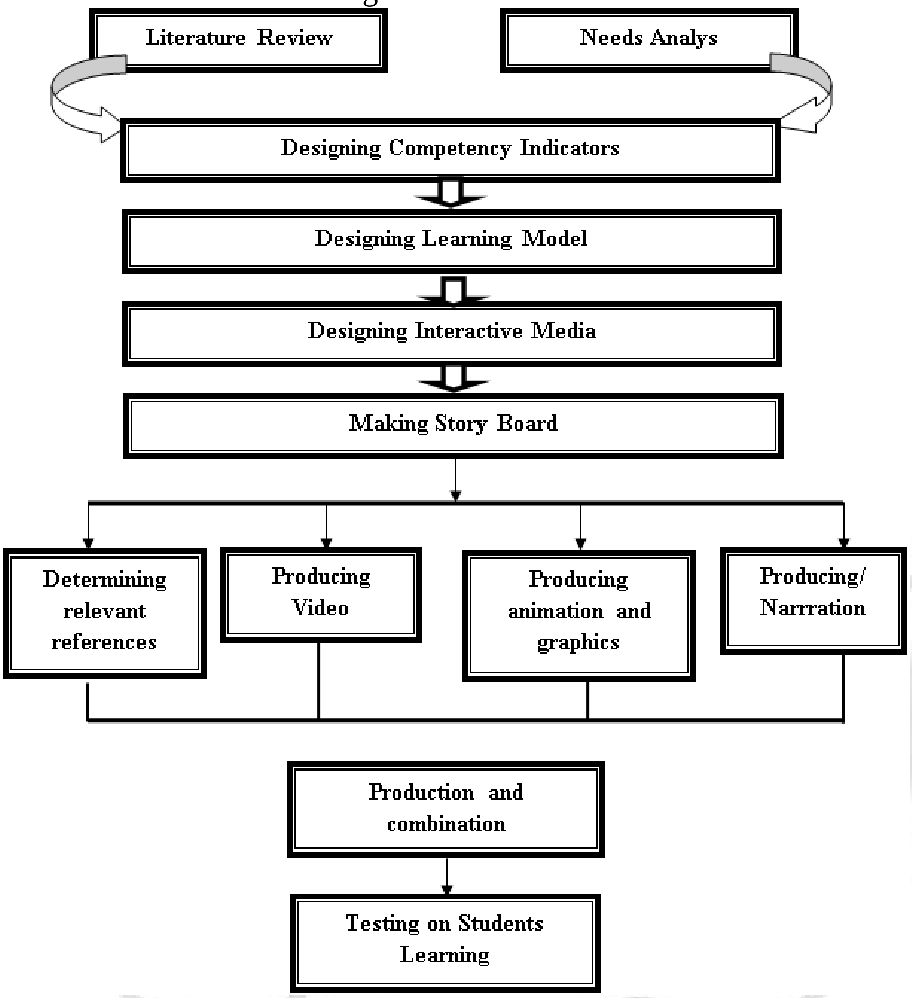

Figure 2. Paradigm of the based on the phylosophy

Thinking-laden interactive multimedia helps students investigate physical phenomena while solving problems in a group Figure 3. Problem-based learning (PBL) is a learning approach that uses real-world problems as a context for students to learn critical thinking and problem-solving skills, as well as to acquire mastery of the knowledge and essential concepts of the subject matter (Sudarman, 2007). PBL challenges students to find solutions to existing problems in the real-world through group work. The fifth step was to find the findings of physical symptoms. Finally, the sixth step presented the findings.

Figure 3. Features of MMI-PS.

The research instrument was a thinking ability test. It is a test of logic thinking (TOLT). TOLT consists of 10 multiple choice questions in which instrument validity and reliability have been ensured. This instrument developed by Tobin and Capie (1981). The value of the validity and reliability of the instrument TOLT was 0.67 and 0.80. Instrument translated into the English language (Tobin and Capie, 1982). The research sample consisted of 35 students per class, i.e. second-semester physics education students. The research carried at an LPTK in Medan, as research and problem-solving learning effectivity test site.

Statistic analysis is t-test was used to find out whether interactive multimedia-based learning containing problem-solving (IMM-PS) can improve students' thinking. Based on the analysis of preliminary study needs, it is found that students and professors of the multimedia program in learning were activated and followed by analyzing interactive multimedia.

With a controller that can be operated by the user, so thus the user can select what is desired for the next process. Example of interactive multimedia includes learning games, applications, etc. The paradigm of the based on philosophy multimedia-based learning is shown in Figure 2. Figure 2 describes the preliminary stage of the study namely the literature review and needs analysis required for the formulation of competency indicators to determine the learning, multimedia, and storyboard designs, features, which finally tested on students and discussed with an expert. Interactive multimedia allows the user to realize potential no longer passive reader, but rather as a co-author, as they determine the sequences of their reading experience potential, will have the ability to rearrange their knowledge with respect to the condition of complex knowledge.

An example of interactive multimedia is shown in Figure 4. The movement of the pendulum harmonic phenomena is often considered simple, but in fact, it is not simple. Many factors give rise to the complexity, such as object of the phenomenon, representation of measurement (such as the position of the pendulum in a particular cycle of oscillation), and representation of the pendulum phenomenon graphic according to time and speed.

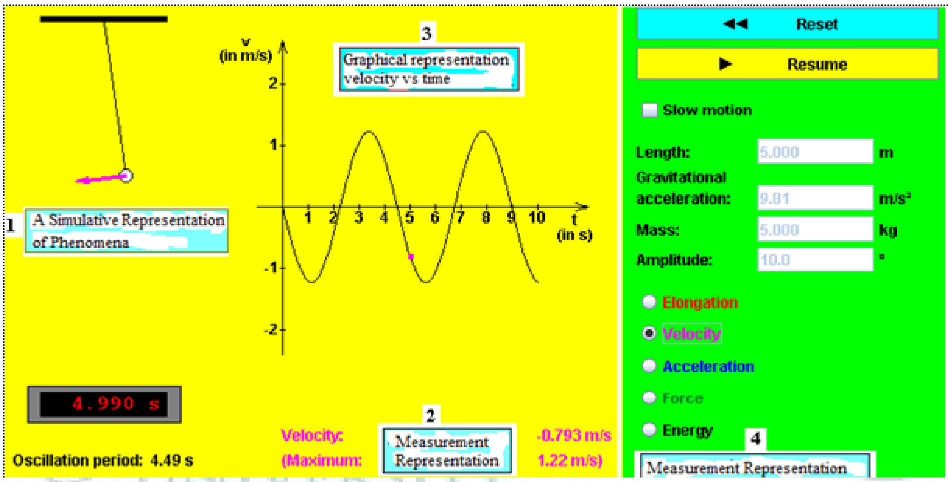

Figure 4. The pendulum symptom, according to the knowledge representative constructs basic knowledge about pendulum.

Figure 4 shows the process of building knowledge according to the complexity of symptoms that can be done according to the user's navigation. The simulation allows users to reconstruct the needs to improve the substantiation and transfer capabilities a complex concept which refers to advanced knowledge obtained (Nickel, 2014) through research simulation. According to Heller and Heller (2010), the strategies of problem-based learning consisted of five steps, : (a) the problem (the focus of the problem), (b) the concept in (describe the physics), (c) planning solutions, (d) out the plan (execute the plan), and (e) an evaluation of the solution.

FINDINGS AND DISCUSSION

Findings

At the beginning of the study, students in both classes were given a pre-test (initial competency test) that aimed to find out whether their thinking ability was on the same level. The results of the experimental class and control class ranged from 0 to10. The score of pre-test results of control and experimental groups is shown in Figure 5.

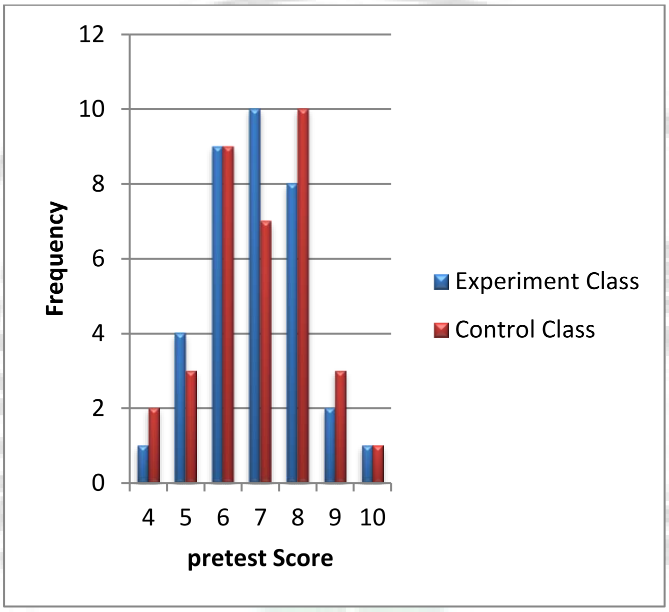

Figure 5. Pretest scores of the experiment classes and control classes.

As shown in Figure 5, in the control class the lowest score of the pre-test was 4 (2 people), and the highest score was 10 (1 person). It was also found similar to the lowest and the highest scores in the experimental group. The difference was only in the number of students obtained the lowest score. In the experimental group, the lowest score was obtained by 1 participant.

The pre-test average score of the control group was higher than the experimental group as shown in Table 1. The average score of the control group was 6.94 and the standard deviation was 1.43. Whilst, the average score of the experimental group was 6.86 and the standard deviation was 1.3.

Table 1. Average value of pretest scores both groups.

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
pretest	experiment	35	6,8571	1,30931	,22131
	control	35	6,9429	1,43369	,24234

Although the average score of the control group was higher than the experimental group, the difference is not significant, as shown in Table 2. The significance was 0.518 which led to accepting the hypothesis, that it is no different in the pre-test score between the control group and the experimental group. This result showed that both groups departing from the same level of understanding (knowledge) of kinematics theory.

Table 2. T-test different of control and experimental groups of pre-test.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
pretest	Equal variances assumed	,423	,518	-,261	68	,795	-,08571	,32819	-,74060	,56917
	Equal variances not assumed			-,261	67,448	,795	-,08571	,32819	-,74070	,56927

Test normality of the pretest and posttest data of the experimental class and the control class is used to determine whether the pretest and posttest data are normally distributed. Normality test is done by using Liliefors test. The normality test results for the pretest and posttest of the two classes are stated in table 3. Following

Table 3. Normality Test

Group		Data		CONCLUSION
		L_{count}	L_{tablel}	
Pretest	Experiment	0,1454	0,1498	Normal
	Control	0,1454	0,1498	
Postest	Exsperiment	0,1483	0,1498	Normal
	Control	0,1346	0,1498	

From the table above, for the experimental class the pretest value was obtained at a price = 0.1454 and for the posttest value obtained a value of 0.1483. At a significant level = 0.05 and n = 35, the price = 0.1498 is obtained>. While in the control class the value of pretest is obtained with a price = 0.1454 and for the posttest value is obtained = 0.1346. At a significant level = 0.05 and n = 35, the price = 0.1498 is obtained>. Thus, it can be concluded that the data from the two samples come from normally distributed populations.

Homogeneity test is performed to determine whether the sample taken is variant homogeneous or not. Homogeneity test of the experimental class pretest and the control class using the two variance similarity test. The results of the homogeneity test calculation are shown in Table 4.

Table 4. The results of the homogeneity test

No	Pretest Data	Varians	F_{count}	F_{talel}	Conclusion
1	Eksperiment Class	1,71	1,205	1,776	Homogen
2	Kontrol Class	2,06			

Table 4 shows that Fcount <Ftable is 1.205 <1.776 with α = 0.05, it can be concluded that the pretest data is homogeneous

In line with the objective of the study, our central concern was the effect of the control factor, i.e. using MMI-PS to improve student's thinking ability. This treatment was implemented in the experimental group. The lowest score was increased after implementing

MMI-PS, which was 6 (1 participant) and the highest score of 10 was achieved by five participants.

However, the lowest score in the control class also increased to 5 (3 participants). The total of participants getting the highest score of 10 was added to 4 participants. The score averages between the two groups were also changed.

Based on Table 3, the experimental group achieved a bigger average score than the control group. In the experimental group, the average score of the post-test was 8.43 with a standard deviation of 1.04. Meanwhile, in the control group, the average score of the post-test was 7.49 with a standard deviation of 1.46.

Since the average scores in both groups were different, we proceeded to t-test. The result is shown in Table 4. As can be seen in Table 4, the p-value (significance) was 0.038. The statistical result indicated that there was a significant difference at 5% between the average score of the experiment and control groups.

Further, we performed a meaningful comparison of pre-test and post-test within the group. Table 5 depicts the t-test in the experimental group before and after the implementation of IMM-PS. It has resulted in a significant value of 0.000, less than 0.05. It implies that IMM-PS improve student thinking ability. The score achieved was increased significantly with IIM-PS implementation.

Table 5. T-test different of experimental group.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 pretest - posttest	-1,57143	,55761	,09425	-1,76297	-1,37988	-16,673	34	,000

Table 6 shows the t-test of score means before and after the learning in the control group. The resulted significance value was 0.000. it implies similar evident between experimental group and control group, i.e. there was an improvement in thinking ability after the learning. However, the improvement in thinking ability was better in the experimental group than in the control group.

Table 6. T-test different of control group.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 pretest - postets	-,54286	,50543	,08543	-,71648	-,36923	-6,354	34	,000

Discussion

This study shows there is an increase in students' thinking skills after being taught by using interactive multimedia based on problem solving (MMI-PS) in line with of study Abungu et al (2014). This current study is strengthening previous studies in the ability of MMI-PS to improve student thinking ability (such as Byun et al., 2014; Manurung and Panggabean, 2017; De Sousa, 2017; Abungu et al., 2014; Arends, 2012; Manurung, 2012; Kharida et al., 2009). The utilization of multimedia in learning encourages students to the process of the invention (discovery learning process) (De Sousa, 2017) and can solve ill-structured problems (Cunningham, 2009).

Interactive multi-media (virtual labs), can be defined as a series computer programs that can visualize abstract phenomenaor complicated experiments carried on real laboratory, so as to increase learning activity in an effort to develop that skill needed in trouble shooting. For example, it is very important to give a real example in the daily life of the benefits of ideal gas. This approach makes the class interesting for students. If the class is interesting, they will be more happy and more likely to absorb lessons. In this activity, the students conduct their own lab with the help of student worksheet. The results of the experiment is analysed then discussed in class and concluded. This makes learning interesting and not boring. It is hoped that this method can aid students in understanding the teaching materials as well as finding solutions for many poorly structured problems. This study aimed to evaluate how using interactive multimedia help lectures improve students' thinking ability and problem solving abilities.

By using a problem-solving model, the thinking ability of the student will be improved (Manurung, 2012; Jabarullah and Hussain, 2019). Manurung (2012) provided evidence of the benefit of using a problem-solving model on dynamic fluid materials. Meanwhile, Jabarullah and Hussain (2019) provided evidence of the significant effect of problem-based learning in increasing student performance of Vocational Education and Training (HTVET). In a problem-based learning approach, students work on authentic problems in a collaborative group (Sada et al., 2015; Ungaretti et al., 2015) in order to enhance deep learning (Delaney et al., 2015).

In our study, the problem-based learning approach was integrated with multimedia. Thus, the improvement of student's ability to think logically was enhanced due to media used. Islam et al. (2014) provided evidence that the use of multimedia animation as teaching media improved students' thinking process. It can be inferred that there exists a difference in logical thinking abilities between the two student classes.

Learning that uses multimedia encourages students to be actively engaged in the thinking process with regards to the material and linking learning to real-life situations. Thereby, students are motivated to remember and apply the knowledge in everyday life situations. In other words, students are not just passively accepting material from a lecturer but are actively solving problems.

Our result also supported previous studies (such as Ibrahim, 2012; Arends, 2012; Adeyemo, 2010). Ibrahim (2012) states that there is an increase in the average cognitive logic thinking ability of students taught using the problem-based learning model. Therefore, by applying this model, students can acquire knowledge and skills more effectively, as proven by Arends (2012). Arends (2012) posits that a problem-based approach to learning in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher acts as a facilitator requires that students be persistent in solving the problems presented. He also states that during the problem-solving process, the problem of the character of the students themselves will be apparent so that students can develop self-reliance and confidence in achieving logical thinking abilities. Adeyemo (2010) also states that there is an increase in cognitive ability among students who are positively affected when problem-solving tasks in physics are discussed.

When using various multimedia combinations, the unique nature of social sciences can be addressed effectively (De Sousa et al., 2017). There exist a difference in logical thinking ability between the two classes. This is because, learning using multimedia helps encourage students to be actively engaged in the process of thinking with regard to the material and link it to a real situation (Erceg et al., 2011). In such an environment, students are encouraged to be able to remember and apply the knowledge in everyday life.

Students are not just passively accepting material from the lecturer but also actively solve problems. In contrast to interactive multimedia-based learning given in the experiment class, teaching activities conducted in the control class failed to improved students' scores ($p<0.05$) (Jarosievitz, 2015). This shows that the method used in the control class was not effective in improving logical reasoning.

This finding also supported Lawson (2010), who argues that certain learning approaches, such as lectures, are not effective in improving logical reasoning. Bello (2014) said that the experimental group exposed to the process skill instruction approach performed significantly better to improve formal thinking ability than the control group exposed to the traditional instruction. Erceg et al. (2011) stated in their work that the students were assigned to solve one part special issue to investigate their problem-solving strategies. Lawson (2010) showed that students' score in 'lawson classroom test of formal reasoning was correlated with their achievement in school subjects i.e. social studies, science, and mathematics. this finding has provided concrete evidence that formal reasoning abilities can be related to students' general performance, not only to science and mathematics. Manurung (2014) studied that in identifying elementary school students' thinking skills, they do logical thinking tasks.

The results showed, to answer the question of physics, students must use the laws of physics to calculate the requested physical quantity, in accordance with the steps to solve the problem. They also have to calculate the number of answers from physics problems in everyday conditions. Tasks like these can help different concepts and techniques of problem-solving are accepted, and train students and teachers to solve problems in everyday life using physical principles and assumptions. Problem-based interactive multimedia learning (MMI-PS) shows physical phenomena in an animated way and there is a nuanced teaching problem solving. While the conventional method is to solve mathematical problems mathematically.

CONCLUSION

In conclusion, learning media in the form of interactive multimedia tools is reasonably capable of providing learning experiences that correspond to the level of cognitive development of students. Barsalo (2014) classifies the learning experience of children ranging from things that most concrete up to things that are considered the most abstract. The classification of such experiences is widely followed by the educational circles in deciding what tools should be appropriate to the particular learning experience (Mukherjee, 2013).

One of them is interactive multimedia to enhance learning motivation and learning students who have lost interest in the course, maybe because of the abstract nature of the subject (Adeyemo, 2010). Students spend more time on computers for recreational and other purposes than for academic purposes (Kainz et al., 2013; Cakiroglu and Yilmaz, 2017; Siddiquah and Salim; 2017; Adlim, 2018). They believe that the use of information and communication technology (ICT) supports learning.

Our results provide evidence that is indeed an effective model of students' thinking. Our findings also inline with Masino and Nin˜o-Zarazu (2016) that interventions are more effective at improving student performance and learning when social norms and intertemporal choices are factored in the design of education policies, and when two or more drivers of change are combined. Manurung (2012) stated that argumentation is thinking ability that can occur in students who carry out discussions and debates to solve assigned problems. Building knowledge-based on epistemic aspects requires a dialogical approach with the evaluation of evidence and rational reasons in scientific ideas.

The topic of Ideal Gas is difficult to teach through conventional learning. After the pre-test, the two classes received different teaching methods. In the control class, a researcher taught the lesson using conventional method where educators provide. learning through lectures. Meanwhile in the experimental class, educators taught using a multimedia-based learning model. Here, educators used computer media to make students more active in analyzing a problem. Learning materials were 1. Understanding and characteristics of ideal gas, 2. Laws on ideal gas and 3. Application of the ideal gas equality equation

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7. **Tanggal 24 Juni 2020 mensubmit kembali Artikel yang sudah diperbaiki sesuai komentar reviewer tanggal 19 juni 2020 melalui OJS Cakrawala Pendidikan**

8. **Tanggal 25 Juni 2020 Review Tahap II, komentar reviewer melalui WhatsApp**

[08:52, 6/25/2020] Endah Retnowati Cakrawala: Bu, revisi blm ada abstrak bhs Indonesia
[08:52, 6/25/2020] Endah Retnowati Cakrawala: Mohon lihat panduan
[08:53, 6/25/2020] Endah Retnowati Cakrawala: Dan contoh yg sudah terbit artikel penulis dari Indonesia

9. **Tanggal 25 Juni 2020 menambahkan abstrak dalam Bahasa Indonesia dan mensubmit Kembali melalui OJS Cakrawala Pendidikan**

IMPROVING STUDENTS' THINKING ABILITY IN PHYSICS USING INTERACTIVE MULTIMEDIA BASED PROBLEM SOLVING (MMI-PS)

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Abstract : The purpose of this paper is to evaluate factors affect student learning outcomes. The independent variable is a teaching method in the form of interactive multi media based on problem solving (MMI-PS) and the dependent variable is students' thinking ability in physics. To answer this goal, a quasi-experimental method was used. Study groups were drawn from the "Educational Personnel Educational Institutions" (LPTK) (training institutions for education practitioners) in Medan, Indonesia. Random cluster samples were used and students are divided into two sample groups, i.e. the experimental and control groups. Data were analyzed using analysis of t-tes. The test of science process skills in the form of formal descriptions as well as reasoning tests in the form of descriptions was used as instruments for this study. The results showed that the problem-solving ability of students who studied physics using interactive multi-media based problem solving was better than students who learn through conventional methods.

Keywords: thinking ability, physics, interactive multimedia, problem solving.

PENINGKATAN KEMAMPUAN BERPIKIR SISWA DALAM FISIKA MENGGUNAKAN MULTIMEDIA INTERAKTIVE BERBASIS PEMECAHAN MASALAH (MMI-PM)

Abstrak : Tujuan dari penelitian ini adalah untuk mengevaluasi faktor-faktor yang mempengaruhi hasil belajar siswa. Variabel bebas adalah metode pengajaran dalam bentuk multi media interaktif berbasis pemecahan masalah (MMI-PM) dan variabel terikatnya adalah kemampuan berpikir siswa dalam fisika. Untuk menjawab tujuan penelitian ini, metode kuasi-eksperimental digunakan. Kelompok sampel diambil dari "Lembaga Pendidikan Tenaga Kependidikan" (LPTK) (lembaga pelatihan untuk praktisi pendidikan) di Medan, Indonesia. Pemeilihan sampel secara acak kelas dan siswa dibagi menjadi dua kelompok sampel, yaitu kelompok eksperimen dan kontrol. Data dianalisis menggunakan analisis t-tes. Tes keterampilan proses sains dalam bentuk deskripsi formal serta tes penalaran dalam bentuk deskripsi digunakan sebagai instrumen untuk penelitian ini. Hasil penelitian menunjukkan bahwa kemampuan pemecahan masalah fisika siswa yang diajarkan menggunakan multimedia interaktif berbasis pemecahan masalah lebih baik daripada siswa yang belajar melalui metode konvensional.

Kata Kunci: kemampuan berpikir, fisika, multimedia interaktif, pemecahan masalah.

INTRODUCTION

Teacher education institutions recognize the power of establishing competent, unconstrained, and adaptive classroom teachers who can reckon with the progressively complex demands of learning. The problems school teachers deal with are mainly real-world, ill-structured problems and are thus extremely emergent and interdisciplinary in nature (Jonassen, 2011). Physics is one of the sciences that underlie the development of technology, hence students need to learn it in the form of general physics (Halliday et al, 2011).

As prospective lecturers, students majoring in physics education are expected to have high thinking ability. The training institute for education practitioners (Lembaga Pendidikan Tenaga Kependidikan or LPTK - Training Institute for Education Practitioners) has not been successfully conducted to the improvement of lecturers' competence. A study by Manurung (2013) at one of LPTK in Medan shows that the teaching of physics is still overly teacher-centered. University teachers tend to learn through lectures, questions, and answers, which we called as the conventional method. The learning system adopted in teaching general physics course still the validity of existing theories carried out by strictly following a set of provided procedures.

The conventional system produced several facts that need to be concerned by a respected authority. The conventional learning system is downright boring as students are required to listen to their lecturer in long hours. The learning is aimed at simply students memorize the theories. As a result, students frequently possess a deficiency of credence, weak competence to work as part of a team, possess weak written and oral communication, etc. (Chen et al., 2013).

Another fact in conventional learning physic was students' lack of experience to be able to solve problems. Problems given are rarely relevant to contextual issues in the everyday lives of students, so this learning becomes less meaningful to students. Those shreds of evidence arise from low participation in teaching and learning activities and their relatively low achievement.

Furthermore, many problems in the teaching of general physics have been identified: (a) the learning process does not present relevant phenomenon, (b) lack of discovery process, (c) lack of learning media, and (d) weak understanding of the concepts. These problems cause difficulties for students to understand the concepts of general physics graphics presented in learning physics.

One of the important factors that influence the low performance of science lecturers is the lack of effective pre-service teacher education (Fhaeizdhyall et al., 2018). Teachers' quality is a major factor in increasing teaching and learning quality. Thus, there is a vital need to improve professionalism in the field of education (Depdiknas, 2010).

A sustainable and effective teacher education to improve teachers' quality is crucial. Equipping with knowledge and hands-on experience in doing physics experiments that involve abstract physics concepts interactive multimedia is relevant because not all experiments can be done directly in the laboratory. Most students experience difficulties in solving physics problems neither do they have a deep understanding of the fundamental concepts in the problem.

To overcome this situation, we propose a computer-assisted learning tool (Bimba et al., 2013) known as the adaptive learning environment for problem-solving (ALEPS). ALEPS is based on "Polya stages of problem-solving" that consists of 1) understanding; 2) planning; 3) applying, and 4) checking. Thinking and problem-solving skills as well as speed in problem solving are only developed through practice and feedback. Testing students on skills they have not had an opportunity to practice is unfair (Heller and Heller, 2010; Gorghiu et al., 2015).

Fenelon (2012) designed a thinking model and laboratory content on the web-based basic physics lecture and found that long-distance students' as those with direct interaction. A virtual for various concepts of basic algebra-based physics through project PHET (physics education technology) is reported by Habibi and Habibi (2015) to cope with a large number of participants course in universities.

Since the advanced of internet technology, computer, and related technology have been studied extensively in its role in learning outcomes (such as Karimova and Zhetpeisova, 2020; Kapi et al., 2018; De Sousa, 2017; Habibi and Habibi, 2015; Chetty, 2015). Habibi and Habibi (2015) and Chetty (2015) revealed that computers can be used to support the implementation of practical physics for gathering, presenting, and manipulating data. Kapi et al (2018) also argue that many forms of interaction may be presented through the computer serving as practices and exercises, tutorials, games, simulation, discovery, and thinking.

The role of multimedia technology in the learning process has been proposed by many scholars (such as Karimova and Zhetpeisova, 2020; Kapin, 2018; De Sousa, 2017; Cunningham, 2009). Karimova and Zhetpeisova (2020) posited that multimedia technology represents one of the most promising areas of computerization of the educational process. The utilization of multimedia in learning encourages students to the process of the invention (discovery learning process) (De Sousa, 2017) and can solve ill-structured problems (Cunningham, 2009).

Kapin (2018) posited interactive multimedia as audio-visual media can show phenomena in physics in a more realistic manner. More real visualization strongly supports the learning process. In addition, students involved in the learning process. As such, students' skills will increase, which in turn will hopefully encourage the emerges of students' creativity.

Thinking is a complex process and is important in every day of learning physics. Problem-solving tests focus at the end of the result or the middle of the process of learning, rather than on the quality of the procedures and the reasoning that leads to results. Thinking skills developed in general physics present a situation where certain information is given, more often as numerical values for the variables in those situations, so that the value of other variables can be determined. So, the problem tends to be well-defined.

Meanwhile, life physical problems or those faced by physicists are mostly ill-structured problems, a problem that must be solved through innovative physics (Cunningham, 2009). Lawson (2010) states that the ability to think is a person's ability to solve problems, to think and devise solutions with a logical sequence (sense), as well as career and work. Thinking ability make problem-solving important to get the work.

Thinking ability shows that a person has formal reasoning. According to Piaget (1964) there are five aspects of the operation of formal reasoning, namely: proportional reasoning, control variables, proportional reasoning, correlational reasoning, and combinatorial reasoning. According to Arends (2012), problem-solving based learning can improve thinking ability.

Based on the study discussed above, this current study will evaluate the improvement of thinking ability in physics through an interactive multimedia-based learning problem solving (MMI-PS). We hypothesize this model can improve thinking ability and skills in solving ill-structured problems (Byun et al., 2014; Manurung and Panggabean, 2017; De Sousa, 2017). The hypothesis of this study is: "Learning by using interactive multimedia based on problem solving (MMI-PS) can improve students' thinking abilities"

METHODS

The research method adopted in this study was an experiment (Fraenkel et al., 2011) by testing the model in a limited class with pre-test–post-test control group design. Time Allocation of time is 2 months. This research involves two classes that were treated differently. Each of the two classes was assigned to experimental and control groups. The experimental class taught using interactive multimedia-based learning containing problem-solving (IMM-PS) while the control group taught using the conventional learning method. The research sample consists of 35 students per class, i.e. second years of physics education students. Second-year students get a general physics, each number 35 persons per class. We performed two (2) studies. Study 1 was the implementation of IMM-PS on an experimental group that was consists of 35 students. Study 2 was performing teaching using a conventional learning method to control group that was consists of 35 students as well. Both studies followed 6 steps as shown in Fig. 1 and 2.

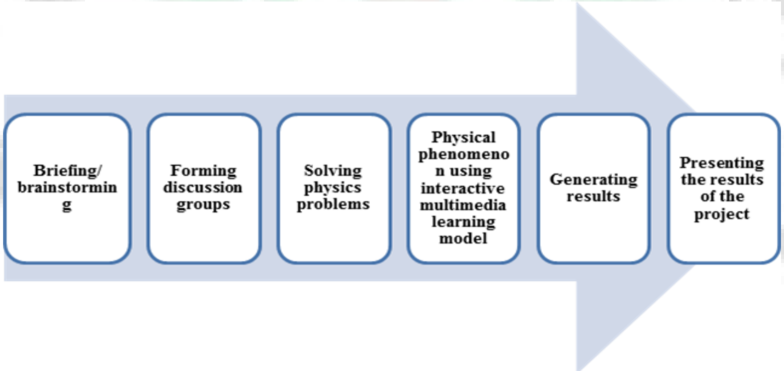

Figure 1. Steps in the interactive multimedia based on learning model containing problem solving.

The study was started with the provision of pre-tests in both groups. Having completed the pre-test, treatment of MMI-PS was implemented in the experimental group. While in the control group was implemented conventional treatment. In the experimental group, the steps were carried out as shown in Figure 1. At the beginning with a briefing for brainstorming steps was called is brainstorming activities is briefing activity.

In the learning instruction, there were discussion groups, to discuss physics problems. The third step was to solve the problems. Problem-solving techniques were deployed in the meeting, where group problem-solving involved the spontaneous contribution of ideas by all members of the group, also in order to compile or find a workaround. The fourth step was to look at physical phenomena to investigate physical phenomena by using problem-solving interactive multimedia and discussion as seen in Figure 2.

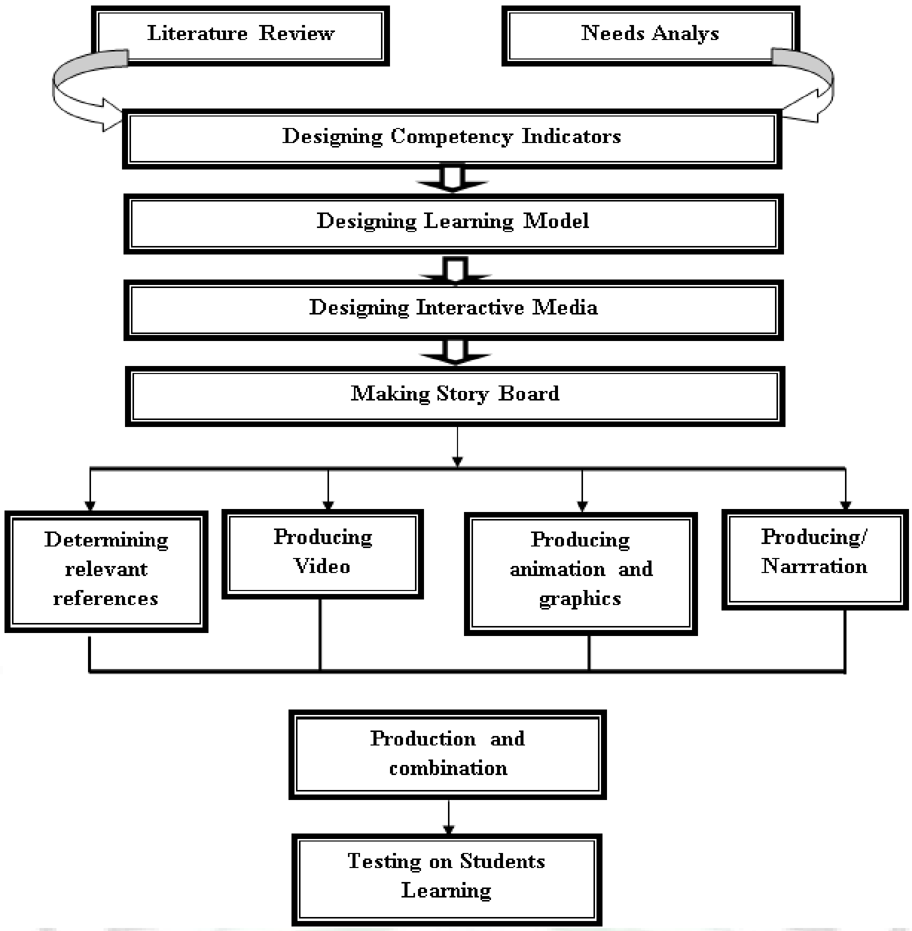

Figure 2. Paradigm of the based on the phylosophy

Thinking-laden interactive multimedia helps students investigate physical phenomena while solving problems in a group Figure 3. Problem-based learning (PBL) is a learning approach that uses real-world problems as a context for students to learn critical thinking and problem-solving skills, as well as to acquire mastery of the knowledge and essential concepts of the subject matter (Sudarman, 2007). PBL challenges students to find solutions to existing problems in the real-world through group work. The fifth step was to find the findings of physical symptoms. Finally, the sixth step presented the findings.

Figure 3. Features of MMI-PS.

The research instrument was a thinking ability test. It is a test of logic thinking (TOLT). TOLT consists of 10 multiple choice questions in which instrument validity and reliability have been ensured. This instrument developed by Tobin and Capie (1981). The value of the validity and reliability of the instrument TOLT was 0.67 and 0.80. Instrument translated into the English language (Tobin and Capie, 1982). The research sample consisted of 35 students per class, i.e. second-semester physics education students. The research carried at an LPTK in Medan, as research and problem-solving learning effectivity test site.

Statistic analysis is t-test was used to find out whether interactive multimedia-based learning containing problem-solving (IMM-PS) can improve students' thinking. Based on the analysis of preliminary study needs, it is found that students and professors of the multimedia program in learning were activated and followed by analyzing interactive multimedia.

With a controller that can be operated by the user, so thus the user can select what is desired for the next process. Example of interactive multimedia includes learning games, applications, etc. The paradigm of the based on philosophy multimedia-based learning is shown in Figure 2. Figure 2 describes the preliminary stage of the study namely the literature review and needs analysis required for the formulation of competency indicators to determine the learning, multimedia, and storyboard designs, features, which finally tested on students and discussed with an expert. Interactive multimedia allows the user to realize potential no longer passive reader, but rather as a co-author, as they determine the sequences of their reading experience potential, will have the ability to rearrange their knowledge with respect to the condition of complex knowledge.

An example of interactive multimedia is shown in Figure 4. The movement of the pendulum harmonic phenomena is often considered simple, but in fact, it is not simple. Many factors give rise to the complexity, such as object of the phenomenon, representation of measurement (such as the position of the pendulum in a particular cycle of oscillation), and representation of the pendulum phenomenon graphic according to time and speed.

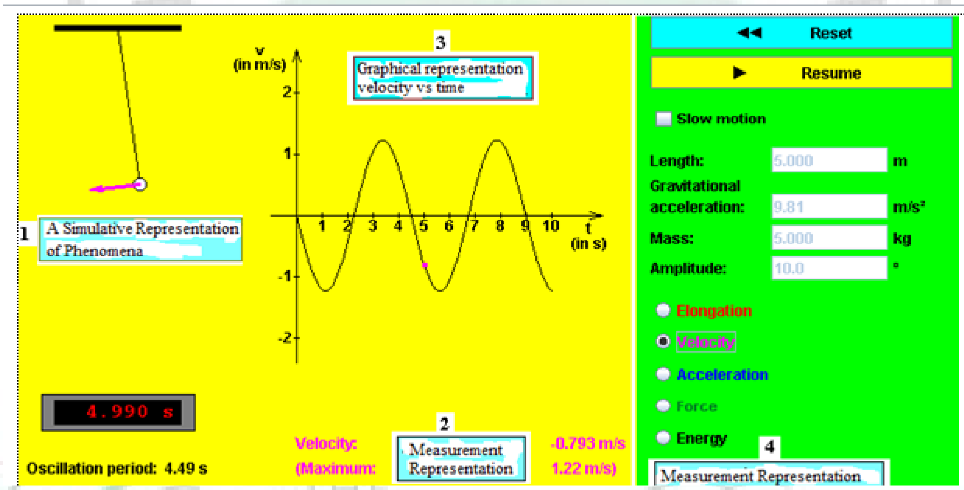

Figure 4. The pendulum symptom, according to the knowledge representative constructs basic knowledge about pendulum.

Figure 4 shows the process of building knowledge according to the complexity of symptoms that can be done according to the user's navigation. The simulation allows users to reconstruct the needs to improve the substantiation and transfer capabilities a complex concept which refers to advanced knowledge obtained (Nickel, 2014) through research simulation. According to Heller and Heller (2010), the strategies of problem-based learning consisted of five steps, : (a) the problem (the focus of the problem), (b) the concept in (describe the physics), (c) planning solutions, (d) out the plan (execute the plan), and (e) an evaluation of the solution.

FINDINGS AND DISCUSSION

Findings

At the beginning of the study, students in both classes were given a pre-test (initial competency test) that aimed to find out whether their thinking ability was on the same level. The results of the experimental class and control class ranged from 0 to10. The score of pre-test results of control and experimental groups is shown in Figure 5.

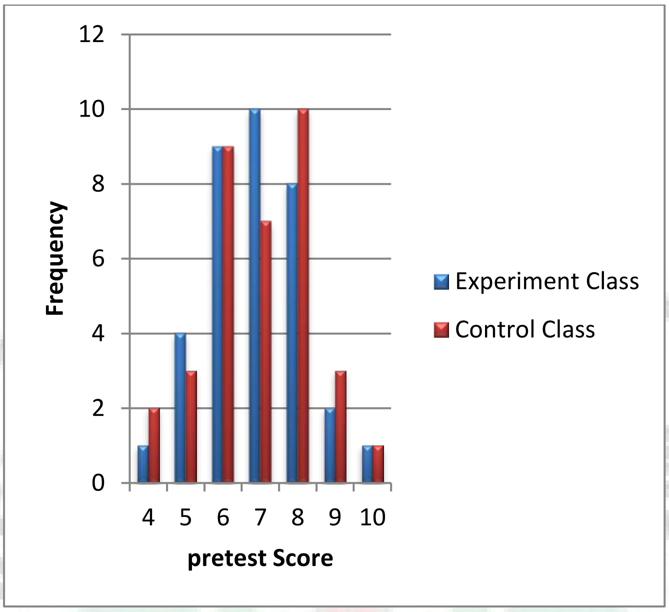

Figure 5. Pretest scores of the experiment classes and control classes.

As shown in Figure 5, in the control class the lowest score of the pre-test was 4 (2 people), and the highest score was 10 (1 person). It was also found similar to the lowest and the highest scores in the experimental group. The difference was only in the number of students obtained the lowest score. In the experimental group, the lowest score was obtained by 1 participant.

The pre-test average score of the control group was higher than the experimental group as shown in Table 1. The average score of the control group was 6.94 and the standard deviation was 1.43. Whilst, the average score of the experimental group was 6.86 and the standard deviation was 1.3.

Table 1. Average value of pretest scores both groups.

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
pretest	experiment	35	6,8571	1,30931	,22131
	control	35	6,9429	1,43369	,24234

Although the average score of the control group was higher than the experimental group, the difference is not significant, as shown in Table 2. The significance was 0.518 which led to accepting the hypothesis, that it is no different in the pre-test score between the control group and the experimental group. This result showed that both groups departing from the same level of understanding (knowledge) of kinematics theory.

Table 2. T-test different of control and experimental groups of pre-test.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
pretest	Equal variances assumed	,423	,518	-,261	68	,795	-,08571	,32819	-,74060	,56917
	Equal variances not assumed			-,261	67,448	,795	-,08571	,32819	-,74070	,56927

Test normality of the pretest and posttest data of the experimental class and the control class is used to determine whether the pretest and posttest data are normally distributed. Normality test is done by using Liliefors test. The normality test results for the pretest and posttest of the two classes are stated in table 3. Following

Table 3. Normality Test

Group		Data		CONCLUSION
		L_{count}	L_{tablel}	
Pretest	Experiment	0,1454	0,1498	Normal
	Control	0,1454	0,1498	
Postest	Exsperiment	0,1483	0,1498	Normal
	Control	0,1346	0,1498	

From the table above, for the experimental class the pretest value was obtained at a price = 0.1454 and for the posttest value obtained a value of 0.1483. At a significant level = 0.05 and n = 35, the price = 0.1498 is obtained>. While in the control class the value of pretest is obtained with a price = 0.1454 and for the posttest value is obtained = 0.1346. At a significant level = 0.05 and n = 35, the price = 0.1498 is obtained>. Thus, it can be concluded that the data from the two samples come from normally distributed populations.

Homogeneity test is performed to determine whether the sample taken is variant homogeneous or not. Homogeneity test of the experimental class pretest and the control class using the two variance similarity test. The results of the homogeneity test calculation are shown in Table 4.

Table 4. The results of the homogeneity test

No	Pretest Data	Varians	F_{count}	F_{talel}	Conclusion
1	Eksperiment Class	1,71	1,205	1,776	Homogen
2	Kontrol Class	2,06			

Table 4 shows that Fcount <Ftable is 1.205 <1.776 with α = 0.05, it can be concluded that the pretest data is homogeneous

In line with the objective of the study, our central concern was the effect of the control factor, i.e. using MMI-PS to improve student's thinking ability. This treatment was implemented in the experimental group. The lowest score was increased after implementing MMI-PS, which was 6 (1 participant) and the highest score of 10 was achieved by five participants.

However, the lowest score in the control class also increased to 5 (3 participants). The total of participants getting the highest score of 10 was added to 4 participants. The score averages between the two groups were also changed.

Based on Table 3, the experimental group achieved a bigger average score than the control group. In the experimental group, the average score of the post-test was 8.43 with a standard deviation of 1.04. Meanwhile, in the control group, the average score of the post-test was 7.49 with a standard deviation of 1.46.

Since the average scores in both groups were different, we proceeded to t-test. The result is shown in Table 4. As can be seen in Table 4, the p-value (significance) was 0.038. The statistical result indicated that there was a significant difference at 5% between the average score of the experiment and control groups.

Further, we performed a meaningful comparison of pre-test and post-test within the group. Table 5 depicts the t-test in the experimental group before and after the implementation of IMM-PS. It has resulted in a significant value of 0.000, less than 0.05. It implies that IMM-PS improve student thinking ability. The score achieved was increased significantly with IIM-PS implementation.

Table 5. T-test different of experimental group.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 pretest - posttest	-1,57143	,55761	,09425	-1,76297	-1,37988	-16,673	34	,000

Table 6 shows the t-test of score means before and after the learning in the control group. The resulted significance value was 0.000. it implies similar evident between experimental group and control group, i.e. there was an improvement in thinking ability after the learning. However, the improvement in thinking ability was better in the experimental group than in the control group.

Table 6. T-test different of control group.

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 pretest - postets	-,54286	,50543	,08543	-,71648	-,36923	-6,354	34	,000

Discussion

This study shows there is an increase in students' thinking skills after being taught by using interactive multimedia based on problem solving (MMI-PS) in line with of study Abungu et al (2014). This current study is strengthening previous studies in the ability of MMI-PS to improve student thinking ability (such as Byun et al., 2014; Manurung and Panggabean, 2017; De Sousa, 2017; Abungu et al., 2014; Arends, 2012; Manurung, 2012; Kharida et al., 2009). The utilization of multimedia in learning encourages students to the process of the invention (discovery learning process) (De Sousa, 2017) and can solve ill-structured problems (Cunningham, 2009).

Interactive multi-media (virtual labs), can be defined as a series computer programs that can visualize abstract phenomenaor complicated experiments carried on real laboratory, so as to increase learning activity in an effort to develop that skill needed in trouble shooting. For example, it is very important to give a real example in the daily life of the benefits of ideal gas. This approach makes the class interesting for students. If the class is interesting, they will be more happy and more likely to absorb lessons. In this activity, the students conduct their own lab with the help of student worksheet. The results of the experiment is analysed then discussed in class and concluded. This makes learning interesting and not boring. It is hoped that this method can aid students in understanding the teaching materials as well as finding solutions for many poorly structured problems. This study aimed to evaluate how using interactive multimedia help lectures improve students' thinking ability and problem solving abilities.

By using a problem-solving model, the thinking ability of the student will be improved (Manurung, 2012; Jabarullah and Hussain, 2019). Manurung (2012) provided evidence of the benefit of using a problem-solving model on dynamic fluid materials. Meanwhile, Jabarullah and Hussain (2019) provided evidence of the significant effect of problem-based learning in increasing student performance of Vocational Education and Training (HTVET). In a problem-based learning approach, students work on authentic problems in a collaborative group (Sada et al., 2015; Ungaretti et al., 2015) in order to enhance deep learning (Delaney et al., 2015).

In our study, the problem-based learning approach was integrated with multimedia. Thus, the improvement of student's ability to think logically was enhanced due to media used. Islam et al. (2014) provided evidence that the use of multimedia animation as teaching media improved students' thinking process. It can be inferred that there exists a difference in logical thinking abilities between the two student classes.

Learning that uses multimedia encourages students to be actively engaged in the thinking process with regards to the material and linking learning to real-life situations. Thereby, students are motivated to remember and apply the knowledge in everyday life situations. In other words, students are not just passively accepting material from a lecturer but are actively solving problems.

Our result also supported previous studies (such as Ibrahim, 2012; Arends, 2012; Adeyemo, 2010). Ibrahim (2012) states that there is an increase in the average cognitive logic thinking ability of students taught using the problem-based learning model. Therefore, by applying this model, students can acquire knowledge and skills more effectively, as proven by Arends (2012). Arends (2012) posits that a problem-based approach to learning in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher acts as a facilitator requires that students be persistent in solving the problems presented. He also states that during the problem-solving process, the problem of the character of the students themselves will be apparent so that students can develop self-reliance and confidence in achieving logical thinking abilities. Adeyemo (2010) also states that there is an increase in cognitive ability among students who are positively affected when problem-solving tasks in physics are discussed.

When using various multimedia combinations, the unique nature of social sciences can be addressed effectively (De Sousa et al., 2017). There exist a difference in logical thinking ability between the two classes. This is because, learning using multimedia helps encourage students to be actively engaged in the process of thinking with regard to the material and link it to a real situation (Erceg et al., 2011). In such an environment, students are encouraged to be able to remember and apply the knowledge in everyday life.

Students are not just passively accepting material from the lecturer but also actively solve problems. In contrast to interactive multimedia-based learning given in the experiment class, teaching activities conducted in the control class failed to improved students' scores ($p<0.05$) (Jarosievitz, 2015). This shows that the method used in the control class was not effective in improving logical reasoning.

This finding also supported Lawson (2010), who argues that certain learning approaches, such as lectures, are not effective in improving logical reasoning. Bello (2014) said that the experimental group exposed to the process skill instruction approach performed significantly better to improve formal thinking ability than the control group exposed to the traditional instruction. Erceg et al. (2011) stated in their work that the students were assigned to solve one part special issue to investigate their problem-solving strategies. Lawson (2010) showed that students' score in 'lawson classroom test of formal reasoning was correlated with their achievement in school subjects i.e. social studies, science, and mathematics. this finding has provided concrete evidence that formal reasoning abilities can be related to students' general performance, not only to science and mathematics. Manurung (2014) studied that in identifying elementary school students' thinking skills, they do logical thinking tasks.

The results showed, to answer the question of physics, students must use the laws of physics to calculate the requested physical quantity, in accordance with the steps to solve the problem. They also have to calculate the number of answers from physics problems in everyday conditions. Tasks like these can help different concepts and techniques of problem-solving are accepted, and train students and teachers to solve problems in everyday life using physical principles and assumptions. Problem-based interactive multimedia learning (MMI-PS) shows physical phenomena in an animated way and there is a nuanced teaching problem solving. While the conventional method is to solve mathematical problems mathematically.

CONCLUSION

In conclusion, learning media in the form of interactive multimedia tools is reasonably capable of providing learning experiences that correspond to the level of cognitive development of students. Barsalo (2014) classifies the learning experience of children ranging from things that most concrete up to things that are considered the most abstract. The classification of such experiences is widely followed by the educational circles in deciding what tools should be appropriate to the particular learning experience (Mukherjee, 2013).

One of them is interactive multimedia to enhance learning motivation and learning students who have lost interest in the course, maybe because of the abstract nature of the subject (Adeyemo, 2010). Students spend more time on computers for recreational and other purposes than for academic purposes (Kainz et al., 2013; Cakiroglu and Yilmaz, 2017; Siddiquah and Salim; 2017; Adlim, 2018). They believe that the use of information and communication technology (ICT) supports learning.

Our results provide evidence that is indeed an effective model of students' thinking. Our findings also inline with Masino and Nin˜o-Zarazu (2016) that interventions are more effective at improving student performance and learning when social norms and intertemporal choices are factored in the design of education policies, and when two or more drivers of change are combined. Manurung (2012) stated that argumentation is thinking ability that can occur in students who carry out discussions and debates to solve assigned problems. Building knowledge-based on epistemic aspects requires a dialogical approach with the evaluation of evidence and rational reasons in scientific ideas.

The topic of Ideal Gas is difficult to teach through conventional learning. After the pre-test, the two classes received different teaching methods. In the control class, a researcher taught the lesson using conventional method where educators provide. learning through lectures. Meanwhile in the experimental class, educators taught using a multimedia-based learning model. Here, educators used computer media to make students more active in analyzing a problem. Learning materials were 1. Understanding and characteristics of ideal gas, 2. Laws on ideal gas and 3. Application of the ideal gas equality equation

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10. **Tanggal 28 Juni 2020 Artikel dinyatakan diterima oleh Redaksi Jurnal Cakrawala Pendidikan**

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Sondang Manurung <sondangrina@gmail.com>

[CP] Editor Decision: Accept

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Endah Retnowati, Ph.D <e.retno@uny.ac.id> 28 Juni 2020 06.27
Kepada: Ms Sondang R Manurung <sondangrina@gmail.com>

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Sincerely,

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13. Artikel pada Tahap Galley Proof

IMPROVING STUDENTS' THINKING ABILITY IN PHYSICS USING INTERACTIVE MULTIMEDIA BASED PROBLEM SOLVING

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Abstract: Interactive multimedia based learning containing problem solving may have been researched, however there are stigma that learning how to do problem solving conventionally particularly for colleague students is still favorable. The purpose of this paper is to evaluate factors affect the student learning outcomes. The independent variable is a teaching method in the form of interactive multimedia based on problem solving (IMM-PS) and the dependent variable is students' thinking ability in physics. Specifically, this study aims to analyze the problem solving abilities of students in physics education programs after they have been exposed to interactive multimedia based problem solving methods. The research type is quasi-experiment. The sample were second year physics education students who studying wave electric magnetic subjects, as many as seventy students. The test of science process skills in the form of formal descriptions as well as reasoning tests in the form of descriptions were used as instruments for this study. The results show that the problem solving ability of students who study physics using interactive multi-media based problem solving is better than students who learn through conventional methods.

Keywords: thinking ability, physic, interactive multimedia, problem solving

PENINGKATAN KEMAMPUAN BERPIKIR SISWA DALAM FISIKA MENGGUNAKAN MULTIMEDIA INTERAKTIF BERBASIS PEMECAHAN MASALAH

Abstrak: Pembelajaran berbasis multimedia interaktif yang memuat pemecahan masalah telah banyak diteliti, namun masih ada stigma bahwa belajar bagaimana memecahkan masalah secara konvensional khususnya untuk mahasiswa masih disenangi. Tujuan dari penelitian ini adalah untuk mengevaluasi faktor-faktor yang mempengaruhi hasil belajar siswa. Variabel bebas adalah metode pengajaran dalam bentuk multi media interaktif berbasis pemecahan masalah (MMI-PM) dan variabel terikatnya adalah kemampuan berpikir siswa dalam fisika. Lebih khusus, penelitian ini bertujuan untuk menganalisis kemampuan pemecahan masalah siswa program pendidikan fisika setelah diberi perlakuan metode pemecahan masalah berbasis multimedia interaktif. Jenis penelitian yang digunakan adalah kuasi eksperimen. Sampenya adalah mahasiswa tahun kedua pendidikan fisika yang sedang belajar magnet elektrik, sebanyak tujuh puluh mahasiswa. Tes keterampilan proses sains dalam bentuk deskripsi formal serta tes penalaran dalam bentuk deskripsi digunakan sebagai instrumen untuk penelitian ini. Hasil penelitian menunjukkan bahwa kemampuan pemecahan masalah fisika siswa yang diajarkan menggunakan multimedia interaktif berbasis pemecahan masalah lebih baik daripada siswa yang belajar melalui metode konvensional.

Kata Kunci: kemampuan berpikir, fisika, multimedia interaktif, pemecahan masalah

INTRODUCTION

Physics is one of the science that underlies the development of technology, so students need to learn it in the form of general physics (Halliday, Resnick, & Walker, 2011). As prospective lecturers, students majoring in physics education are expected to have high thinking ability. The improvement of lecturers' competence has not been successfully conducted by the training institute for education practitioners (*Lembaga Pendidikan Tenaga Kependidikan* or LPTK or Training Institute for Education Practitioners). A study by Manurung (2014) at one of LPTK in Medan shows that the teaching of physics is still overly teacher-centred. University teachers tend to learn through lectures, questions and answers. The implementation of the general physics course still the validity of existing theories, carried out by strictly following a set of provided procedures, instead of encouraging students to develop their thinking through experiment. In addition, it was also found that: (a) methods used in these general physics lectures are downright boring as students are required to listen to their lecturer in long hours; the learning is aimed simply students to the theories; and problems presented tends to be academic (book oriented), (b) students lack of experience to be able to solve problems; problems given are rarely relevant to contextual issues in everyday lives of student, so thus learning becomes less meaningful to students. Those evidents arise from low participation in teaching and learning activities and their relatively low achievement. Furthermore, a number of problems in the teaching of general physics have been identified: (a) the learning process does not present relevant phenomenon, (b) lack of discovery process, (c) lack of learning media, and (d) weak understanding of the concepts. these problems cause difficulties for students to understand the concepts of general physics graphics presented in learning physics.

One of the important factors that influence the low performance of science lecturers is the lack of effective pre-service teacher education (Fhaeizdhyall, Nazamud-Din, Sabbir, & Ibrahim, 2018). Teachers' quality is a major factor in increasing teaching and learning quality. Thus, there is a vital need to improve professionalism in the field of education (Depdiknas, 2010). A sustainable and effective teacher education to improve teachers' quality is crucial. Equipping with knowledge and hands-on experience in doing physics experiments that involve abstract physics concepts interactive multimedia is relevant because not all experiments can be done directly in laboratory. Most students experience difficulties in solving physics problems neither do they have a deep understanding of the fundamental concepts in the problem. To overcome this situation, we propose a computer-assisted learning tool known as the adaptive learning environment for problem solving (ALEPS) based on "Polya stages of problem solving" that consists of 1) understanding; 2) planning; 3) applying, and 4) checking (Bimba, Idris, Mahmud, Abdullah, Abdul-Rahman, & Bong, 2013). Thinking and problem-solving skills as well as speed in problem solving are only developed through practice and feedback. Testing students on skills they have not had an opportunity to practice is unfair (Heller & Heller, 2010; Gorghiu, Drăghicescu, Cristea, Petrescu, & Gorghiu, 2015).

Fenelon & Breslin (2012) designed a thinking model and laboratory content on the web-based basic physics lecture, and found that long-distance students' as those with direct interaction. And virtual for various concepts of basic algebra-based physics through project phet (physics education technology) are reported by Habibi & Habibi (2015) to cope with the large number of participants course in universities. Furthermore Habibi & Habibi (2015); Chetty (2015) stated that computers can be used to support the implementation of practical physics for gathering, presenting, and manipulating data. Kapi, Osman, Ramli, & Taib (2018) also argue that a number of forms of interaction may be presented through theof computer serving as practices and exercises, tutorials, games, simulation, discovery, and thinking. According to de Sousa, Richter, & Nel (2017) the utilization of multimedia in learning encourages students to the process of invention (discovery learning process) and can solve ill structured problems (Cunningham, 2009). Kapi *et al*. (2018) said that interactive multimedia as audio-visual media can show phenomena in physics in a more real manner. A more real visualization strongly supports c in the learning process. in addition, students get in their learning process. thus, students’ skill will increase, which in turn will hopefully encourage the emergence of students’ creativity.

Thinking is a complex process and is important in the everyday of learning physics. problem-solving tests focus at the end of result or the middle of the process of learning, rather than on the quality of the procedures and the reasoning that leads to results. Thinking skills developed in general physics present a situation where certain information is given, more often as numerical values for the variables in those situations, so that the value of other variables can be determined. So, problem tends to be well-defined. Meanwhile, life physical problems or those faced by physicist are mostly ill-structured problems, a problem that must be solved through innovative physics (Cunningham, 2009). Lawson (1978) states that the ability to think is a person's ability to solve problems, to think and devise solutions with a logical sequence (sense), as well as career and work. Thinking ability make problem solving important to get the work.

Thinking ability shows that a person has formal reasoning. according to Piaget (1964) there are five aspects of the operation of formal reasoning, namely: proportional reasoning, control variables, proportional reasoning, correlational reasoning, and combinatorial reasoning. According to (Arends, 2012), problem solving based learning can improve thinking ability.

Based on the description above, this article will explain the improvement of thinking ability in physiscs through an interactive multimedia-based learning problem solving (MMI-PS), because this model can improve thinking ability and skills in solving ill-structured problems (Byun, Kwon, & Lee, 2014; de Sousa *et al*., 2017).

METHODS

The research method adopted in this study is experiment (Fraenkel, Wallen, & Hyun, 2011) by testing the model in a limited class with pre-test–post-test control group design. This research involves two classes that were treated differently. Each of the two classes was assigned into experimental and control groups. The experimental class taught using the interactive multimedia-based learning containing problem solving (IMM-PS) while the control group taught using conventional learning method. The research sample consist of 35 students per class, i.e. second years physics education students. Second year students get a wave electric magnetic subjects, each number 35 persons per class. We performed two (2) studies. Study 1 is implementation of IMM-PS on experimental group that is consists of 35 students. Study 2 is performing teaching using conventional learning method to control group that is consists of 35 students as well. Both studies follow 6 steps as shown on Fig. 1 and 2.

Starting with the provision of pre-tests in both groups, then given treatment that is giving IMM-PS in the experimental group, conventional treatment in the control group. After that the test post is given. In the experimental group the steps were carried out as shown in Figure 1. In the beginning with a briefing for branstorming steps is called is brainstorming activities is briefing activity.

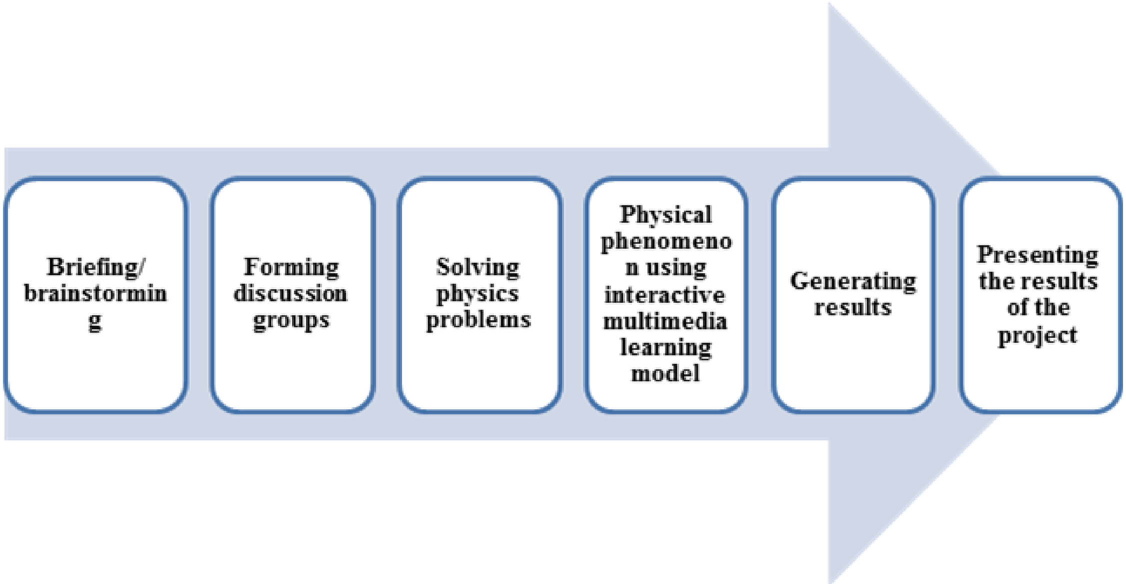

Figure 1. Steps in the Interactive Multimedia Based on Learning Model Containing Problem Solving

In the learning instruction there are discussion groups, to discuss physics problems. The third step is to solve the problems and problem-solving techniques will be made in the meeting, where group problem-solving involves the spontaneous contribution of ideas by all members of the group, also in order to compile or find a work around. The fourth step is to look at physical phenomena to investigate of physical phenomena by using problem-solving interactive multimedia and discussion. Thinking-laden interactive multimedia helps students investigate physical phenomenon while solving problems in a group. problem based learning (PBL) is a learning approach that uses real-world problems as a context for students to learn critical thinking and problem-solving skills, as well as to acquire mastery of the knowledge and essential concepts of the subject matter (Sudarman, 2007). PBL challenges students to find solutions to existing problems in the real-world through group work. The fifth step is to find the findings of physical symptoms. Finally, the sixth step presented the findings

The research instrument is a thinking ability test is test of logic thinking (TOLT), TOLT consisting of 10 multiple choice questions which instrument validity and reliability have been ensured. This instrument developed by Tobin & Capie (1981). The value of the validity and reliability of the instrument TOLT is .67 and .80. Instrument translated into the English language (Tobin & Capie, 1982). The research sample consisted of 35 students per class, i.e. second semester physics education students. The research carried at a LPTK in Medan, as a research and problem solving learning effectivity test site.

Anova is used to find out wheter interactive multimedia-based learning containing problem solving (IMM-PS) can improve students' thinking. Based on the analysis of preliminary study needs, it was found that students and professors of the multimedia program in learning were activated and followed by analyzing interactive multimedia. With a controller that can be operated by user, so thus user can select what is desired for the next process. Examples of interactive multimedia include: multimedia interactive learning games, applications, etc. of multimedia-based learning is shown in Figure 2.

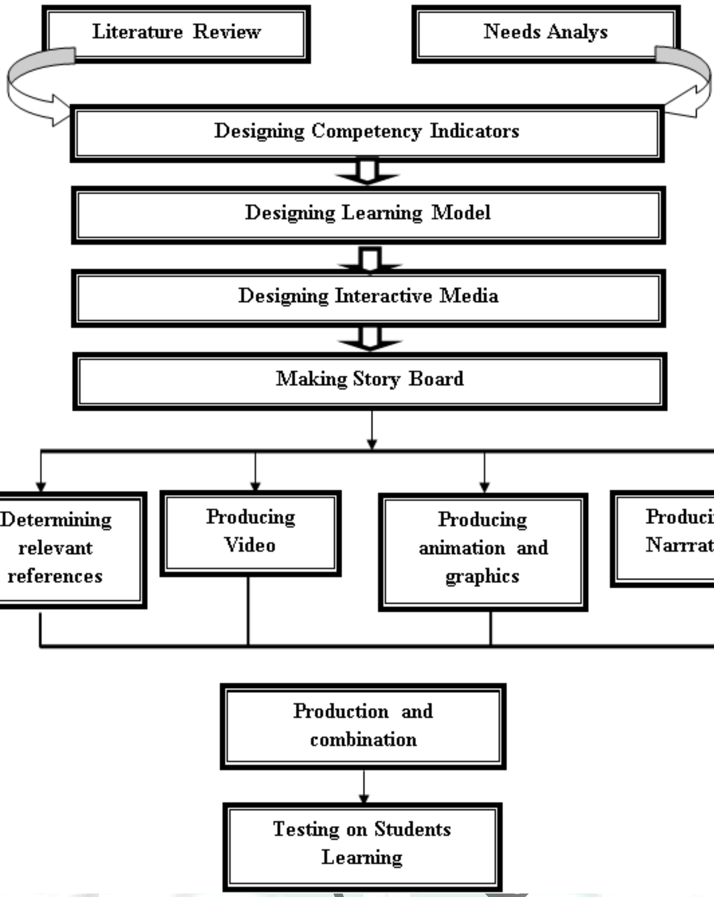

Figure 2. Paradigm of the Based on the Phylosophy

Figure 2 Describes the preliminary stage of the study namely the literature review and needs analysis required for the formulation of competency indicators to determine the learning, multimedia and story board designs, features , which finally tested on students and discussed with an expert. Interactive multimedia allows the user to realise potential no longer passive reader, but rather as a co-author, as they determine the sequences of their reading experience potential, will have the ability to rearrange their knowledge with respect to the condition of complex knowledge.

Examples of interactive multimedia shown on Figure 3. The movement of the pendulum harmonic phenomena is often considered simple, but in fact, since a number of representations: (1) from the object of the phenomenon, (2) representation of measurement, such as the position of the pendulum in a particular cycle of oscillation, (3) representation of the pendulum phenomenon graphic according to time and speed. Designation of pendulum symptoms in interactive multimedia.

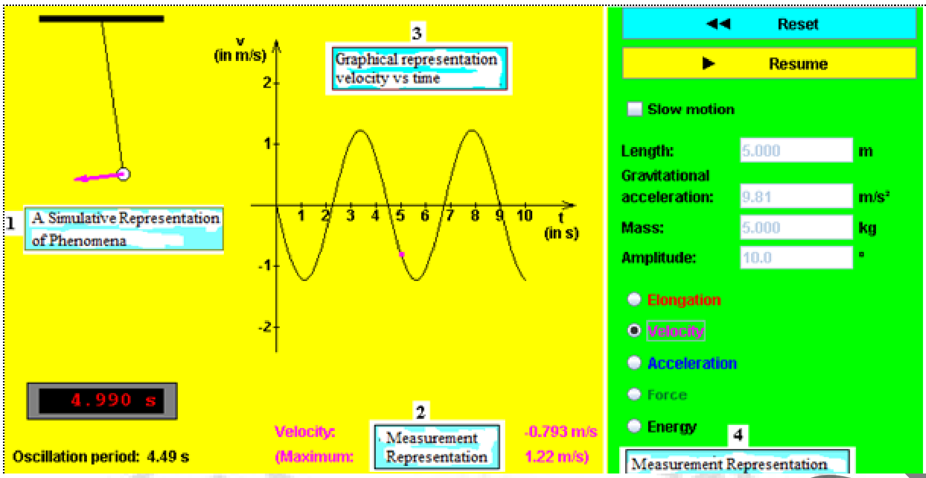

Figure 3. The Pendulum Symptom, According to the Knowledge Representative Constructs Basic Knowledge about Pendulum

Figure 3 shows the process of building knowledge according to the complexity of symptoms that can be done according to user's navigation,the simulation allows user to reconstruct the needs to improve the substantiation and transfer capabilities a complex concept which refers to advanced knowledge obtained (Nickel, 2014). Through research simulation. According to Heller & Heller (2010) the strategies of problem-based learning consisted of five steps: a) the problem (the focus of the problem), b) the concept in (describe the physics), c) planning solutions (plan the solution), d) out the plan (execute the plan), and e) an evaluation the solution (evaluate the solution).

FINDINGS AND DISCUSSION

Findings

In the beginning of the study, students in both classes were given a pre-test (initial competency test) that aimed to find out whether their thinking ability was on the same level. The results of the experimental class and control class ranged from 0 to10. Based on the pre-test results of the experimental class, the lowest score was 4 (1 person), while the highest score was 10 (1 person) (Figure 4). The average score was 6.86 and the standard deviation was 1.3. Whereas, in the control class the lowest score was 4 (2 people), and the highest score was 10 (1 person) (Figure 4). The average score was 6.94 and the standard deviation was 1.43.

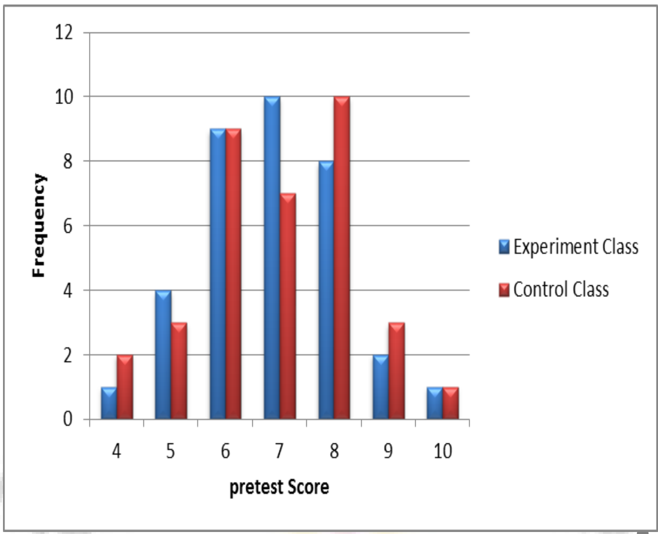

Figure 4. Pretest Scores of the Experiment Classes and Control Classes

The pre-test scores of the experimental and control classes–were not significantly different ($p < .05$), meaning that both classes the same initial capabilities and acquisition value. Data of pretest and posttest in experiment group is shown in Table 1.

Table 1. Data of Pretest Scores and Posttest Score in Experiment Group

No	Pretest Value					Score	Posttest Value			
	Scores	***F***	$\bar{x}$	S^2	***S***		***F***	$\bar{x}$	S^2	***S***
1.	4	1	6.86	1.71	1.31					
2.	5	4				5	-			
3.	6	9				6	1	8.43		
4.	7	10				7	6		1.08	1.04
5.	8	8				8	10			
6.	9	2				9	13			
7.	10	1				10	5			
Total		35						35		

F = Frequency; $\bar{x}$ = Average; S^2 = Variance; *S* = Standard Deviation

As the post test result, the lowest score increased from 4 to 6 (1 person) in the experimental class (table 2). The number of students who the highest score, 10, also increased to people (5). in addition, the class score average improved from 6.86 to 8.43 with a standard deviation from 1.31 to 1.04. In the control class, the lowest score 5 (3 people), and the highest score 10 (4 people) with an average of 7.49 and a standard deviation of 1.46. There also a great difference the number of students who achieved a score of 9 (13 students from the experiment class as opposed to only 4 students the control class) (Table 2).

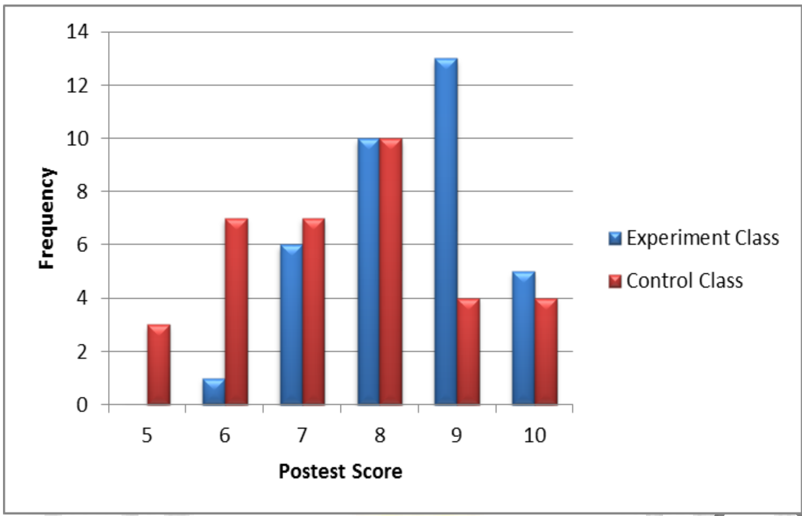

Figure 5. Posttest Scores of the Experiment Classes and Control Classes

Table 2. Comparison of score averages in Pre-test and Post-tests of Thinking Abilities by the Experimental and Control Groups

Group	*N*	*M*	*Sd*	*Df*	T_{sum}	T_{table}
Experimental	35	8,43	1,04	68	2,876	1,669
Control	35	7,49	1.46	68		

Significant at $p < .05$

The statistical analysis (1) indicates that there is a significant difference ($p < .05$), between the average score of the experiment and control group where the group experiment is influenced experimentation IMM-PS, conventional teaching method, as conducted in the control group, did not result in significant difference between the students' achievement before and after treatment ($p < .05$) (Table 3).

Table 3. Comparison of Control Group's Average Scores Before and After Treatment

Group	*N*	*M*	*Sd*	*Df*	T_{sum}
Control Group Before Treatment	35	6.94	1.43	68	.12*
Control Group After Treatment	35	7.49	1.46	68	

*Not Significant at $p < .05$

Discussion

Abungu, Okere, & Wachanga (2014) states that the ability of computer-assisted formal reasoning and learning deals with logical thinking ability of chemistry (chemistry student). The results of this study that using a problem-solving model, especially on dynamic fluid materials, resulted in a very good average scores and moderately increased students' ability to think. Kharida, Rusilowati, & Pratiknyo (2009) states in his research that there is an increase in the average thinking ability of students taught with problem based learning model. According to Arends (2012), a problem based learning approach to learning, in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher as a facilitator then student must be persistent in solving the problems presented, then all the characters of the students will show themselves and students can develop independence and confidence so that the ability to think can be achieved.

Based on this study, the test results average of students from the experiment class increased from 6.86 to 8.43, while in the control class, it increased from 6.94 to 7.49. The statistical analysis showed that students from the experiment class attained significantly higher post test average compared to students from the control class ($p < .05$). In addition, the average N-Gain value of students taught using problem based learning model is .5 or 50%, with a moderate level improvement in logical thinking competence. Meanwhile, the average n-gain value of students taught using the conventional approach is .2 or 20%. This means that the improvement of students' logical thinking ability in the experimental class is greater than in the control class. Thus, we can conclude that student's ability to think logically were enhanced due to the influence of the problem-based learning model on kinematic physics education. Similar result was obtained by Islam, Ahmed, Islam, & Shamsuddin (2014) who stated that the use of multimedia animation as teaching media improved students' thinking process; in which students in experiment class obtained .682 improvement, while students in control class only .326 improvement. It can be inferred from his results, as well as ours, that there exists a difference in logical thinking abilities between the two student classes. This is because learning that uses multimedia encourages students to be actively engaged in the thinking process with regards to the material and linking learning to real-life situations. Thereby, students are motivated to remember and apply the knowledge in everyday life situations. In other words, students are not just passively accepting material from a lecturer but are actively solving problems.

Similar results were also obtained by Ibrahim & Rebello (2012); Arends (2012); and Adeyemo (2010). Ibrahim & Rebello (2012) states that there is an increase in average cognitive logic thinking ability of students taught using the problem-based learning model. Therefore, by applying this model, students can acquire knowledge and skills more effectively, as supported by Arends (2012) who states that a problem-based approach to learning in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher acts as a facilitator requires that students be persistent in solving the problems presented. He also states that during the problem-solving process, the problem of the character of the students themselves will be apparent so that students can develop self-reliance and confident in achieving logical thinking abilities. Adeyemo (2010) also states that there is an increase in cognitive ability among students who are positively affected when problem-solving tasks in physics are discussed.

de Sousa *et al*. (2017) state that when using various multimedia combinations, the unique nature of social sciences can be addressed effectively. This result, as well as ours, inferred that there exist a difference in logical thinking ability between the two classes. this is because, learning using multimedia helps encourage students to be actively engaged in the process of thinking with regard to the material and link it to real situation (Erceg, Maruˇsi´C, & Sliˇsko, 2011). Thereby, they are encouraged to be able to remember and apply the knowledge in everyday life. In this case, students are not just passively accepting material from lecturer but also actively solve problems. Arends (2012) who states that a problem based learning approach to learning in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher as a facilitator then students must be persistent in solving the problems presented, during the solve the problem of unwitting students, then all the characters themselves will appear that students can develop self-reliance , and confidence so that logical thinking ability can be achieved (Özreçberoğlu & Çağanağa, 2018).

In contrast to interactive multimedia based learning given in the experiment class, teaching activities conducted in the control class failed to improved students' score ($p < .05$). This shows that the method used in the control class was not effective in improving logical reasoning. This finding is also supported by Lawson (1978), who argues that certain learning approaches, such as lectures, are not effective in improving logical reasoning. Bello (2014) said that the experimental group exposed to the process skill instruction approach performed significant better to improve formal thinking ability than the control group expose to the traditional instruction. Erceg *et al*. (2011) stated in their work that the students were assigned to solve one part special issue to investigate their problem-solving strategies. Lawson (1978) showed that students' score in 'Lawson classroom test of formal reasoning was correlated with their achievement in school subjects i.e. social studies, science and mathematics. this finding has provided concrete evidence that formal reasoning abilities can be related to students' general performance, not only to science and mathematics. Subali, Rusdiana, & Sabandar (2013) said that descriptively the most MPK-GI group (empowerment conceptual model empowerment) excel in achieving critical thinking skills.

The results showed, to answer the question of physics, students must use the laws of physics to calculate the requested physical quantity, in accordance with the steps to solve the problem. They also have to calculate the quantity of answers from physics problems in everyday conditions. Tasks like these can help different concepts and techniques of problem solving are accepted, and train students and teachers to solve problems in everyday life using physical principles and assumptions.

In conclusion, learning media in the form of interactive multimedia tools is reasonably capable of providing learning experiences that correspond to the level of cognitive development of students. Barsalo (2014) classifies learning experience of children ranging from things that most concrete up to things that are considered the most abstract. The classification of such experiences is widely followed by the educational circles in deciding what tools should be appropriate to the particular learning experience (Mukherjee, 2013. One of them is interactive multimedia to enhance learning motivation and learning students who have lost interest in the course, may be because of the abstract nature of the subject (Adeyemo, 2010; Siddiquah & Salim (2017) said that students spend more time on computers for recreational and other purposes than for academic purpose (Çakıroğlu & Yilmaz, 2017; Kainz, Jakab, & Kardos, 2013; Adlim, Nuzulia, & Nurmaliah, 2018). They believe that the use of information and communication technology (ICT) supports their learning our results provide proof that is indeed an effective mode students' thinking. Masino & Niño-Zarazúa (2016) stated that our findings suggest that interventions are more effective at improving student performance and learning when social norms and intertemporal choices are factored in the design of education policies, and when two or more drivers of change are combined. Argumentation is thinking ability that can occur in students who carry out discussions and debates to solve assigned problems. Building knowledge based on epistemic aspects requires a dialogical approach with evaluation of evidence and rational reasons in scientific ideas.

CONCLUSION

In conclusion, learning media in the form of interactive multimedia tools is reasonably capable of providing learning experiences that correspond to the level of cognitive development of students. Edgar Dale classifies learning experience of children ranging from things that most concrete up to things that are considered the most abstract. The classification of such experiences is widely followed by the educational circles in deciding what tools should be appropriate to the particular learning experience (Arsyad, 2018), one of them is interactive multimedia to enhance students' skills in generic science class (Cronje & Fouche, 2008). Our results provide proof that is indeed an effective mode students' thinking

ACKNOWLEDGMENT

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IMPROVING STUDENTS' THINKING ABILITY IN PHYSICS USING INTERACTIVE MULTIMEDIA BASED PROBLEM SOLVING

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Abstract: Interactive multimedia based learning containing problem solving may have been researched, however there are stigma that learning how to do problem solving conventionally particularly for colleague students is still favorable. The purpose of this paper is to evaluate factors affect the student learning outcomes. The independent variable is a teaching method in the form of interactive multimedia based on problem solving (IMM-PS) and the dependent variable is students' thinking ability in physics. Specifically, this study aims to analyze the problem solving abilities of students in physics education programs after they have been exposed to interactive multimedia based problem solving methods. The research type is quasi-experiment. The sample were second year physics education students who studying wave electric magnetic subjects, as many as seventy students. The test of science process skills in the form of formal descriptions as well as reasoning tests in the form of descriptions were used as instruments for this study. The results show that the problem solving ability of students who study physics using interactive multimedia based problem solving is better than students who learn through conventional methods.

Keywords: thinking ability, physic, interactive multimedia, problem solving

PENINGKATAN KEMAMPUAN BERPIKIR SISWA DALAM FISIKA MENGGUNAKAN MULTIMEDIA INTERAKTIF BERBASIS PEMECAHAN MASALAH

Abstrak: Pembelajaran berbasis multimedia interaktif yang memuat pemecahan masalah telah banyak diteliti, namun masih ada stigma bahwa belajar bagaimana memecahkan masalah secara konvensional khususnya untuk mahasiswa masih disenangi. Tujuan dari penelitian ini adalah untuk mengevaluasi faktor-faktor yang mempengaruhi hasil belajar siswa. Variabel bebas adalah metode pengajaran dalam bentuk multi media interaktif berbasis pemecahan masalah (MMI-PM) dan variabel terikatnya adalah kemampuan berpikir siswa dalam fisika. Lebih khusus, penelitian ini bertujuan untuk menganalisis kemampuan pemecahan masalah siswa program pendidikan fisika setelah diberi perlakuan metode pemecahan masalah berbasis multimedia interaktif. Jenis penelitian yang digunakan adalah kuasi eksperimen. Sampelnya adalah mahasiswa tahun kedua pendidikan fisika yang sedang belajar magnet elektrik, sebanyak tujuh puluh mahasiswa. Tes keterampilan proses sains dalam bentuk deskripsi formal serta tes penalaran dalam bentuk deskripsi digunakan sebagai instrumen untuk penelitian ini. Hasil penelitian menunjukkan bahwa kemampuan pemecahan masalah fisika siswa yang diajarkan menggunakan multimedia interaktif berbasis pemecahan masalah lebih baik daripada siswa yang belajar melalui metode konvensional.

Kata Kunci: kemampuan berpikir, fisika, multimedia interaktif, pemecahan masalah

INTRODUCTION

Physics is one of the science that underlies the development of technology, so students need to learn it in the form of general physics (Halliday, Resnick, & Walker, 2011). As prospective lecturers, students majoring in physics education are expected to have high thinking ability. The improvement of lecturers' competence has not been successfully conducted by the training institute for education practitioners (*Lembaga Pendidikan Tenaga Kependidikan* or LPTK or Training Institute for Education Practitioners). A study by Manurung (2014) at one of LPTK in Medan shows that the teaching of physics is still overly teacher-centred. University teachers tend to learn through lectures, questions and answers. The implementation of the general physics course still the validity of existing theories, carried out by strictly following a set of provided procedures, instead of encouraging students to develop their thinking through experiment. In addition, it was also found that: (a) methods used in these general physics lectures are downright boring as students are required to listen to their lecturer in long hours; the learning is aimed simply students to the theories; and problems presented tends to be academic (book oriented), (b) students lack of experience to be able to solve problems; problems given are rarely relevant to contextual issues in everyday lives of student, so thus learning becomes less meaningful to students. Those evidents arise from low participation in teaching and learning activities and their relatively low achievement. Furthermore, a number of problems in the teaching of general physics have been identified: (a) the learning process does not present relevant phenomenon, (b) lack of discovery process, (c) lack of learning media, and (d) weak understanding of the concepts. these problems cause difficulties for students to understand the concepts of general physics graphics presented in learning physics.

One of the important factors that influence the low performance of science lecturers is the lack of effective pre-service teacher education (Fhaeizdhyall, Nazamud-Din, Sabbir, & Ibrahim, 2018). Teachers' quality is a major factor in increasing teaching and learning quality. Thus, there is a vital need to improve professionalism in the field of education (Depdiknas, 2010). A sustainable and effective teacher education to improve teachers' quality is crucial. Equipping with knowledge and hands-on experience in doing physics experiments that involve abstract physics concepts interactive multimedia is relevant because not all experiments can be done directly in laboratory. Most students experience difficulties in solving physics problems neither do they have a deep understanding of the fundamental concepts in the problem. To overcome this situation, we propose a computer-assisted learning tool known as the adaptive learning environment for problem solving (ALEPS) based on "Polya stages of problem solving" that consists of 1) understanding; 2) planning; 3) applying, and 4) checking (Bimba, Idris, Mahmud, Abdullah, Abdul-Rahman, & Bong, 2013). Thinking and problem-solving skills as well as speed in problem solving are only developed through practice and feedback. Testing students on skills they have not had an opportunity to practice is unfair (Heller & Heller, 2010; Gorghiu, Drăghicescu, Cristea, Petrescu, & Gorghiu, 2015).

Fenelon & Breslin (2012) designed a thinking model and laboratory content on the web-based basic physics lecture, and found that long-distance students' as those with direct interaction. And virtual for various concepts of basic algebra-based physics through project phet (physics education technology) are reported by Habibi & Habibi (2015) to cope with the large number of participants course in universities. Furthermore Habibi & Habibi (2015); Chetty (2015) stated that computers can be used to support the implementation of practical physics for gathering, presenting, and manipulating data. Kapi, Osman, Ramli, & Taib (2018) also argue that a number of forms of interaction may be presented through theof computer serving as practices and exercises, tutorials, games, simulation, discovery, and thinking. According to de Sousa, Richter, & Nel (2017) the utilization of multimedia in learning encourages students to the process of invention (discovery learning process) and can solve ill structured problems (Cunningham, 2009). Kapi *et al*. (2018) said that interactive multimedia as audio-visual media can show phenomena in physics in a more real manner. A more real visualization strongly supports c in the learning process. in addition, students get in their learning process. thus, students' skill will increase, which in turn will hopefully encourage the emergence of students' creativity.

Thinking is a complex process and is important in the everyday of learning physics. problem-solving tests focus at the end of result or the middle of the process of learning, rather than on the quality of the procedures and the reasoning that leads to results. Thinking skills developed in general physics present a situation where certain information is given, more often as numerical values for the variables in those situations, so that the value of other variables can be determined. So, problem tends to be well-defined. Meanwhile, life physical problems or those faced by physicist are mostly ill-structured problems, a problem that must be solved through innovative physics (Cunningham, 2009). Lawson (1978) states that the ability to think is a person's ability to solve problems, to think and devise solutions with a logical sequence (sense), as well as career and work. Thinking ability make problem solving important to get the work.

Thinking ability shows that a person has formal reasoning. according to Piaget (1964) there are five aspects of the operation of formal reasoning, namely: proportional reasoning, control variables, proportional reasoning, correlational reasoning, and combinatorial reasoning. According to (Arends, 2012), problem solving based learning can improve thinking ability.

Based on the description above, this article will explain the improvement of thinking ability in physiscs through an interactive multimedia-based learning problem solving (MMI-PS), because this model can improve thinking ability and skills in solving ill-structured problems (Byun, Kwon, & Lee, 2014; de Sousa *et al.*, 2017).

METHODS

The research method adopted in this study is experiment (Fraenkel, Wallen, & Hyun, 2011) by testing the model in a limited class with pre-test–post-test control group design. This research involves two classes that were treated differently. Each of the two classes was assigned into experimental and control groups. The experimental class taught using the interactive multimedia-based learning containing problem solving (IMM-PS) while the control group taught using conventional learning method. The research sample consist of 35 students per class, i.e. second years physics education students. Second year students get a wave electric magnetic subjects, each number 35 persons per class. We performed two (2) studies. Study 1 is implementation of IMM-PS on experimental group that is consists of 35 students. Study 2 is performing teaching using conventional learning method to control group that is consists of 35 students as well. Both studies follow 6 steps as shown on Figure 1 and 2.

Starting with the provision of pre-tests in both groups, then given treatment that is giving IMM-PS in the experimental group, conventional treatment in the control group. After that the test post is given. In the experimental group the steps were carried out as shown in Figure 1. In the beginning with a briefing for branstorming steps is called is brainstorming activities is briefing activity.

In the learning instruction there are discussion groups, to discuss physics problems. The third step is to solve the problems and problem-solving techniques will be made in the meeting, where group problem-solving involves the spontaneous contribution of ideas by all members of the group, also in order to compile or find a work around. The fourth step is to look at physical phenomena to investigate of physical phenomena by using problem-solving interactive multimedia and discussion. Thinking-laden interactive multimedia helps students investigate physical phenomenon while solving problems in a group. problem based learning (PBL) is a

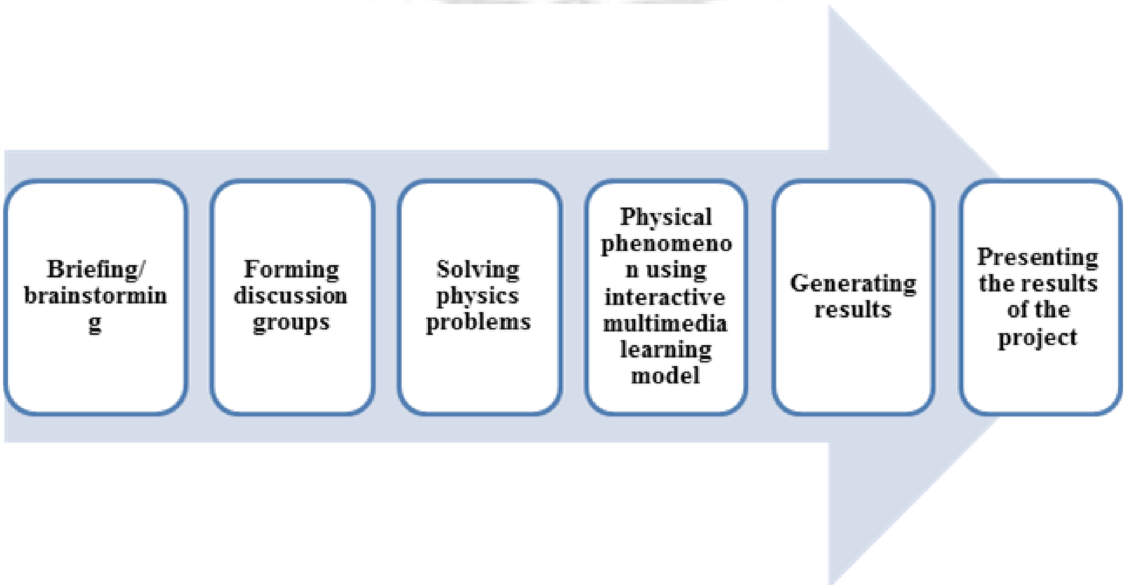

Figure 1. Steps in the Interactive Multimedia Based on Learning Model Containing Problem Solving

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learning approach that uses real-world problems as a context for students to learn critical thinking and problem-solving skills, as well as to acquire mastery of the knowledge and essential concepts of the subject matter (Sudarman, 2007). PBL challenges students to find solutions to existing problems in the real-world through group work. The fifth step is to find the findings of physical symptoms. Finally, the sixth step presented the findings

The research instrument is a thinking ability test is test of logic thinking (TOLT), TOLT consisting of 10 multiple choice questions which instrument validity and reliability have been ensured. This instrument developed by Tobin & Capie (1981). The value of the validity and reliability of the instrument TOLT is .67 and .80. Instrument translated into the English language (Tobin & Capie, 1982). The research sample consisted of 35 students per class, i.e. second semester physics education students. The research carried at a LPTK in Medan, as a research and problem solving learning effectivity test site.

Anova is used to find out wheter interactive multimedia-based learning containing problem solving (IMM-PS) can improve students' thinking. Based on the analysis of preliminary study needs, it was found that students and professors of the multimedia program in learning were activated and followed by analyzing interactive multimedia. With a controller that can be operated by user, so thus user can select what is desired for the next process. Examples of interactive multimedia include: multimedia interactive learning games, applications, etc. of multimedia-based learning is shown in Figure 2.

Figure 2 describes the preliminary stage of the study namely the literature review and needs analysis required for the formulation of competency indicators to determine the learning, multimedia and story board designs, features , which finally tested on students and discussed with an expert. Interactive multimedia allows the user to realise potential no longer passive reader, but rather as a co-author, as they determine the sequences of their reading experience potential, will have the ability to rearrange their knowledge with respect to the condition of complex knowledge.

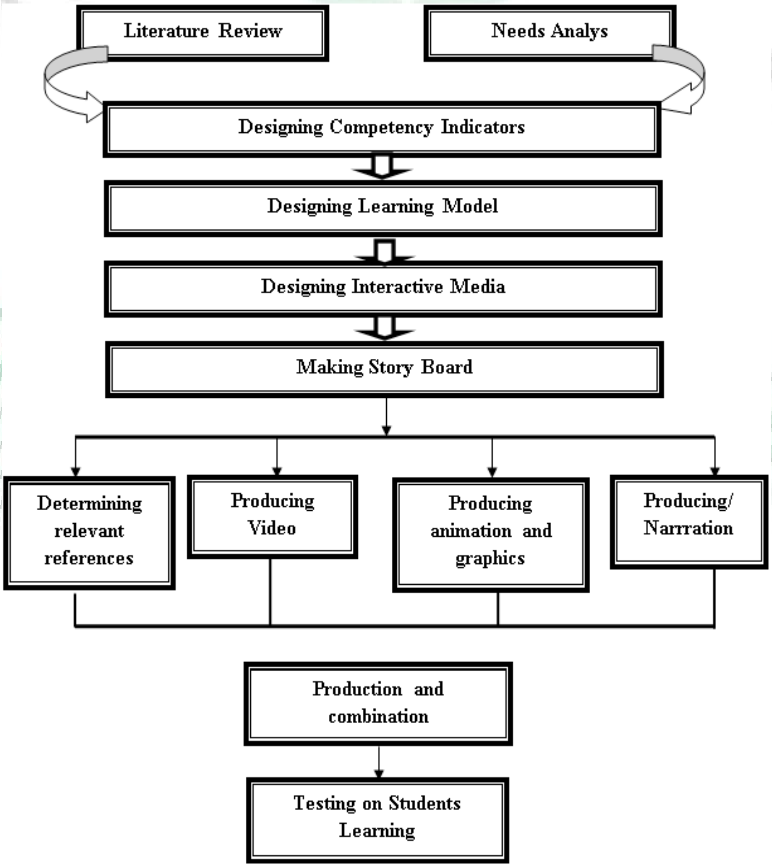

Figure 2. Paradigm of the Based on the Phylosophy

Examples of interactive multimedia shown on Figure 3. The movement of the pendulum harmonic phenomena is often considered simple, but in fact, since a number of representations: (1) from the object of the phenomenon; (2) representation of measurement, such as the position of the pendulum in a particular cycle of oscillation; (3) representation of the pendulum phenomenon graphic according to time and speed. Designation of pendulum symptoms in interactive multimedia.

Figure 3 shows the process of building knowledge according to the complexity of symptoms that can be done according to user's navigation,the simulation allows user to reconstruct the needs to improve the substantiation and transfer capabilities a complex concept which refers to advanced knowledge obtained (Nickel, 2014). Through research simulation. According to Heller & Heller (2010) the strategies of problem-based learning consisted of five steps: a) the problem (the focus of the problem), b) the concept in (describe the physics), c) planning solutions (plan the solution), d) out the plan (execute the plan), and e) an evaluation the solution (evaluate the solution).

FINDINGS AND DISCUSSION

Findings

In the beginning of the study, students in both classes were given a pre-test (initial competency test) that aimed to find out whether their thinking ability was on the same level. The results of the experimental class and control class ranged from 0 to10. Based on the pre-test results of the experimental class, the lowest score was 4 (1 person), while the highest score was 10 (1 person) (Figure 4). The average score was 6.86 and the standard deviation was 1.3. Whereas, in the control class the lowest score was 4 (2 people), and the highest score was 10 (1 person) (Figure 4). The average score was 6.94 and the standard deviation was 1.43.

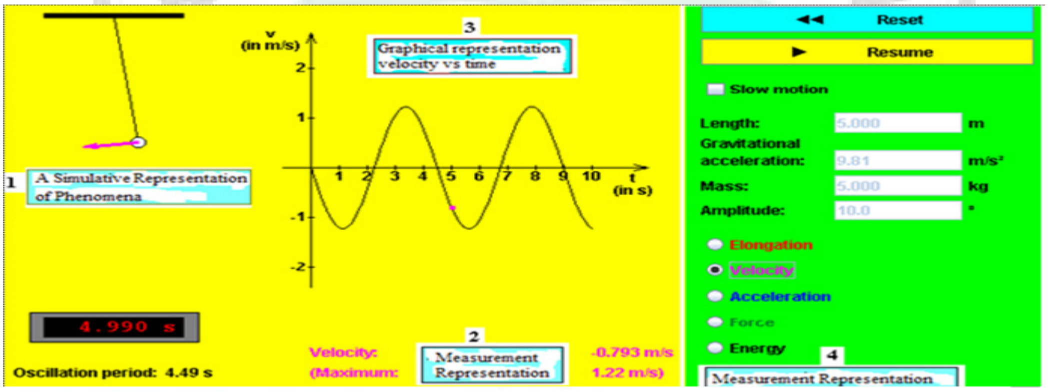

Figure 3. The Pendulum Symptom, According to the Knowledge Representative Constructs Basic Knowledge about Pendulum

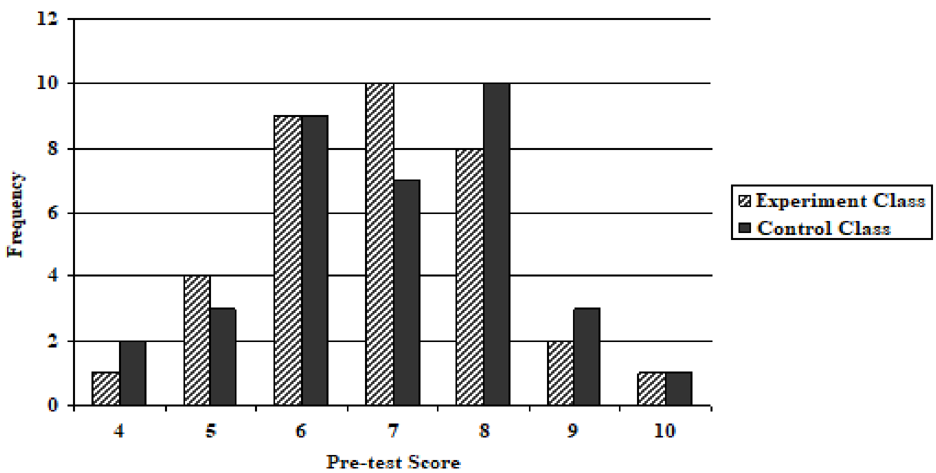

Figure 4. Pretest Scores of the Experiment Classes and Control Classes

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The pre-test scores of the experimental and control classes were not significantly different ($p < .05$), meaning that both classes the same initial capabilities and acquisition value. Data of pre-test and post-test in experiment group is shown in Table 1.

As the post test result, presented in the Figure 5, the lowest score increased from 4 to 6 (1 person) in the experimental class (table 2). The number of students who the highest score, 10, also increased to people (5). In addition, the class score average improved from 6.86 to 8.43 with a standard deviation from 1.31 to 1.04. In the control class, the lowest score 5 (3 people), and the highest score 10 (4 people) with an average of 7.49 and a standard deviation of 1.46. There also a great difference the number of students who achieved a score of 9 (13 students from the experiment class as opposed to only 4 students the control class) (see Table 2).

The statistical analysis (1) indicates that there is a significant difference ($p < .05$), between the average score of the experiment and control group where the group experiment is influenced experimentation IMM-PS, conventional teaching method, as conducted in the control group, did not result in significant difference between the students' achievement before and after treatment ($p < .05$) (see Table 3).

Discussion

Abungu, Okere, & Wachanga (2014) states that the ability of computer-assisted formal reasoning and learning deals with logical thinking ability of chemistry (chemistry student). The results of this study that using a problem-solving model, especially on dynamic fluid materials, resulted in a very good average scores and moderately increased students' ability to think. Kharida, Rusilowati, & Pratiknyo (2009)

Table 1. Data of Pre-test Scores and Post-test Score in Experiment Group

No	Pretest Value					Posttest Value				
	Scores	F	$\bar{x}$	S^2	S	Score	F	$\bar{x}$	S^2	S
1.	4	1								
2.	5	4				5	-			
3.	6	9				6	1			
4.	7	10	6.86	1.71	1.31	7	6	8.43	1.08	1.04
5.	8	8				8	10			
6.	9	2				9	13			
7.	10	1				10	5			
	Total	**35**					**35**			

Note: F = Frequency; $\bar{x}$ = Average; S^2 = Variance; S = Standard Deviation

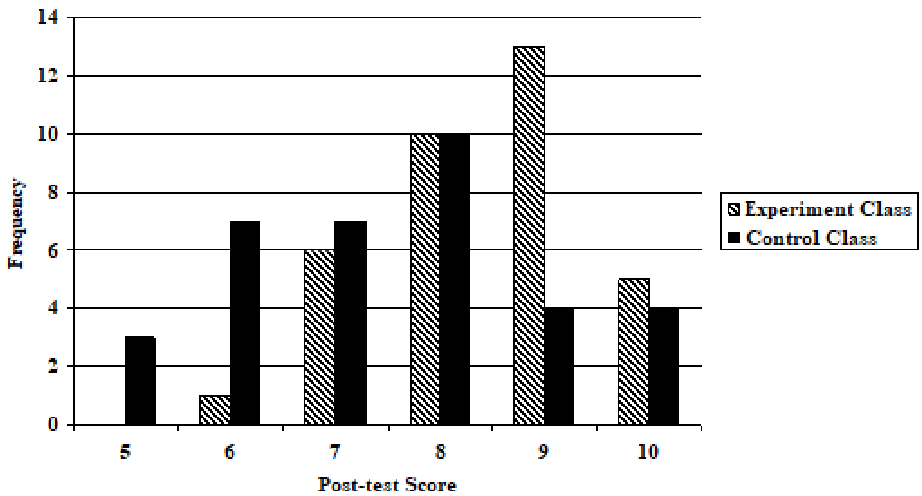

Figure 5. Posttest Scores of the Experiment Classes and Control Classes

Table 2. Comparison of Score Averages in Pre-test and Post-tests of Thinking Abilities by the Experimental and Control Groups

Group	*N*	*M*	*SD*	*df*	t_{sum}	t_{table}
Experimental	35	8.43	1.04	68	2.876	1.669
Control	35	7.49	1.46	68		

Note: Significant at $p < .05$

Table 3. Comparison of Control Group's Average Scores before and after Treatment

Group	*N*	*M*	*SD*	*df*	t_{sum}
Control group before treatment	35	6.94	1.43	68	.12*
Control group after treatment	35	7.49	1.46	68	

Note: *Not Significant at $p < .05$

states in his research that there is an increase in the average thinking ability of students taught with problem based learning model. According to Arends (2012), a problem based learning approach to learning, in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher as a facilitator then student must be persistent in solving the problems presented, then all the characters of the students will show themselves and students can develop independence and confidence so that the ability to think can be achieved.

Based on this study, the test results average of students from the experiment class increased from 6.86 to 8.43, while in the control class, it increased from 6.94 to 7.49. The statistical analysis showed that students from the experiment class attained significantly higher post test average compared to students from the control class ($p < .05$). In addition, the average N-Gain value of students taught using problem based learning model is .5 or 50%, with a moderate level improvement in logical thinking competence. Meanwhile, the average n-gain value of students taught using the conventional approach is .2 or 20%. This means that the improvement of students' logical thinking ability in the experimental class is greater than in the control class. Thus, we can conclude that student's ability to think logically were enhanced due to the influence of the problem-based learning model on kinematic physics education. Similar result was obtained by Islam, Ahmed, Islam, & Shamsuddin (2014) who stated that the use of multimedia animation as teaching media improved students' thinking process; in which students in experiment class obtained .682 improvement, while students in control class only .326 improvement. It can be inferred from his results, as well as ours, that there exists a difference in logical thinking abilities between the two student classes. This is because learning that uses multimedia encourages students to be actively engaged in the thinking process with regards to the material and linking learning to real-life situations. Thereby, students are motivated to remember and apply the knowledge in everyday life situations. In other words, students are not just passively accepting material from a lecturer but are actively solving problems.

Similar results were also obtained by Ibrahim & Rebello (2012); Arends (2012); and Adeyemo (2010). Ibrahim & Rebello (2012) states that there is an increase in average cognitive logic thinking ability of students taught using the problem-based learning model. Therefore, by applying this model, students can acquire knowledge and skills more effectively, as supported by Arends (2012) who states that a problem-based approach to learning in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher acts as a facilitator requires that students be persistent in solving the problems presented. He also states that during the problem-solving process, the problem of the character of the students themselves will be apparent so that students can develop self-reliance and confident in achieving logical thinking abilities. Adeyemo (2010) also states that there is an increase in cognitive ability among students who are positively affected when problem-solving tasks in physics are discussed.

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de Sousa *et al*. (2017) state that when using various multimedia combinations, the unique nature of social sciences can be addressed effectively. This result, as well as ours, inferred that there exist a difference in logical thinking ability between the two classes. this is because, learning using multimedia helps encourage students to be actively engaged in the process of thinking with regard to the material and link it to real situation (Erceg, Maruˇsi´C, & Sliˇsko, 2011). Thereby, they are encouraged to be able to remember and apply the knowledge in everyday life. In this case, students are not just passively accepting material from lecturer but also actively solve problems. Arends (2012) who states that a problem based learning approach to learning in which students work on authentic problems with a view to drawing up their own knowledge, while the teacher as a facilitator then students must be persistent in solving the problems presented, during the solve the problem of unwitting students, then all the characters themselves will appear that students can develop self-reliance , and confidence so that logical thinking ability can be achieved (Özreçberoğlu & Çağanağa, 2018).

In contrast to interactive multimedia based learning given in the experiment class, teaching activities conducted in the control class failed to improved students' score ($p < .05$). This shows that the method used in the control class was not effective in improving logical reasoning. This finding is also supported by Lawson (1978), who argues that certain learning approaches, such as lectures, are not effective in improving logical reasoning. Bello (2014) said that the experimental group exposed to the process skill instruction approach performed significant better to improve formal thinking ability than the control group expose to the traditional instruction. Erceg *et al*. (2011) stated in their work that the students were assigned to solve one part special issue to investigate their problem-solving strategies. Lawson (1978) showed that students' score in 'Lawson classroom test of formal reasoning was correlated with their achievement in school subjects i.e. social studies, science and mathematics. this finding has provided concrete evidence that formal reasoning abilities can be related to students' general performance, not only to science and mathematics. Subali, Rusdiana, & Sabandar (2013) said that descriptively the most MPK-GI group (empowerment conceptual model empowerment) excel in achieving critical thinking skills.

The results showed, to answer the question of physics, students must use the laws of physics to calculate the requested physical quantity, in accordance with the steps to solve the problem. They also have to calculate the quantity of answers from physics problems in everyday conditions. Tasks like these can help different concepts and techniques of problem solving are accepted, and train students and teachers to solve problems in everyday life using physical principles and assumptions.

In conclusion, learning media in the form of interactive multimedia tools is reasonably capable of providing learning experiences that correspond to the level of cognitive development of students. Barsalo (2014) classifies learning experience of children ranging from things that most concrete up to things that are considered the most abstract. The classification of such experiences is widely followed by the educational circles in deciding what tools should be appropriate to the particular learning experienc*e (*Mukherjee, 2013. One of them is interactive multimedia to enhance learning motivation and learning students who have lost interest in the course, may be because of the abstract nature of the subject (Adeyemo, 2010; Siddiquah & Salim (2017) said that students spend more time on computers for recreational and other purposes than for academic purpose (Çakıroğlu & Yilmaz, 2017; Kainz, Jakab, & Kardos, 2013; Adlim, Nuzulia, & Nurmaliah, 2018). They believe that the use of information and communication technology (ICT) supports their learning our results provide proof that is indeed an effective mode students' thinking. Masino & Niño-Zarazúa (2016) stated that our findings suggest that interventions are more effective at improving student performance and learning when social norms and intertemporal choices are factored in the design of education policies, and when two or more drivers of change are combined. Argumentation is thinking ability that can occur in students who carry out discussions and debates to solve assigned problems. Building knowledge based on epistemic aspects requires a dialogical approach with evaluation of evidence and rational reasons in scientific ideas.

CONCLUSION

In conclusion, learning media in the form of interactive multimedia tools is reasonably capable of providing learning experiences that correspond to the level of cognitive development of students. Edgar Dale classifies learning experience of children ranging from things that most concrete up to things that are considered the most abstract. The classification of such experiences is widely followed by the educational circles in deciding what tools should be appropriate to the particular learning experience (Arsyad, 2018), one of them is interactive multimedia to enhance students' skills in generic science class (Cronje & Fouche, 2008). Our results provide proof that is indeed an effective mode students' thinking.

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