

PAPER • OPEN ACCESS

ICT learning media comparative studies: simulation, e-modules, videos

To cite this article: A Suyatna 2020 *J. Phys.: Conf. Ser.* **1572** 012036

View the [article online](#) for updates and enhancements.



IOP | ebooks™

Bringing together innovative digital publishing with leading authors from the global scientific community.

Start exploring the collection—download the first chapter of every title for free.

ICT learning media comparative studies: simulation, e-modules, videos

A Suyatna

Faculty of Teacher Training and Education, Universitas Lampung, Indonesia

*asuyatna@yahoo.com

Abstract. This study was aimed to determine an effective model of ICT learning media: simulation, e-modules, video to improve science learning outcomes of cognitive domains and science process skills (SPS). We used a quasi-experiment with pretest-posttest group design. This study examined the comparison of three ICT-based media implementation in "Unit and Measurement" learning. The media used were simulations, e-modules, and video. The sample involved three classes of seventh graders in Bandar Lampung which were taken purposively. Each class was treated by using simulations, e-modules, and videos. Data were collected by using test and observation techniques. Data was analyzed by using paired sample t-test, one-way ANOVA, and multiple comparisons. The results indicated that the use of ICT media simulation, e-modules, and videos that were guided by the worksheet could significantly improve the learning outcomes in the cognitive domains of junior high school students at the level of trust 95%. There was a significant difference in the average learning outcomes on cognitive domains and SPS among learning aided by interactive simulation, e-modules, and videos. The learning outcomes which the class was assisted by the e-module ICT media model show the highest result.

1. Introduction

A teacher must be able to utilize Information and Communication Technology (ICT) in learning that was able to improve learning in the classroom and laboratory [1]. Based on observations in the Lampung Province, there were already many teachers of Natural Sciences who utilize ICT-based media on learning process in class. But the use of ICT media had not been optimally used to improve the quality of learning in the classroom especially in the laboratory. The use of ICT media is only limited to display of scientific phenomena to clarify the material delivered by the teacher. Utilization of ICT media like this makes the learning process centered on the teacher, students only become spectators, less interactive, do not practice Science Process Skills (SPS). The specific objective of this research is to determine the effectiveness of ICT media model to improve learning outcomes in the cognitive domain and SPS domain. We chose the physics topic of Unit and Measurement. The material was designed so the basic competencies "Students can make basic measurements carefully using appropriate measuring instruments in everyday life" could be reached. We treated students so that they could measure and find the results of their measurements correctly.

Science learning has goals on students to have the abilities, there are: (a) develop curiosity, positive attitudes, and awareness of relationship that is influential between science, environment, technology, and society, (b) develop an understanding variety of natural phenomena, concepts and principles of



science that are useful and can be applied in everyday life, (c) carry out scientific inquiry to develop thinking ability, attitude and scientific attitude and communication, (d) increase awareness to participate in maintaining, protecting, and conserving the environment and natural resources, (e) enhance the knowledge, concepts and skills of Natural Sciences as a basic to continue education to the next level [2].

Science learning in junior high school students needs to emphasize the provision of direct learning experience through the use and development of scientific skills and attitudes. Inappropriate use of ICT media will only make science learning a process of transfer of knowledge, the process of transferring knowledge from teacher to student. Such learning will only make students memorize scientific concepts and principles but do not understand why a phenomenon can occur. Thus it is difficult to build thinking ability, scientific attitude, communication, and increase awareness to participate in maintaining, protecting and conserving the environment. The selection of the right ICT media model will be effective to improve cognitive learning outcomes and SPS, therefore determining the right ICT media model is very important for learning science in schools.

1.1 The Nature of Learning Science

The essence of natural science in learning process are attitudes, processes, products, and applications [2] is expected to emerge, so students can experience the learning process as a whole, understand natural phenomena through problem solving activities, scientific methods, and emulate the way scientists work in finding new fact. The use of ICT media that is not appropriate in the learning process will make students study science only as a product, memorizing concepts, theories and laws. As a result, science as a process, attitude and application is not touched in learning. Learning will be more teacher-centered, teachers only explain science as a product and students memorize factual information. Learners only learn science in the lowest cognitive domain.

Science learning in schools: (a) must strengthen students in the use of equipment and techniques in scientific work; (b) must enable students to carry out their own investigations, carry out scientific observations, arrange hypotheses, and carry out experiments; (c) must enable students to conduct hand-on investigations in their school environment; (d) making science a reality by connecting students with their environment, community, and daily life; (e) must provide learning opportunities that are relevant to the life and community of students. Thus, besides students understanding the science material will also have an impact on the ability to think critically, logically, systematically; being creative, persistent, disciplined, following the rules, being able to work together, being open, confident; have work skills, communication skills and other social skills.

The selection of models and ways of utilizing the appropriate ICT media will be able to meet the science learning requirements and have an impact as described above. However, in order to reach this purpose required supporting learning tools such as the Lesson Plan that complete the requirements [3], and Student Worksheets can direct students to do a series of activities to achieve the learning objectives.

1.2 Utilization of ICT Media

ICT media for practicum simulation in Physics subjects in high school is as good as practicum using actual equipment [4]. Likewise, if ICT media is used for remediation learning for students who have not yet completed learning, it can make 100% of students pass the minimum passing score [5]. Many people have evaluated the use of information technology in extensively supporting curriculum implementation [6], including the authors. The author has conducted various studies on the effectiveness of the utilization of ICT in learning physics, including simulations of physics experiments using application programs that are already available on the market. Furthermore, the authors develop various media learning physics and test it. Experimental simulation media and computer-based tutorials on learning physics are useful for improving skills, practicing science SPS, increasing cognitive domains and learning activities, and build good character of students [7-8]. The interactive digital physics module proves physics learning to be effective, interesting, and easy to use by students independently based on the results of implementation trials [9-10]. The results of the study above are certainly influenced by

packaging of learning resources, completeness of teaching materials, diversity of activities, as well as teacher-student interactions and students provided in a learning medium.

Learning media had advantages to: (a) clarify the presentation of the message to become not too verbalistic, (b) overcome the limitations of space, time and senses, (c) overcome the passivity of students, and (d) provide stimulation, experience, and the same apperception [11]. The way of computers utilization in learning process could be classified into five types, they were: (a) the drill and practice program, which is a program that is designed for students to for question exercise, (b) tutorial program (e-module), which is a program designed so computer can be used as tutor in the learning process, (c) demonstration program, which is a program used to visualize abstract concepts, (d) simulation program, which is a program used to visualize a dynamic process, and (e) instructional game program, which is a program used for games using computer instructions in order to improve understanding of the material being taught [12-13]. It means the utility of ICT as a learning media could be many forms, such as: (1) learning models which students can learn through repeated exercises, so that students can change and improve abilities, certain skills, (2) simulation learning is imitation of abstract learning which can be seen clearly through the monitor screen, (3) learning games where students are involved in mental operations in the form of games, (4) tutorial learning with e-modules that is provided with a module system, the computer will display new information that needs to be known and understood and responded by students, (5) learning the type of test, in this case the students explain what has been mastered and not yet mastered, so there is feedback in order to improve the next learning process.

ICT media in interactive science learning had widely used as a simulation tool. Simulation is an imitation of a real world process or system. Simulation is a model of the results of simplification of reality [14]. So in addition to reflecting a simple situation, the simulation must be experimental, it means that the simulation illustrates the ongoing process. Simulation involves generating processes and observing processes to draw conclusions from the systems they represent. Although the simulation is not drawn like the real world, the simulation almost resembles a real situation so in analysis the students can see an animation that can help them. Simulation practicum is a practicum model that utilizes software to support its implementation, where the material is presented in simulations or processes of occurrence, ways or procedures of work and spelling things out with and without special tools with a complete presentation of animation.

Computer simulations provide opportunities for dynamic, interactive and individual learning. Simulations and complex work environments can be arranged to resemble the real world. The advantages of simulation include: (a) giving participants a reality picture, (b) making students understand correctly about an activity (c) the risk work becomes smaller.

The results of the study [4] concluded there was no difference in the physics learning outcomes of students practicum using computer simulations with students who practiced hand-on. Practicum by simulation can almost replace practicum by hand. To realize results like this, a simulation practicum guide is used which involves many student activities. Students not only watch the teacher demonstrate a phenomenon on the LCD screen, but students actively compile hypotheses, collect data, analyze data, graph the relationships between the variables studied and draw conclusions.

Students in its function as a substitute tutor can interact with computers that have been specifically programmed. Usually the Computer Asisted Learning (CAI) tutor mode is one of a number of independent learning techniques, which are used in certain student-oriented training and educational situations. If the computer is used interactively in an independent instructional capacity, form and quality of student responses depends on the sophistication of the computer and the program. Computer media is used in learning because it provides advantages that other learning media do not have, namely the ability of computers to interact individually with students.

An interactive computer-based learning program allows students to do a causal simulation. This was supported by the opinion of [15] who describes several advantages the interactive computer-based learning program, they were: (a) it could raise student's motivation, student's attention in generating work and improve learning control, (b) it could be a unique instructional tool that can connect students to information sources, help students visualize problems and problems, track learning progress, connect

students to learning tools, (c) it could support for new teaching approaches including cooperative, intelligence sharing, problem solving, and high-level intellectual skills, (d) it could increased teacher's productivity where teachers have free time to help students during learning (as a facilitator), provide more accurate and faster information, giving instructors the opportunity to produce teaching materials to become more interesting and student-friendly more quickly, and (e) it help students train the skills needed in the era of information technology, among others, for technology, information and visual literacy.

1.3 Science Process Skills

Science process skills was possible to be trained through learning using ICT media, because almost all SPS trained in hands-on practicum also be trained on practicum in a simulation, except for direct measurements and assembling tools. In the syllabus model developed by [16], it was stated that SPS includes the ability to: (a) identifying and determining free and bound variables, (b) determine what is measured, (c) observation skills using as many senses as possible (not only the sense of sight), gathering relevant facts, looking for similarities and differences, and classifying, (d) skills in interpreting observations such as separately recording each type of observation, and can link the results of observations, (e) the skill of finding a pattern in the observation series, (f) skill in predicting what will happen based on observations, and (g) the skill of using tools or materials and why they are used. Among the seven SPS indicators, only skills using tools or materials may be difficult to practice with learning using ICT media. Basic SPS include observing, classifying, measuring and using numbers, making conclusions, predicting, communicating, and using the relationship of space and time. Whereas integrated SPS consist of interpreting data, operational definitions, control variables, making hypotheses and experimenting [17]. The SPS as described above can be formed through ICT-assisted learning, as long as the ICT media is appropriate and also equipped with the appropriate worksheet.

2. Research Methode

2.1 Experiment Design

This study conducted a quasi-experimental with pretest-posttes group design. We examined the comparison of three ICT-based media implementation in "Unit and Measurement" learning. The media used were simulations, e-modules, and videos. The sample used were three classes of seventh graders in Bandar Lampung that were taken purposively by considering the average equivalence of initial cognitive abilities. The first class taught Unit and Measurement material with the help of ICT experimental simulation media, the second class was assisted by e-module media, and the third class was assisted by video media. The learning process in each class lasts for 2 times face to face with an allocation of 5 x 40 minutes. During the face-to-face learning process in class, each media is aired by the teacher in front of the class using LCD projectors to guide student learning. Students are grouped into 5 groups, each group consisting of 5-6 people. Each group has a laptop that can be used to operate the media. The operation of the media in each group is guided by the Student Worksheet (LKPD) which is in accordance with the media content and has been validated by experts.

2.2 Data and Data Collection Techniques

Program effectiveness data is measured from student learning outcomes seen from two aspects namely cognitive and psychomotor. Cognitive concerns students' understanding of science material that is marked by the achievement of cognitive aspects of learning objectives. Psychomotor is characterized by the achievement of SPS indicators. For cognitive aspects, the data collection uses a written test technique with multiple choice questions with four options. The test is carried out twice, namely pretest and posttest. Psychomotor aspects, the data collection technique uses observation sheets. SPS observations are made on the aspects of measuring, comparing, creating data, inferring data, and communicating. Every aspect is measured using a scale of 0-3. A score of 3 is given if all indicators of each sub-skill are carried out properly. A score of 0 is given if none of the indicators for each sub-skill is implemented.

2.3 Data Analyze Techniques

The data of the pretest and posttest were analyzed by counting the number of correct answers then divided by the total number of questions, multiplied by one hundred. The SPS value was calculated by averaging the acquisition of each aspect's score and then it is converted to a hundred scale. The difference in average learning outcomes in both the cognitive and SPS domains was examined using the inferential statistical tests were performed using paired sample t-tests, one-way anava followed by multiple comparisons tests by first testing the normality of data distribution.

3. Result and Discussion

3.1 Comparison of Learning Outcomes Using ICT Media: Simulation, e-modules, Videos

The effectiveness of the ICT media model that compared the interactive simulation, e-module, and video was discussed. ICT assisted learning experimental simulation was implementing where students conducted experiments by experiencing and proving themselves something learned using virtual laboratory equipment in the form of computer software. In learning with this experimental method students are given the opportunity to experience themselves or do it themselves, follow a process, observe an object, analyze, prove and draw their own conclusions about an object, using virtual equipment that is designed to resemble the actual tool. Learning using the simulation ICT media model is one of the methods used by teachers in learning activities. The simulation method displays symbols or equipment that replace the actual process of events or objects. Errors that might occur in the actual tool can be anticipated because the simulation media has been designed without tool errors. Simulation media is basically one of the learning strategies that aims to provide a more concrete learning experience through the creation of imitations of experiences that are close to the real situation.

The learning process using the ICT media model e-module follows the contents of the e-module tool step by step. Systematics of ICT media e-modules are as follows: (a) Introduction, (b) Presentation of information/material, (c) Questions and response, (d) Assessment of user responses, (e) Provision of feedback, (f) Repetition, (g) Segment of lesson settings, (h) Closing. The ICT media e-module content summarizes all the contents of other ICT media models, such as loading videos, experiment simulations, and interactive question exercises. The video used in this research was interactive-tutorial, which guides students to understand a material through visualization. Students can also interactively follow practical activities as taught in the video. The use of video teaches a process, for example how to use a thermometer, how to use a calipers and micrometer, how to measure temperatures, read scales and make measurement results, including performing calibrations. Videos can present information, describe processes, explain complex processes, and teach a skill. But the variables presented in the video cannot be manipulated. Interaction between users and videos is very limited.

The cognitive learning outcomes of the three classes were presented in Table 1. Table 1 showed that the Asymp. Sig (2-tailed) pretest, posttest and gain on all parameters indicate that the data has a normal distribution because of the Asymp. Sig (2-tailed) above 0.05. Then the paired sample t-test is performed, which tests the difference between the average pre-test and post-test.

Table 1. Data on cognitive learning outcomes of Unit and Measurement and Normal Distribution Tests and the average difference test of pre-test with posttest

Parameter	Model Media ICT group		
	Simulation	E-module	Video
N	33	33	32
pre-test average score	42.2	39.3	44.5
post-test average score	69.0	72.6	67.7
Gain average score	26.8	33.3	22.9
% Gain average score	64%	85%	66%
gain Standard deviation	13.26	8.76	11.57
Asymp sig (2tailed)	0.328	0.74	0.665
p (post-pre test)	0.000*	0.000*	0.000*

*) Significantly different at 95% confidence level

Table 1 showed that the gain of learning outcomes "Unit and Measurement" of the three different classes. Based on the results of the paired sample t-test, p values <0.05 were obtained to test the difference in the average pre-test and post-test, both learning aided by ICT media simulation, e-modules, and video. That is, learning by using these media can significantly improve cognitive learning outcomes [18-20]. The average gain of learning outcomes in classes learned with assisted of ICT media experimental simulation 26.8, classes learned with assisted e-module 33.3 and classes learned assisted with video 22.9. To be more convincing and so that the results can be generalized, a third difference test was conducted using One Way ANOVA. The test results are presented in Table 2

Table 2. Test the difference in average learning outcomes Unit and Measurement of simulation, e-modules, and videos media groups

	<i>Sum of Squares</i>	<i>df</i>	<i>Mean Square</i>	<i>F</i>	<i>Sig.</i>
<i>Between Groups</i>	1615.082	2	807.541	6.272	0.003
<i>Within Groups</i>	12231.734	95	128.755		
<i>Total</i>	13846.816	97			

Table 2 showed the Sig. F count is 0.003. This value is smaller than 0.05, so it can be concluded that there is a significant difference in the average increase in cognitive domains learning outcomes in the "Unit and Measurement" material between classes whose learning is assisted by simulation, e-modules, and videos ICT media models. The average increase in learning outcomes in classes with learning assisted by the ICT e-module media model is higher than for classes using other ICT media models.

The results of the Multiple Comparisons test as presented in Table 3 indicated that the average increase in learning outcomes that is significantly different in the classroom learning assisted by ICT media e-module with video. Whereas the average increase in learning outcomes in classrooms whose learning is assisted by ICT media e-module with simulations does not appear to be significantly different.

Table 3 Analysis of multiple comparisons of learning outcomes learning assisted by ICT media model: Simulation, E-modules, video

(I) Media group	(J) Media group	Mean Difference (I-J)	Std. Error	Sig.
Simulation	E-module	-6.21212	2.79345	0.090
	Video	3.63163	2.81518	0.438
E-module	Simulation	6.21212	2.79345	0.090
	Video	9.84375*	2.81518	0.003
Video	Simulation	-3.63163	2.81518	0.438
	E-module	-9.84375*	2.81518	0.003

*) Significantly different at 95% confidence level

The ICT media model of the Unit and Measurement module provides a program that describes procedures and mentors and trains students to use micrometer, calipers, thermometer, balance, and stop watch. The learning outcomes of students whose learning using the ICT media model: e-Module is better than using video and simulation ICT media models. In the use of the e-module, the teacher's role is more as a facilitator and instructor of learning. E-modules can direct students to learn independently. This finding is in line with the results of research [21] which states that e-modules for fluids materials can be used by students as a material which is fun and adds to the knowledge for students and deserve to be used as independent studies. This module is suitable to be used to study independently, through this module learning becomes fun and increases knowledge, this will certainly be able to improve student learning outcomes. Similar research on e-books that have similar characteristics to interactive e-modules shows that e-books are effective in improving students' creative thinking skills. The increased creative thinking skills related to the design and characteristics of the e-book [22]. Interactive e-modules as well as interactive e-books are better than static books, especially in improving critical thinking skills [23-25]. The results of these studies are the reasons, e-modules are better than simulation media and video.

3.2 Difference of SPS on simulation, e-module, video ICT media model

SPS covers six aspects of assessment, namely observing, formulating hypotheses, conducting experiments, interpreting data, applying concepts, and communicating. SPS in class assisted by ICT media model simulation, e-modules, videos are observed during the learning process. The acquisition of SPS scores and the results of normality tests of students from each class are presented in Table 4.

Table 4 Average SPS Unit and Measurement Scores and normality distribution test

No	Parameter	ICT Media Model		
		Simulation	E-modul	Video
1	N	33	33	32
2	Average score of SPS	67	71.6	64.2
3	Maximum score	81	88	81
4	Minimum score	44	50	50
5	Deviation Standard	8.04	8.66	7.70
6	Asymp. Sig (2-tailed)	0.098	0.151	0.317

Based on Table 4, it can be seen that the Asymp value. Sig (2-tailed) SPS scores in all classes indicate that the data have a normal distribution because of the Asymp value. Sig (2-tailed) above 0.05. The results of this study indicate that there are differences in average SPS Unit and Measurement using ICT media model simulation, e-modules, and videos. The average value of SPS simulation is 67, e-module 72, and video 64. It can be concluded that SPS Unit and Measurement of students whose learning is assisted by the ICT e-module media model is higher compared to simulation media and video models. To be more convincing and so that the conclusions can be generalized, a third difference test was conducted using the One Way ANOVA. The test results are presented in Table 5. It appears that the Sig. F count is 0.002. This value is smaller than 0.05, so it can be concluded that there is a significant difference in the average SPS score on the " Unit and Measurement" material between classes whose learning is assisted by ICT simulation media models, e-modules, and videos.

Table 5 Different SPS Test of Unit and Measurement of simulation, e-modules, and videos ICT media groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	900.162	2	450.081	6.780	0.002
Within Groups	6306.257	95	66.382		
Total	7206.418	97			

The different average SPS between Unit and Measurements learning using interactive simulation, e-modules, and videos a further test was examined by using Tukey HSD Multiple Comparisons as in Table 6. The test results show the SPS average significantly different scores were classrooms whose learning is assisted by ICT media e-modules with video. Whereas the average increase in learning outcomes in classrooms whose learning is assisted by ICT e-module media with simulations does not appear to be significantly different.

Table 6. Results of multiple comparison analysis on SPS of simulation, e-modules, videos groups

(I) Media Group	(J) Media Group	Mean Difference (I-J)	Std. Error	Sig.
Simulation	E-modul	-4.42424	2.00577	0.093
	Video	2.96307	2.02138	0.346
E-modul	Simulation	4.42424	2.00577	0.093
	Video	7.38731*	2.02138	0.002
Video	Simulation	-2.96307	2.02138	0.346
	E-modul	-7.38731*	2.02138	0.002

*) Significantly different at 95% confidence level

The results of the study showed that the SPS of students in the learning of Unit and Measurements assisted by the ICT media model e-module was better than simulation and video. This is possible because the e-module media model directs students to make observations, conduct experimental simulations, analyze and interpret data. This e-module media directives are indicators of SPS. Although the simulation media model also has these facilities, the implementation must be directed by the teacher. Whereas the video media model is only dominated by observation, which is only a small part of the SPS aspect. The results of this study are supported by findings [26] that e-modules developed based on the

five stages of PBL, can improve science process skills in the medium category. The application of inquiry-assisted e-modules contributes to students' SPS [27]. The e-module used in this study was designed to have the same characteristics as the results of the above study, which was developed with the stages of a scientific approach. Therefore, it can be concluded that the interactive e-module that is designed contains stages that are in accordance with the scientific approach and is equipped with experimental simulations and the presentation of physical phenomena can foster SPS.

4. Conclusion and Suggestion

4.1 Conclusion

Based on the research findings and discussion it can be concluded: (1) the use of ICT media simulation, e-modules, and videos that are guided by the worksheet can significantly improve the learning outcomes of "Unit and measurements" in the cognitive realm of junior high school students at the level of trust 95%, (2) There a significant difference in the average learning outcomes of "Unit and measurements" on cognitive domains and SPS domains among learning aided by interactive simulations, e-modules, and videos. The learning outcomes which the class was assisted by the e-module ICT media model show the highest result.

4.2 Suggestion

Based on research findings and experience in implementing ICT media assisted learning, it is suggested: 1) In choosing the ICT media model that will be used, it is necessary to pay attention to the contents of the ICT media model, the characteristics of the natural science material to be learned and the operational verb of the content standard that is the learning objective. 2) For the learning process to optimize student activities, it is necessary to use worksheets specifically designed to accompany the ICT media used. 3) For learning to be student-centered, each group of students needs to have a computer and before learning begins, the teacher must ensure that the ICT media that will be used already exists in each group's computer.

5. References

- [1] Permendiknas Nomor 16 Tahun 2007 Tentang Standar Kompetensi Guru
- [2] Permendiknas Nomor 22 Tahun 2006 Tentang Standar Isi Untuk Satuan Pendidikan Dasar dan Menengah
- [3] Permendiknas Nomor 41 Tahun 2007 Tentang Standar Proses Untuk Satuan Pendidikan Dasar dan Menengah
- [4] Suyatna A, Nyeneng IDP, Joko K 2010 The Comparison of Physics Learning Result of Senior High School Students Experimented By Using Computer Simulation and Hand on. In *Proceeding International Seminar Globalization of Education: Professionalism of Lecturers and Teachers on Challenges and Opportunities*. Postgraduate Programs. Lampung University
- [5] Suyatna A 2004 Penggunaan Paket Program Komputer Interaktif Dalam Pembelajaran Remediasi Fisika di Madrasah Aliyah (PTK di kelas 1.3 MAN 1 Bandar Lampung). *Jurnal Pendidikan MIPA* 3(2)
- [6] Cox M, Abbott C, Webb M, Blakeley B, Beauchamp T & Rhodes V 2003 ICT and attainment: A review of the research literature. *Coventry: Becta (ICT in Schools Research and Evaluation Series)*. Retrive in <http://www.becta.org.uk>
- [7] Utami P B, Suyatna A, Viyanti 2014 Pemanfaatan Media TIK Simulasi Sebagai Suplemen Demonstrasi Pada Pembelajaran Alat Ukur Di SMP. *Jurnal Pembelajaran Fisika* 2(1) 65-79
- [8] Himawan I, Suyatna A, Viyanti 2014 Pemanfaatan Media Teknologi Informasi Dan Komunikasi Tutorial Sebagai Substitute Demonstrasi. *Jurnal Pembelajaran Fisika* 4(2) 81-93
- [9] Yurika J, Suyatna A, Viyanti 2014 Pemanfaatan Media Teknologi Informasi Dan Komunikasi Tutorial Sebagai Suplemen Eksperimen. *Jurnal Pembelajaran Fisika* 2(1) 15-26

- [10] Hutagalung RS, Suyatna A, Maharta N 2016 Pengembangan Modul Pembelajaran Menggunakan Learning Content Development System Materi Impuls dan Momentum. *Jurnal Pembelajaran Fisika* **4**(2) 115-125
- [11] Sadiman AS, Haryono A, Rahardjito 2005 Media Pendidikan. Raja Grafindo. Jakarta
- [12] Merrill PF, K Hammos, BR Vincent, PL Reynolds, L Cristensen, dan MN Tolman. 1995 *Computer in education (3 ed)*. Allyn & Bacon. Boston
- [13] Simonson MR & Thomson 1994 *Educational computing foundations (2rd ed.)*. Macmillan Publishing Company. New York
- [14] Bactiar 2005 *Media Pembelajaran Untuk Sekolah*. Bumi Aksara. Jakarta.
- [15] Roblyer M & Doering AH 2010 *Integrating Educational Technology Into Teaching*. Pearson. Boston
- [16] BSNP 2006 Model Pembelajaran Terpadu IPA. Depdiknas. Jakarta
- [17] Turiman P, Omar J, Daud A M, & Osman K 2012 Fostering the 21st century skills through scientific literacy and science process skills. *Procedia-Social and Behavioral Sciences* **59** 110-116.
- [18] Suhandi A, Sinaga P, Kaniawati I, & Suhendi E 2009 Efektivitas penggunaan media simulasi virtual pada pendekatan pembelajaran konseptual interaktif dalam Meningkatkan pemahaman konsep dan meminimalkan miskonsepsi. *Jurnal Pengajaran MIPA* **13**(1) 35-48
- [19] Alfiriani A & Hutabri E 2017 Kepraktisan dan Keefektifan Modul Pembelajaran Bilingual Berbasis Komputer. *Jurnal Kependidikan* **1**(1) 12-13.
- [20] Diani R, Yuberti Y, & Syafitri S 2016 Uji Effect Size Model Pembelajaran Scramble dengan Media Video terhadap Hasil Belajar Fisika Peserta Didik Kelas X MAN 1 Pesisir Barat. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni* **5**(2) 265-275.
- [21] Sari YP., Sunaryo, Serevina V., Astra, I.M. 2019. Developing E-Module for fluids based on problem-based learning (PBL) for senior high school students. In *Journal of Physics: Conference Series* **1185** (1) p. 012052. IOP Publishing
- [22] Adawiyah R, Harjono A, Gunawan G, & Hermansyah H (2019, February). Interactive e-book of physics to increase students' creative thinking skills on rotational dynamics concept. In *Journal of Physics: Conference Series* **1153** (1) 012117. IOP Publishing.
- [23] Suyatna A, Distrik I W, Herlina K, Suyanto E, & Haryaningtias D (2018, September). Developing interactive e-book of relativity theory to optimize self-directed learning and critical thinking skills. In *AIP Conference Proceedings* **2014**(1) p. 020065). AIP Publishing.
- [24] Lohr M 2014 *EBooks as PDF Files, in EPub Format or as Interactive IBooks? Digital Books in Physics Lessons of Secondary Education*. International Association for the Development of the Information Society.
- [25] Hadaya A, & Hanif M 2019 The Impact of Using the Interactive E-Book on Students' Learning Outcomes. *International Journal of Instruction* **12**(2)
- [26] Serevina V, Sunaryo, Raihanati, Astra I M, Sari IJ 2018 Development of E-Module Based on Problem Based Learning (PBL) on Heat and Temperature to Improve Student's Science Process Skill. *Turkish Online Journal of Educational Technology-TOJET* **17**(3) 26-36.
- [27] Pratono A, Sumarti S S, & Wijayati N. 2018 Contribution of Assisted Inquiry Model of E-Module to Students Science Process Skill. *Journal of Innovative Science Education* **7**(1) 62-68.

Acknowledgment

Thank you to the Research Directorate and Community Service, Ministry of Research Technology and Higher Education as well as Research and Community Service Institutions Lampung University who have funded this research.