

DEVELOPMENT OF LCDS-BASED INTERACTIVE ELECTRONIC SCHOOL BOOK ON BLACKBODY RADIATION AS SELF-INSTRUCTIONAL MATERIALS FOR FOSTERING STUDENT'S CRITICAL THINKING

Meta Dwi Ayuningtias¹, Agus Suyatna^{2*}, Eko Suyanto³, Legborsi Nwineh⁴

^{1,2,3} Physics Education Department, Universitas Lampung, Jl. Prof. Dr. Soemantri Brojonegoro No. 1, Bandar Lampung, Indonesia

⁴Department of Vocational and Technology Education, Rivers State University, Port Harcourt, Nigeria

*Corresponding address: asuyatna@yahoo.com

Received: May 10th, 2018. Accepted: October 9th, 2018. Published: October 28th, 2018

Abstract: This study aims to develop an LCDS- based the interactive electronic school book on blackbody radiation that is valid as self-instructional materials to foster students' critical thinking skills. The method used was research and development. The stages of the research were determining the existing potentials and problems, information gathering, product design, product validation, the final revision of the product, and feasibility tests and practicality of operation. The research instrument used was a questionnaire. Interactive electronic school book has supporting contents, namely user manual, user learning process, video, animation, simulations, and interactive tests. Expert test for product consists of content validation with the score of 3,36 (very appropriate) and design validation with the score of 3,45 (very appropriate). Readability of LCDS-based interactive electronic school book on blackbody radiation got the score of 3, 23 which belongs to the good quality. The practicality aspects got a score of 3.28 which means it can be operated independently.

© 2018 Physics Education, UIN Raden Intan, Lampung, Indonesia.

Keywords: critical thinking, electronic school book, interactive, LCDS, self-instructional materials

INTRODUCTION

Currently, education in Indonesia has implemented the new 2013 curriculum that is expected to improve education in Indonesia for the better. The 2013 curriculum also implements scientific approaches in various subjects (Depdikbud, 2013). So, students are required to have the ability to think critically in solving all problems in life. Critical thinking is convergent thinking, the process of assessing the validity or value of an emerging thing and executing by applying the principles (Alter, 2009). Critical thinking as a high-level thinking activity requires a set of cognitive skills (Baker & Pomeroy, 2001). Critical thinking skills can help students to learn and adapt to all forms of change that take place over time (Ongardwanich,

Kanjanawasee, & Tuipae, 2015). Practicing thinker is a stage of critical thinking development, they have enough skill in thinking to critique their own plan for systematic practice, and to construct a realistic critique of their powers of thought to solve the contextual problem (Mutakinati, Anwari, & Yoshisuke, 2018). To deal with learning in the 21st-century, everyone must have critical thinking skills, digital literacy knowledge and skills, information literacy, media literacy, and master information and communication technologies (Jagodzina & Wolski, 2015).

The students' critical thinking ability is predicted to be improved by using instructional media that provoke students' creative and innovative thinking. The use of Information Technology (IT) as a learning medium is already a demand.

Although the design of IT-based media (Information Technology) requires special skills, it does not mean that media is avoided and abandoned. IT-based learning media can be internet, intranet, mobile phone, and CD Room / Flash Disk. Learning media based on interactive information technology makes learning more interesting and can visualize or describe abstract material by using the animation media in accordance with the situation in the field. Learning media use of three-dimensional (3D) virtual can make users more involved in the interaction, and gender will not influence how involved students are toward the interactivity but experience and spatial ability would (Yilmaz, Baydas, Karakus, & Goktas, 2015). Interactive multimedia used in learning is an excellent medium to improve the learning process by providing opportunities for students to develop skills, identify problems, organize, analyze, evaluate, and communicate information (Wiyono K., Liliyasi, Setiawan, A., Paulus, 2012).

Creating electronic books can be done using electronic book software. Microsoft provides LCDS for free that allows creating high-quality learning content, interactive and accessible online. LCDS have a lot of excellent content such as simulation, video, moving animation, law, and theory and there are also interactive quizzes. The cooperative-based learning set assisted with animation media is proper and can be used to enhance students' learning outcome (Mahbub, Kirana, & Poedjiastoeti, 2016). The profile of developing multimedia-based audio-video experiment has an interesting display, harmonious facilities, systematic and practical in used as well as become a solution of the practicum that not mastered yet (Rante, Sudarto, & Ihsan, 2013). It is therefore recommended that teaching and Learning with technologies such as computer simulators. The utilization of computer simulation in the instruction was

either carried out outside of Nigeria or not in the area of electrical installation is recommended (Nwineh & Okwelle, 2018).

Physics is one branch of natural science that is closely related to everyday life. However, many students consider physics subject matter is very difficult because the physics subject matter not only deals with something that can be observed but also something abstract like in the material of blackbody radiation. As already known, physics is a science learning category that requires experimental activities to understand the concepts or principles. In addition to increasing critical thinking skill, it also increases students' learning achievement, because the students independently learn to get the results of the experiment which they do to prove a theory. This process can help students develop their knowledge because of the conduct the experiment by themselves which is later perfected by the teacher's explanation (Wartono, Hudha, & Batlolona, 2018). For that, it is required tools or media such as electronic books that can visualize or illustrate the concept and improve students' critical thinking skills according to the demands of the 2013 curriculum.

Result of questionnaire of student' need to be obtained through electronic book criterion desired by student, 33, 3% student wanted it to contain description of physics material along with video showing phenomenon, 18, 2% student wanted it to load simulation of practicum that can be done independently, 66, 7% student wanted it to load interactive exercise questions with feedback for exam exercises and college entrance preparation, and 6, 1% of students wanted it to be operated independently or in groups. This is in accordance with the teacher's opinion in the questionnaire filled by the teacher.

Based on the explanation above, the development of the LCDS-based interactive electronic school book on blackbody radiation as self-instructional

materials to foster students' critical thinking skills was indispensable. The purpose of this research is the development of a valid LCDS-based interactive electronic school book on blackbody radiation as self-instructional materials to foster students' critical thinking skills and also knowing the feasibility and practicality of operation of this book.

METHOD

The method used was research and development method. Development undertaken was the development of an interactive electronic school book on black-body radiation material for the twelfth-grade students. The developed interactive electronic school books can be used independently by students or with teacher guidance.

As a first step to obtain the aspects to be studied, the distribution of needs analysis questionnaires was carried out. This needs analysis was carried out through questionnaire distribution techniques to teachers and students. The needs questionnaire was given to the twelfth-grade physics teachers and students at Public Senior High School Sixteen Bandar Lampung. The results of this questionnaire analysis were used to find out the expected product by teachers and students.

Design research in the development referred to Sugiyono's opinion (Sugiyono, 2011). Stages used in the study was only up to stage 6 which is the feasibility test and practicality of operation because the conditions in the field were not possible to be carried out until the dissemination. The procedure or research stages of product development are shown in Figure 1.

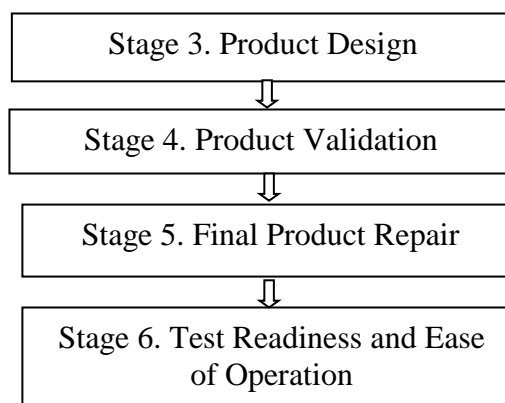
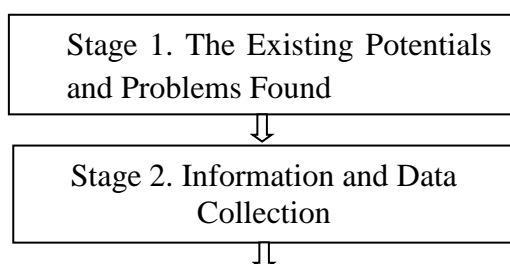


Figure 1. *Electronic school books interactive production steps*

Data analysis was done through the validation test and readability test and the practicality of operation. Validity test was done by using a design test and material test. Material tests and design tests were carried out by experts to evaluate the content or material and design of the interactive electronic school book on black body radiation material. The material and design expert tests were carried out by two physics education lecturers with a Doctoral degree, namely Dr. Abdurahman, M.Sc. and the chief lecturer; Drs. I Dewa Putu Nyeneng, M.Sc. In addition, the material and design expert tests were also conducted by three high school physics teachers who were certified as educators namely Levi Prihata, S.Pd., Joko Purwanto, S.Pd., and Zulimah, S.Pd. the assessment of design and the material were done using a questionnaire.

This assessment questionnaire had four answer choices according to the content of the statement, namely score 4 "Very Appropriate", score 3 "Appropriate", score 2 "less appropriate" and score 1 "inappropriate". So that the total assessment score can be calculated using the following formula:

$$\frac{\text{Number of scores on the instrument}}{\text{The highest total score value}} \times 4$$

Converting score into value statement can be seen in Table 1 and Table 2.

Table 1. Conversion assessment score into a value statement quality

Average Score	Category
3,26 - 4,00	Very Appropriate
2,51 - 3,25	Appropriate
1,76 - 2,50	Less Appropriate
1,01 - 1,75	Inappropriate

Feasibility and practicality of operation tests were performed by the students using a questionnaire. The product was tested on seven students of the twelfth-grade students of Senior High School 16 Bandar Lampung consisted of three males and four females. Seven students were given the same treatment, namely learning using the developed product. Then the students were asked to complete the feasibility and practicality instrument. This assessment questionnaire had four answer choices according to the content of the statement, namely score 4 "Very Good" and "Very Easy", score 3 "Good" and "Easy", score 2 "Good Enough" and "Easy Enough", and score 1 "Not Good" and "Not Easy".

Table 2. Conversion assessment score into a value statement quality

Average Score	Category	Category
3,26 - 4,00	Very Good	Very Easy
2,51 - 3,25	Good	Easy
1,76 - 2,50	Good Enough	Easy Enough
1,01 - 1,75	Not Good	Not Easy

RESULTS AND DISCUSSION

The result of this research development is an interactive electronic school book based on LCDs on black-body radiation as self-instructional materials to foster students' critical thinking skills. The Basic Competency used is applying quantum concepts in explaining blackbody radiation, photoelectric effects, and scattering of physics material in high school on the twelfth-grade students."

In detail, the results of each stage of the development procedure were carried out as follows.

The Existing Potentials and Problems Found

Potentials based on a need's analysis conducted and observations showed that in schools there are facilities such as LCD and computers that can be used and the students' ability to operate the computer. The problems found showed that many students did not really understand the concept in learning physics because of the lack of media to support the learning. Based on the result of questionnaire analysis the students' needs are listed in Table 3.

Table 3. Results of the analysis of the needs of students

Percentage	Criteria
45,5%	Student' Worksheet
48,5%	Virtual laboratory
75,8%	Experiments directly
33,3%	Video
39,4%	Printed books
24,2%	Interactive electronic book

Based on the potentials and problems found in the field in the needs analysis, the researcher felt the need to develop an interactive electronic school book that contains material, image, video, animation, simulation, discussion questions, and interactive tests.

Collection of Information

Information obtained from the literature read directly from books, journals, articles, and accessed via the Internet. In addition, the distribution of the questionnaire of needs analysis and material component questionnaire were also carried out. The questionnaire was given to several lecturers to gather material information needed in product development.

Based on the results of information gathering, the components that need to be developed in the interactive electronic school book on blackbody radiation materials, among others:

- 1) Learning materials were developed, namely the Law of Stefan-Boltzmann Law, Shifting Wien, Rayleigh-Jeans Law, and the hypothesis of quantum Planck to emphasize the transition material the failure of classical physics in discussing the microscopic material towards the study of modern physics and displays a graph of the Stefan-Boltzmann law, Wien shift law, and the Rayleigh-Jeans Law.
- 2) Animations that need to exist in the interactive electronic school book on black-body radiation material is radiation that enters the enclosed space cannot get out again and discoloration on the metal at a given heat continuously. While the simulation needs to exist in the interactive electronic school book on blackbody radiation material is to determine the wavelength and intensity of radiation is affected by the surface temperature.
- 3) The examples, assignments and interactive tests for each sub-material displayed.

Product Design

The interactive electronic school book was developed using the LCDS 2.8 program, Microsoft power point 2010, Macromedia Flash 8, and ispring quiz maker. The design of interactive electronic school book development in this research was as follows; (1) Covers containing material titles, blackbody radiation illustrations, developer names, authors' names, and levels of schools; (2) Instructions containing instructional manual and instructions for using interactive electronic school book; (3) Basic competence; (4) Indicators; (5) Learning Objectives; (6) Materials containing images, phenomena, animations, simulations, initial questions, and material presentation and examples of questions; (7) Interactive Test; (8) Reference list; (9) Glossary.

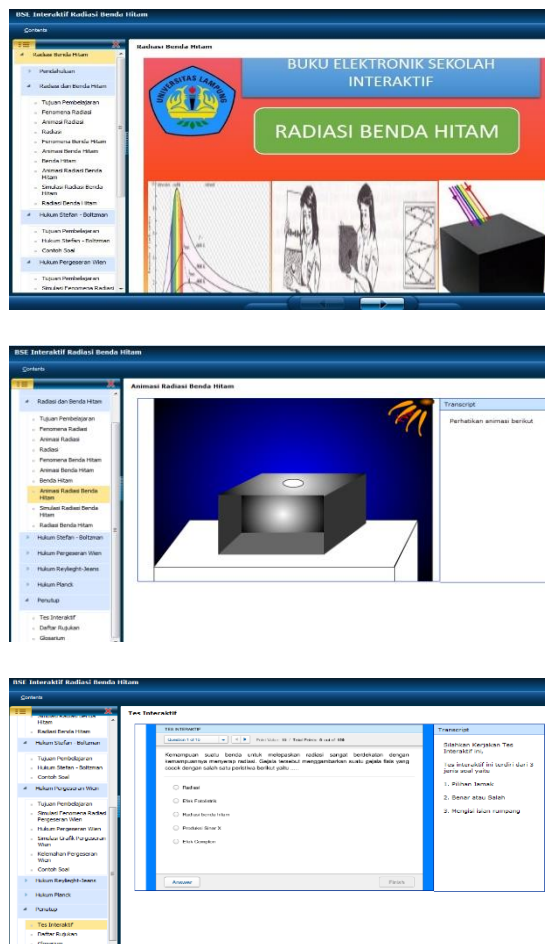


Figure 2. Interactive Electronic School Book Display

Product Validation

After the initial product was finished, the next step was to test the validity by a team of experts consisting of material experts and design experts. Material experts examined whether the content component of the interactive electronic school book was in accordance with the value of the quality set by the Center for Curriculum and Books. While the design experts assess suitability indicators such as component design on the cover, suitability of the content design component of the book and the overall packaging of the book design.

The results of material validation and design assessment can be seen in table 4 and table 5.

Table 4. Results of expert validation toward the product's material

No.	Aspect	Score	Category
1.	The aspect of	3.35	Very
2.	Conformity	3.28	Appropriate
3.	Learning	3.3	Very
4.	Material	3.5	Appropriate
	Accuracy		Very
	Up-to-date		Appropriate
	Compliance		Very
	Material with Scientific Approach		Appropriate

Table 5. Results of expert validation toward the product's design

No	Aspect	Score	Category
1.	Layout design	3,2	Match
2.	Typography	3,4	Very Appropriate
3.	Illustrations Conformity interactive.	3,45	Very Appropriate
4.	electronic school book for independent study	3,6	Very Appropriate

Based on Table 4 and Table 5 it can be seen that the feasibility of the components of the material in interactive electronic school book has met the criteria as a medium that can help teachers and students in learning black-body radiation material with reference to scientific approach, and feasibility of design within

the interactive electronic school book has met the criteria as a medium that can help teachers and students in the learning process.

Products Improvement

Based on the results of expert material and design validation, suggestions were obtained. The next step was to make improvements to the product. The suggestions for improvements were that; it should have a good level of indicators, using operational verbs with the basic concept of online learning, learning objectives must be clear, presenting examples of video of radiation phenomena, and present examples of real-life radiation in the field of technology. Suggested improvements for the design; it should use a harmonic background color and availability of user instruction manual.

Feasibility and Practicality

The product was tested on seven students of twelfth grade consisting of three males and four females. This test aims to see the feasibility and practicality of operation of the product.

The results of the feasibility and practicality of operation can be seen in table 6.

Table 6. The test results

No.	Statement	Score Tester
1.	The use of language in the interactive electronic book is easy to understand independently	3.28
2.	Use of language in the electronic book is communicative and interactive	3.28
3.	Use of language in the electronic book is interactive and not causing double meanings	3.28
4.	Interactive electronic books are using good sentence structure, so it is easy to understand	3.28
5.	Use of language in the interactive electronic book is appropriate	3.14
6.	Language use can encourage critical thinking	3.14
7.	Directive/ command/guide is easy for students to understand	3.14
8.	Question is able to facilitate students' understanding of interactive electronic books	3.28
9.	Chronology of presentation is able to make the interactive electronic book easily understood	3.28
10.	Coverage content (images, animations, simulations) is able to make the interactive electronic book easy to learn	3.42

Based on the results of feasibility and practicality of operation tested on the 7 students, it can be seen that overall interactive electronic school book is good in terms of feasibility and practicality of operation so that it can be used as self-

instructional materials that can explain the concept of blackbody radiation.

As for the final design of an interactive electronic school book on black-body radiation material, can be seen in figure 2

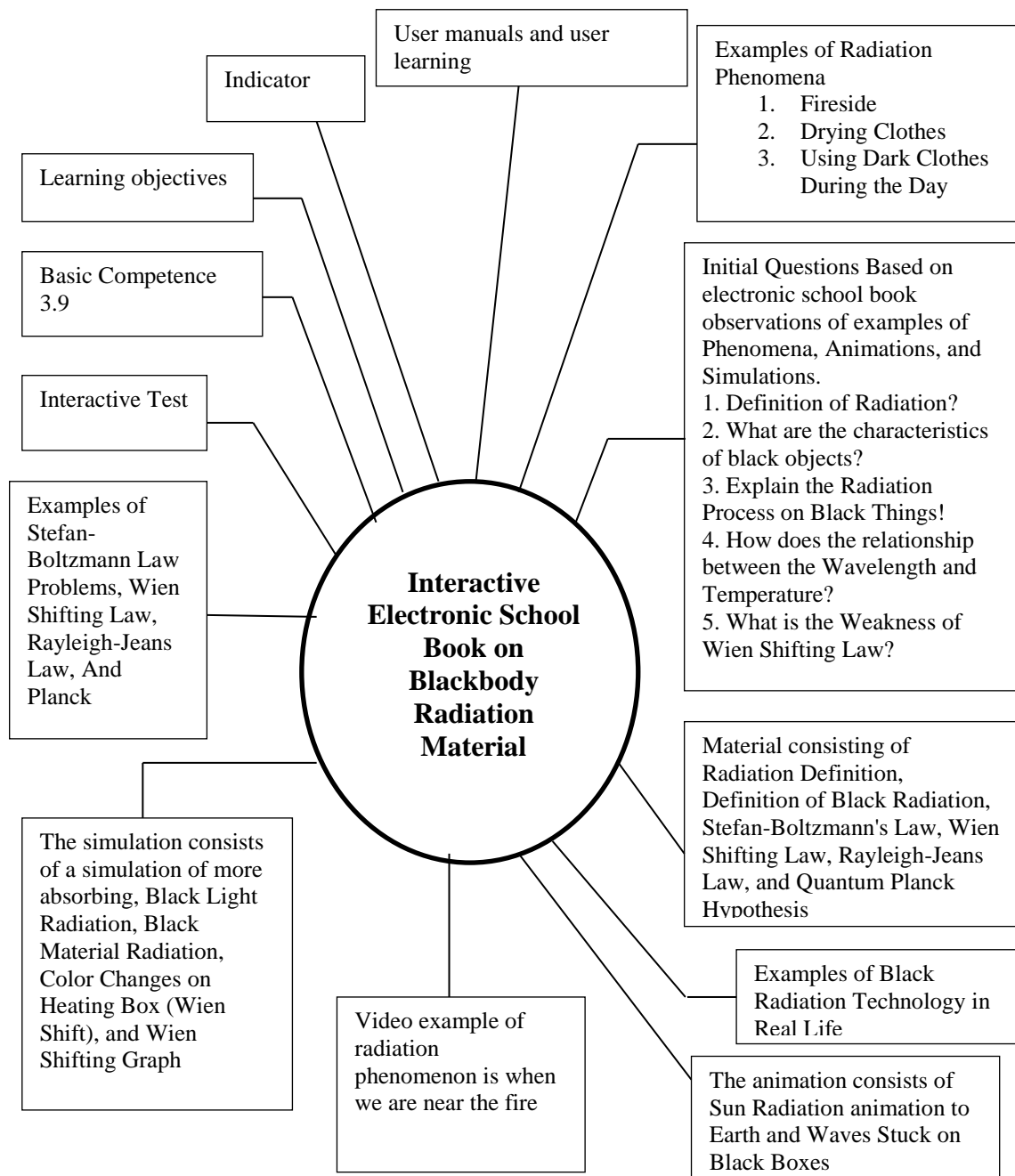


Figure 3. Interactive electronic school book structure of blackbody radiation

Discussion about the development of LCDS-based interactive electronic school book on blackbody radiation material is the appropriateness of interactive

electronic school book design as self-instructional material and foster critical thinking skills as well as product development shortcomings.

The appropriateness of interactive electronic school book design as self-instructional material to foster critical thinking skills

Interactive electronic school book on blackbody radiation can be used as self-instructional materials by students. There are instructions for usage and instructions on studying using the electronic school book. The existence of instruction manuals and study instructions make it easier for students to the book as self-instructional materials. The instruction manuals contain how to use and operate an interactive electronic school book, while the study instructions contain a way to learn. Moreover, to any existing menu in an interactive electronic school book on blackbody radiation material, there are also directives and guidance measures that facilitate student learning.

Interactive electronic school book on blackbody radiation material can also be used to foster critical thinking skills. The use of interactive multimedia is more efficient in learning than the conventional media (Gerven, Paas, Van, Hendriks, & Schmidt, 2003). There is some content on the interactive electronic school book on blackbody radiation material that can improve critical thinking skills, among other the phenomenon example of pictures and video, the original question, animation, simulation, and exposure of the material and interactive tests. The use of multimedia in the electronic school book can improve critical thinking skills. Students tended to view the integrating Interactive Whiteboard (IWB) learning environment as providing more opportunities for them to think and to perform inquiry learning, and that the digital teaching materials presented using IWB were not only interesting and simple to operate, but also more challenging and stimulating (Yang, Wang, & Chiu, 2015). Interactive multimedia Android-System game can improve critical thinking skills on the effective category which is proven

through the observations (Wardani, Lindawati, & Kusuma, 2017).

The example content of blackbody radiation phenomena in the form of pictures and video will help students to identify and characterize a phenomenon of blackbody radiation so that students are able to hypothesize a definition. This is appropriate with the critical thinking indicators defining the term and considers a definition. Students who are using e-learning contained interactive video gain better learning outcomes significantly and gain confidence level higher than students who used the conventional media (Zhang, Zhou, Briggs, & Nunamaker, 2006).

Furthermore, there are several animation and simulation in an interactive electronic school book to foster critical thinking skills. The animations and simulations will help the students to process and analyze an event so that they are able to identify and analyze the arguments. This is appropriate with the critical thinking indicators defining the term and consider a definition and identify assumptions. The existence of a significant impact of online learning for transferring knowledge-based animation and student motivation (Rosen, 2009). The simulation is an efficient and effective way to learn complex and dynamic concepts. The efficiency gained by reducing the time required to achieve the objectives in learning and effectiveness gained by achieving better results in the task being studied (Parush, Hamm, & Shtub, 2002).

After the animation and simulation displayed on interactive electronic school book, then there is the initial question that refers to the answers based on the observations on animation or simulation. The initial inquiry will help the students in arguing or answering questions based on their prior knowledge. By giving a problem, students become more creative in thinking, and they can be challenged so that it can grow great curiosity to solve problems (questions) encountered in the

learning process. A statistically significant relationship was found between the critical thinking dispositions and the problem-solving skills of students (Ozyurt, 2015). Physics students' learning outcome increases due to the problems that students are required to actively think (Hartini, Kusdiwelirawan, & Fitriana, 2014). The application of the Problem-Based Learning model is able to increase critical thinking skills and creative action of the students (Nuswowati, Susilaningsih, Ramlawati, & Kadarwati, 2017).

Furthermore, there is a brief exposure to the material in several sub-materials after initial questions. With the exposure of the material that contains the answer to the initial question, will assist the students in comparing the answer with the exposure of the material and the results of the electronic school book observations made. This is in accordance with indicators of critical thinking which is to consider and analyze the results of the induction argument.

There is also an interactive test at the end of the exposure of the material; the interactive tests will help students to foster their critical thinking skills. In addition, the evaluation tool simplifies the interchange of information on physics among teachers and lecturers (Morera, Arauzo-azofra, & García-hernández, 2012). The program interactive quiz can be used to train the ability to discover physical phenomena presented in a matter that contains illustrations of physical phenomena such as interactive animations, interactive video and interactive graphics as well as feedback responses of the students and the improvement of learning outcomes (understanding) regarding the exploration of physical phenomena after the use of interactive quizzes.

Advantages and Disadvantages of the Developed Product

Interactive electronic school book based on LCDS has some advantages and

disadvantages. The advantages namely blackbody radiation material classified as an abstract material can be visualized through illustrations, animations, simulations, video learning, and can be operated offline on your laptop or computer. So it becomes a book that is attractive and desirable by the user and easy to use. While the weaknesses are it is not possible to add an equation because there is no Microsoft Equation. So to overcome the shortcomings the equation or text must be changed into jpg format or another supporting format, the use of other applications such as PowerPoint, learning videos cannot be played before first installing Microsoft Silverlight, and to open the Interactive electronic school book should be using the Mozilla support.

CONCLUSIONS AND SUGGESTIONS

Based on the results of research and discussion, it can be concluded that the developed product is valid as self-instructional materials to foster critical thinking skills that contain material in the form of text, images, animations, simulations, and interactive tests. The score test about the subject matter from the subject material expert is 3.36 (very appropriate), and from the design, the expert is 3.45 (very appropriate). Moreover, the feasibility gained a mean score of 3.23. The practicality of operation gained a mean score of 3.28 so that it can be operated independently.

This research has limitations. Namely, this product has not been tested in the field to look for the effectiveness of this interactive electronic school book. For further development, it is advisable to do a test on the actual student. This testing can be done by comparing the results of learning and critical thinking skills class that uses the interactive electronic school book with the class using the printed book. Besides that, the composition of the image, animation, simulation, and selection of diction in the prologue is expected to be packaged more interestingly so that it can motivate students more in using this book.

ACKNOWLEDGMENTS

The authors highly appreciate the subject material expert and design expert for constructive suggestions and feedback on the development of interactive electronic school book on black-body radiation material. Thank you to the Research Institute and Community Service of Lampung University who has funded this research

REFERENCES

- Alter, F. (2009). Understanding The Role Of Critical And Creative Thinking In Australian Primary School Visual Arts Education. *International Art in Early Childhood Research Journal*, 1(1), 1–12.
- Baker, M., & Pomeroy, C. (2001). Relationships Between Critical And Creative Thinking. *Journal of Southern Agricultural Education Research*, 51(1), 173–188.
- Depdikbud. (2013). Permendikbud No. 81A Tentang Implementasi Kurikulum Pedoman Umum Pembelajaran, 201–209.
- Gerven, P. W. M. Van, Paas, F., Van, J. J. G., Hendriks, M., & Schmidt, H. G. (2003). The Efficiency Of Multimedia Learning Into Old Age. *British Journal of Educational Psychology*, 73, 489–505.
- Hartini, T. I., Kusdiwelirawan, A., & Fitriana, I. (2014). Pengaruh Berpikir Kreatif Dengan Model Problem Based Learning (PBL) Terhadap Prestasi Belajar Fisika Siswa Dengan Menggunakan Tes Open Ended. *Jurnal Pendidikan IPA Indonesia*, 3(1), 8–11.
- Jagodzin, P., & Wolski, R. (2015). Assessment Of Application Technology Of Natural User Interfaces In The Creation Of A Virtual Chemical Laboratory. *J Sci Educ Technol*, 24(1), 16–28. <https://doi.org/10.1007/s10956-014-9517-5>
- Mahbub, M. Z., Kirana, T., & Poedjiastoeti, S. (2016). Development Of Stad Cooperative Based Learning Set Assisted With Animation Media To Enhance Students' Learning Outcome in MTS. *Jurnal Pendidikan IPA Indonesia*, 5(2), 247–255. <https://doi.org/10.15294/jpii.v5i2.6004>
- Morera, L., Arauzo-azofra, A., & García-hernández, L. (2012). Analysis Of Online Quizzes As A Teaching And Assessment Tool. *Journal of Technology and Science Education*, 2(1), 39–45.
- Mutakinati, L., Anwari, I., & Yoshisuke, K. (2018). Analysis Of Students' Critical Thinking Skill Of Middle School Through Stem Education Project-Based Learning. *Jurnal Pendidikan IPA Indonesia*, 7(1), 54–65. <https://doi.org/10.15294/jpii.v7i1.10495>
- Nuswowati, M., Susilaningsih, E., Ramlawati, & Kadarwati, S. (2017). Implementation Of Problem-Based Learning With Green Chemistry Vision To Improve Creative Thinking Skill And Students' Creative Actions. *Jurnal Pendidikan IPA Indonesia*, 6(2), 221–228. <https://doi.org/10.15294/jpii.v6i2.9467>
- Nwineh, L., & Okwelle, P. (2018). Acquisition Of Practical Skills In Domestic Electrical Installation: Computer Simulation Versus Demonstration Approach. *Journal of Technical Education and Training*, 10(1), 45–55.
- Ongardwanich, N., Kanjanawasee, S., & Tuipae, C. (2015). Development of 21 st Century Skill Scales as Perceived by Students. *Procedia - Social and Behavioral Sciences*, 191, 737–741. <https://doi.org/10.1016/j.sbspro.2015.04.716>

- Ozyurt, O. (2015). Examining The Critical Thinking Dispositions and The Problem Solving Skills of Computer Engineering Students. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(2), 353–361. <https://doi.org/10.12973/eurasia.2015.1342a>
- Parush, A., Hamm, H., & Shtub, A. (2002). Learning Histories in Simulation-Based Teaching : The Effects on Self-Learning and Transfer. *Computers & Education*, 39, 319–332. [https://doi.org/10.1016/S0360-1315\(02\)00043-X](https://doi.org/10.1016/S0360-1315(02)00043-X)
- Rante, P., Sudarto, & Ihsan, N. (2013). Pengembangan Multimedia Pembelajaran Fisika Berbasis Audio-Video Eksperimen Listrik Dinamis Di SMP. *Jurnal Pendidikan IPA Indonesia*, 2(2), 203–208.
- Rosen, Y. (2009). The Effects of An Animation-Based On-Line Learning Environment on Transfer of Knowledge And on Motivation for Science And Technology Learning. *J. Educational Computing Research*, 40(4), 451–467. <https://doi.org/10.2190/EC.40.4.d>
- Sugiyono. (2011). Metode Penelitian Kuantitatif dan Kualitatif R&D, 9, 53–57.
- Wardani, S., Lindawati, L., & Kusuma, S. (2017). The Development Of Inquiry By Using Android-System-Based Chemistry Board Game To Improve Learning Outcome And Critical Thinking Ability. *Jurnal Pendidikan IPA Indonesia*, 6(2), 196–205. <https://doi.org/10.15294/jpii.v6i2.8360>
- Wartono, W., Hudha, M. N., & Batlolona, J. R. (2018). How Are The Physics Critical Thinking Skills of The Students Taught by Using Inquiry-Discovery Through Empirical and Theoretical Overview ? *EURASIA Journal of Mathematics, Science and Technology Education*, 14(2), 691–697. <https://doi.org/10.12973/ejmste/80632>
- Wiyono K., Liliyasi, Setiawan, A., Paulus, C. . (2012). Model Multimedia Interaktif Berba-sis Gaya Belajar Untuk Meningkatkan Penguasaan Konsep Pendahuluan Fisika Zat Padat, 2(2), 264–275.
- Yang, K., Wang, T., & Chiu, M.-H. (2015). Study The Effectiveness of Technology-Enhanced Interactive Teaching Environment on Student Learning of Junior High School Biology. *Eurasia Journal of Mathematics, Science & Technology Education*, 11(2), 263–275. <https://doi.org/10.12973/eurasia.2015.1327a>
- Yilmaz, R. M., Baydas, O., Karakus, T., & Goktas, Y. (2015). An Examination of Interactions in A Three-Dimensional Virtual World. *Computers & Education*, 88, 256–267. <https://doi.org/10.1016/j.compedu.2015.06.002>
- Zhang, D., Zhou, L., Briggs, R. O., & Nunamaker, J. F. (2006). Instructional Video in E-Learning : Assessing The Impact of Interactive Video on Learning Effectiveness. *Information & Management*, 43, 15–27. <https://doi.org/10.1016/j.im.2005.01.004>

INQUIRY-DISCOVERY EMPOWERING HIGH ORDER THINKING SKILLS AND SCIENTIFIC LITERACY ON SUBSTANCE PRESSURE TOPIC

Wartono¹, Johannis Takaria², John Rafafy Batlolona*³, Sascha Grusche⁴,
Muhammad Nur Hudha⁵, Y. M. Jayanti⁶

¹ Department of Physics, Faculty of Mathematics and Natural Sciences, State University of Malang, Indonesia

^{2,3} Primary School Teacher Education Study Program, Teaching and Education Faculty, Pattimura University, Indonesia

⁴ Physics Education, Pädagogische Hochschule Weingarten, Kirchplatz 2, 88250 Weingarten, Germany

^{5,6} Physics Education Study Program, Faculty of Science and Technology, Universitas Kanjuruhan Malang, Indonesia

*corresponding author: johanbatlolona@gmail.com; john_batlolona@yahoo.co.id

Received: July 1st, 2018. Accepted: October 21st, 2018. Published: October 28th, 2018

Abstract: Inquiry-discovery learning plays an important role in improving high-order thinking skills (HOTS) and scientific literacy (SL). In this HOTS and SL research, it was designed with Inquiry-discovery based learning. The purpose of this study was to promote Inquiry discovery models in empowering higher-order thinking skills and scientific literacy in physics with different classes. This research used Quasi-Experimental Design research, and Pretest-Posttest Control Group Design. The research analysis design matrix used two-way ANOVA. The sample was taken from two classes, namely the experimental and control classes of 68 students. The results of the study prove that Inquiry discovery can improve HOTS and SL physics of students. Thus, inquiry-discovery can be recommended to increase student's HOTS and SL physics when compared to conventional classes. The novelty of this study is that inquiry-discovery learning models are more likely to reconstruct students' scientific knowledge of physics on aspects of HOTS and SL with real-world life.

© 2018 Physics Education, UIN Raden Intan, Lampung, Indonesia.

Keywords: HOTS, SL, initial ability, inquiry-discovery, substance pressure

INTRODUCTION

One component that must be developed in learning today is high-order thinking skills (Madhuri, Kantamreddi, & Prakash Goteti, 2012; Polly, Ausband, Polly, & Ausband, 2014). The HOTS concept originated from Bloom's taxonomy of cognitive domains introduced in 1956 (Forehand, 2011). The cognitive domain involves knowledge and development of intellectual skills (Bloom, 1956). This includes withdrawal or recognition of specific facts, procedural patterns, and concepts that function to develop intellectual abilities and skills. There are six main categories of cognitive processes, starting from the simplest to the most complex. Bloom categorizes intellectual behavior into six levels of thought: knowledge, understanding, application,

analysis, synthesis, and evaluation (Clark, 2010; Yahya, Toukal, & Osman, 2012).

HOTS is a thought process that involves mental activities in an effort to explore complex, reflective and creative experiences that are carried out consciously to achieve learning goals, namely gaining knowledge that includes the level of analytical thinking, synthesis, evaluative and producing many productive solutions (Miri, David, & Uri, 2007). HOTS consists of analysis, evaluation, synthesis, developing skills in problem solving, concluding, estimating, predicting, generalizing and creative thinking (Wilks, 1995), while other aspects are asking questions, decision making, critical and systematic thinking (Dillon & Scott, 2002; Zohar, 2004; Zoller, Dori, & Lubezky, 2002). HOTS can be seen from the achievements reached by each student,

including the results of the state and private junior high school national exams in Indonesia. In 2016, the average scores of 890 schools were 65.05. In 2017, the average scores of 8,882 schools that used Computer-Based National Examination were 55.51 while the average scores of 17,760 schools are 52,96 in 2018 (Kemdikbud, 2018). This fact proves that Indonesian student achievement has declined. Thus, the teacher as the main trainer of learning is required to be able to facilitate students in thinking in each learning process (W. Wartono, Diantoro, & Bartlolona, 2018; Wartono Wartono, Hudha, & Batlolona, 2018). One aspect that facilitates students to think high is experiment-based learning that is shown in Figure 1.

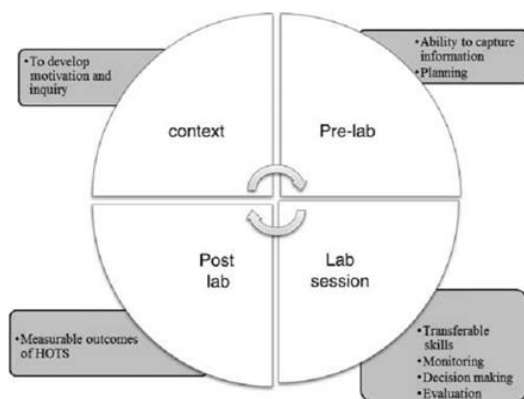


Figure 1. Experimental workflow with HOTS (Madhuri et al., 2012)

In addition to the abilities that must be possessed by each student, another aspect that can be empowered is scientific literacy. SL is defined as the ability to use scientific knowledge, identify questions, draw conclusions based on available evidence, and understand and make decisions regarding nature and changes made to nature through human activities (Firman, 2007; PISA 2006 Programme for International Student Assessment, 2006). SL ability is defined as a person's ability to distinguish scientific facts from various information, recognize and analyze the use of scientific inquiry methods and the ability to organize, analyze, and interpret

quantitative data and scientific information (Gormally, Brickman, & Lut, 2012). SL can also be defined as the basic knowledge and skills needed by an individual to participate in the scientific process (Turgut, 2007). The concepts of mathematical literacy, computer literacy, biological literacy, chemical literacy, communication literacy and statistical literacy that all appear after the definition of scientific literacy (Çepni, S., Ayvaci, H. Ş., & Bacanak, 2004).

The 2000 and 2003 PISA results divide the SL aspects into three important domains, among others, science content, science processes, and science application contexts (OECD, 2001, OECD, 2004a) while the 2006 and 2009 PISA developed SL into four major domains including science content, scientific competence/process, science applications, and attitudes. Domain attitudes in PISA 2006 and 2009, more supportive of scientific inquiry, confidence, interest in science and a sense of responsibility for resources and the environment (OECD, 2006). In PISA 2009 the definition of SL was the same as in PISA 2006, and divided SL into four domains as in PISA 2006, except that the difference is attitude domains were not included in the test items in PISA 2009 (OECD, 2010); while PISA 2015 emphasizes science, reading and mathematical skills (OECD, 2014).

SL is important to be mastered by students in relation to the way students can understand the environment, health, economy, politics and other problems faced by a modern society that is highly dependent on ICT, as well as the development of science (Yuenyong, 2013). One of the efforts to increase SL in physics learning is by fostering understanding of concepts. Increasing HOTS and SL in each student depends on their initial abilities (Fives, Huebner, Birnbaum, & Nicolich, 2014; W. Wartono et al., 2018).

Initial ability is a prerequisite that students must have before entering the next higher learning. A student who has the good initial ability will more quickly understand the learning material so that it has an effect on learning outcomes. In contrast to students who have initially weak knowledge will adversely affect their learning outcomes (Piten, Rakkapao, & Prasitpong, 2017). Therefore, students must have the initial ability before starting learning so that they can participate in learning activities well.

It must be noted that the initial ability will affect a student in receiving new knowledge. Therefore, if the initial knowledge of students is low it will affect the next learning (Jonassen, 1991) so that it will affect their ability to think high-level and scientific literacy. Therefore, in the learning process, teachers should choose models that can grow HOTS and SL students and in accordance with the objectives to be achieved in learning activities. The learning model that is used must be able to involve students and find their own constructive new concepts. One learning model that involves and trains students to learn to find is inquiry-discovery learning.

Inquiry-discovery learning is a combination of two learning models namely the inquiry model and discovery model. An inquiry is an extension of the discovery process that is used more deeper meaning that the inquiry process contains higher-level mental processes to obtain and obtain information by conducting observations or experiments (Sund, R. B., & Trowbridge, 1973). An inquiry is more directed to the process of investigation, excavation, finding the latest things, and reviewing objects that must be studied (Meijerman, Storm, Moret, & Koster, 2013), while discovery prioritizes reflection, thinking, experimenting, and exploring (Bruner, 1961). Discovery is a learning model that finds concepts through a series of data or information obtained

through observation or experiment and provides opportunities for students to find themselves without the help of teachers (Saab, Van Joolingen, & Van Hout-Wolters, 2005). Learning with discovery can encourage students to learn through active involvement or experience by experimenting to discover their own concepts and principles (In'am, Akhsanul; Hajar, 2017).

Inquiry-discovery learning is learning that allows students to use all their potentials both cognitive, effective, and psychomotor, especially mental processes to discover their own concepts or principles of physics and can train other mental processes that characterize a scientist (Klahr & Nigam, 2004). By inquiry-discovery learning, the discovery of knowledge by means of observation, experimentation, and problem-solving can be achieved, the knowledge gained by students will be more meaningful because, in this learning, students themselves are looking for and discovering their knowledge (Tompo, Ahmad, & Muris, 2016).

The use of inquiry-discovery learning is very relevant to the steps of the scientific method, and learning theories such as Piaget's cognitive theory, conditioning and constructive (Richardson & Renner, 1970).

Investigation and discovery of concepts need to be trained in students in learning activities so that students are accustomed to independent learning and able to understand the material being studied. Physics material at junior high and high school level is still considered difficult by students (Batlolona, J. R. & Haumahu., 2016). One of the physics materials at junior high school is the pressure and its application in everyday life. The pressure material on liquid and its application in daily life is abstract material, so students find it difficult to understand the concepts being taught (Loverude, Kautz, & Heron, 2003; Susman & Pavlin,

n.d.). Learning in this material is very necessary to be visualized so that students can see clearly about the phenomenon that exists. Visualization of the phenomenon can make students really understand the concept as a whole (Taale, 2011). Based on the problems described above, the aim of this research is to promote Inquiry-discovery learning models in empowering higher-order thinking skills and scientific literacy in physics with different classes

METHOD

Research Background

This study used a type of Quasi-Experimental Design research and Pretest-Posttest Control Group Design. The research analysis design matrix used two-way ANOVA.

Population and Research Sample

The population in this study were all eighth-grade students of public junior high school 10 in Malang city. This study used two classes as samples, namely VIII C class as the experimental class and VIII B as the control class, where the sampling technique used is cluster random sampling. The sample selection was determined by looking at the students' initial abilities as seen from the results of the formative tests.

The measurement instrument to measure HOTS and SL in this study used a description test form, which was arranged based on indicators in these variables, while the initial ability was taken from the previous formative test scores. Before the instrument was used, it was tested to meet the requirements of validity and reliability with a value of 0.7 and 0.8.

The data in this study were collected through the test and non-test instruments, which means both quantitative and qualitative. Quantitative data were collected through written tests namely pretest and posttest. Qualitative data were collected through interviews of the initial and final test results. The learning process

uses inquiry-discovery learning developed.

The results of HOTS and SL were then tested to find out the improvement achieved by students in that ability. The Improvement of high-order thinking skills and scientific literacy can be known by performing the N-Gain test.

Data analysis

The analysis technique used in this study is quantitative and qualitative data analysis techniques. Qualitative data analysis techniques are by conducting interviews. The two types of quantitative data analysis techniques used are prerequisite tests and hypothesis testing using SPSS 16.0 for Windows. The two types of prerequisite tests are the normality test and homogeneity test. The normality test uses a One-Sample Kolmogorov-Smirnov Test and homogeneity test using the Test of Homogeneity of Variances, while the hypothesis test uses a two-way ANOVA test (Two-Way ANOVA). Criteria for testing hypotheses ($\alpha = 0.05$), namely if $\text{sig} > 0.05$ then $H_0 = \text{accepted}$, $H_1 = \text{rejected}$ and if $\text{sig} < 0.05$ then $H_0 = \text{rejected}$, $H_1 = \text{accepted}$.

RESULTS AND DISCUSSION

Student Initial Capacity Value Data

Description of students' initial ability data for the experimental class and control class is presented in Table 1.

Table 1. Initial Students' Ability

Learning	Number of Samples	Average
Inquiry-discovery	34	67,40
Conventional	34	67,43

Based on Table 1, it can be seen, that the average value of the initial ability of the experimental class students is 67.40, while the control class has an average value of 67.43. Based on these results, the difference in the average value of the initial ability of students between the

experimental class and the control class is 0.03. Table 1 shows the data of students' initial ability scores between the experimental class and the control class is evenly distributed. Furthermore, the description of HOTS data and student SL is shown in Tables 2 and 3.

Table 2. Student HOTS Value Data

Class	Type of Test	The number of students	Average
Experiment	Pretest	34	48,63
			78,97
Control	Posttest	34	44,71
			71,97

Table 3. Student SL Value Data

Class	Type of Test	The number of students	Average
Experiment	Pretest	34	54,53
			81,65
Control	Posttest		52,50
			73,32

Test for N-Gain HOTS and SL

Based on the results of the HOTS N-Gain test, it shows an increase in both students who learn with inquiry-discovery and conventional learning. Firstly, the results of the HOTS N-Gain average test in the experimental class were 30, the standard deviation was 2.63, while in the control class the N-Gain mean test results were 27, and the standard deviation was 2.50. These results indicate students who learn with inquiry-discovery learning are higher than students who learn with conventional learning from both the mean and standard deviation. Secondly, the result of the N-Gain SL test in the experimental class is 27, the standard deviation is 2.62, while in the control class the N-Gain average test results are 21, and the standard deviation is 2.28. These results indicate students who learn with inquiry-discovery learning are higher than students who learn with conventional learning both viewed from the average and standard deviation.

Normality Test Results for HOTS and SL

The results of the normality test based on the One-Sample Kolmogorov-Smirnov Test statistic showed that the results of pretest SL students in the experimental class using inquiry-discovery learning had $Sig > \alpha$ (0.574 > 0.05), and the posttest had $Sig > \alpha$ (0.454 > 0.05). In the same way, the results of the pretest of high-order thinking skills of students in the control class using conventional learning have $Sig > \alpha$ (0.726 > 0.05) and the posttest has $Sig > \alpha$ (0.318 > 0.05). Therefore, it can be concluded that the value of students' high-order thinking skills is normally distributed. The results of the normality test of scientific literacy values based on the One-Sample Kolmogorov-Smirnov Test statistic showed that the results of pretest scientific literacy using inquiry-discovery learning had $Sig > \alpha$ (0.653 > 0.05), and the posttest had $Sig > \alpha$ (0.827 > 0.05). Similarly, the results of the pretest of scientific literacy using conventional learning have $Sig > \alpha$ (0.496 > 0.05) and posttest has $Sig > \alpha$ (0.536 > 0.05). Therefore, it can be concluded that the value of scientific literacy based on learning that is used is normally distributed.

Homogeneity Test Results for HOTS and SL values

The result of homogeneity test using the Test of Homogeneity of Variances shows that the results of the homogeneity test of high-order thinking skills using inquiry-discovery learning have $Sig > \alpha$ (0.525 > 0.05) and the results of the homogeneity test of high-order thinking skills using conventional learning have $Sig > \alpha$ (0.739 > 0.05). Therefore, it can be concluded that the value of high-order thinking skills comes from a homogeneous group. Similarly, the results of the homogeneity test using the Test of Homogeneity of Variances showed that the results of the scientific literacy homogeneity test using inquiry-discovery learning had $Sig > \alpha$ (0.387 > 0.05) and the

results of the test of scientific literacy homogeneity using conventional learning had $\text{Sig} > \alpha$ ($0.723 > 0,05$). Therefore, it can be concluded that the value of scientific literacy comes from a homogeneous group.

HYPOTHESIS TESTING

Hypothesis 1 Test Results

Based on the results of ANOVA analysis of two lanes of high-order thinking skills shows that $\text{Sig} > \alpha$ ($0,000 < 0,05$), then H_0 is rejected and H_1 is accepted so that it can be concluded that students' high-order thinking skills taught with inquiry-discovery learning are higher than students who taught with conventional learning.

Hypothesis 2 Test Results

Based on the results of the two-way ANOVA analysis of the interaction between inquiry-discovery learning towards high-order thinking skills in terms of the students' initial ability shows that $\text{Sig} > \alpha$ ($0.737 < 0.05$). Therefore, it can be concluded that H_0 is accepted and H_1 is rejected, this indicates that it is not there is an interaction between inquiry-discovery learning and higher-order thinking skills in terms of initial abilities.

Hypothesis 3 Test Results

Based on the results of two-way ANOVA analysis with Tukey's further test, high-order thinking skills of students with inquiry-discovery learning and conventional based on high initial ability shows that $\text{Sig} < \alpha$ ($0.012 < 0.05$). Therefore, it can be concluded that the students' higher order thinking skills with initial abilities height taught by inquiry-discovery learning is higher than students taught with conventional learning.

Hypothesis 4 Test Results

Based on the results of one-way ANOVA analysis with Tukey's advanced test students' high-order thinking skills with inquiry-discovery learning and

conventional based on low initial ability shows that $\text{Sig} < \alpha$ ($0.003 < 0.05$). H_0 is rejected, and H_1 is accepted so that it can be concluded that the students' high-order thinking skills with low initial abilities who are taught with inquiry-discovery learning are higher than students taught with conventional learning.

Hypothesis 5 Test Results

Based on the results of ANOVA analysis of two scientific literacy pathways shows that $\text{Sig} > \alpha$ ($0,000 < 0,05$), then H_0 is rejected and H_1 is accepted so it can be concluded that students' scientific literacy taught by inquiry discovery is higher than students taught with conventional learning.

Hypothesis 6 Test Results

Based on the results of the Two-Way ANOVA analysis, interaction between inquiry-discovery learning to scientific literacy in terms of the students' initial abilities showed that $\text{Sig} < \alpha$ ($0.002 < 0.05$). Therefore, it can be concluded that H_0 is rejected and H_1 is accepted, this indicates that there is an interaction between inquiry-discovery learning of scientific literacy in terms of initial abilities.

Hypothesis 7 Test Results

Based on the results of one-way ANOVA analysis with Tukey's posthoc test, students' 'scientific literacy with inquiry-discovery learning and conventional based on high initial ability shows that $\text{Sig} < \alpha$ ($0,000 < 0,05$), H_0 is rejected and H_1 is accepted. Therefore, it can be concluded that students' scientific literacy with high initial abilities taught with inquiry-discovery learning is higher than students taught with conventional learning.

Hypothesis 8 Test Results

Based on the results of one-way ANOVA analysis with Tukey's posthoc test, students' 'scientific literacy with inquiry-discovery learning and

conventional based on low initial ability shows that $\text{Sig} < \alpha$ ($0,000 < 0,05$), H_0 is rejected and H_1 is accepted. Therefore, it can be concluded that students' scientific literacy with low initial ability taught by inquiry discovery is higher than students taught with conventional learning.

Based on the results of statistical test data analysis, it shows that students who are taught with inquiry-discovery learning reached higher achievement than students taught with conventional learning do. This is evidenced by the results of the analysis that is $\text{Sig} < \alpha$ and is supported by mean values and N-Gain higher-order thinking skills taught using inquiry-discovery learning is higher than the value of higher-order thinking skills taught using conventional learning. This is because inquiry-discovery learning models are more likely to facilitate students in high-order thinking. This can be seen clearly in the 6 stages of inquiry-discovery shown in Table 4 when compared to conventional learning which relies more on teachers as a source of knowledge information.

Inquiry-discovery learning gives students' direct experience, strengthens memory, and adds confidence in a concept with the process of finding itself. This is based on the results of interviews with some students who use inquiry-discovery learning. They stated that they experience an increase in the value of higher-order thinking because they do the practicum in the learning process and the learning video that enhances their memory of application of material or concept that the teacher who only told the application of the material. In addition, the practicum encouraged the development of student HOTS (Costa, 1985). The results of other studies stated that students who were taught with inquiry-discovery learning reached higher achievement than students taught with conventional learning (Wartono Wartono et al., 2018).

The results of the study also prove that there is no interaction between learning

used and the students' initial ability to HOTS. Inquiry-discovery learning with initial abilities and conventional learning with initial ability does not influence each other on HOTS in matter pressure. This is in accordance with the reality on the ground when conducting research, in which students who have a high initial ability are very enthusiastic during the learning process. Students with high initial ability have more curiosity compared to other students. Furthermore, some students with low initial ability state that they do not like science lessons and some say they do not like science lessons, especially physics.

The results of the statistical test data analysis show that HOTS students with high initial ability who are taught with inquiry-discovery learning are higher than students taught with conventional learning. Based on the results of interviews with several students with high initial abilities who used inquiry-discovery learning, they got good grades because they had carried out the practicum on the material being tested and watched the video of material application and had done a lot of exercises during the learning process.

The results of statistical test data analysis also showed that HOTS students with low initial ability who were taught with inquiry discovery were higher than students taught with conventional learning. Based on the results of interviews with some students with low initial abilities who used inquiry-discovery learning, they got better grades from the pre-test because they had carried out the practicum and watched the video of material application and the exercises were sufficient, even though they still have not achieved minimal mastery in the posttest scores. The results of interviews with low initial ability students also said that they did not like science lessons.

Thus, HOTS with high discovery-inquiry learning groups will achieve the highest achievement and low groups will

achieve lower achievement than high initial ability students will. Based on the results of his research also shows that students with high and low initial abilities have an increase (Madhuri et al., 2012).

The results of the study prove that inquiry-discovery learning and conventional learning affect scientific literacy. This is supported by the results of research showing that SL students who are taught with inquiry discovery are higher than students taught with conventional learning. The results of this study in

accordance with the research (Fatmawati, I.N & Utari, 2015) show that the application of levels of inquiry can improve the scientific literacy of junior high school students.

The success of inquiry-discovery learning is due to being able to train students to find concepts and facts about scientific phenomena with the potential of students so that they are able to understand the concepts learned through direct experience (Belton, 2016) and can improve students' learning outcomes.

Table 4. Inquiry-discovery learning stages Eggen & Kauchak (1996)

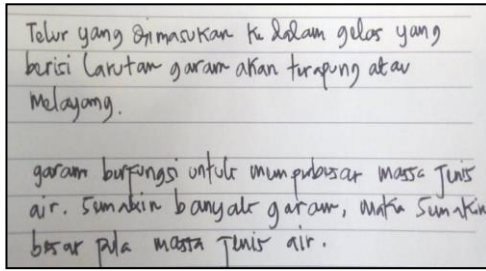
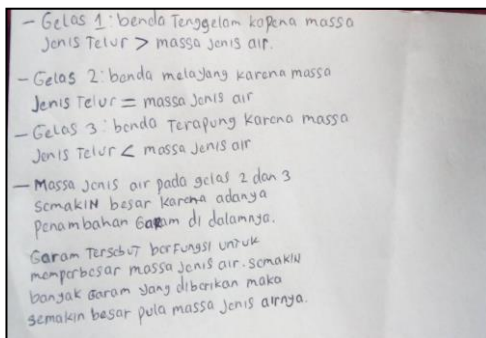
Phase	Teacher Activities	Students Activities
Presenting questions or problems	<ul style="list-style-type: none"> • Provide a stimulus in the form of a problem in students • Guiding students to identify problems • Divide students into groups 	<ul style="list-style-type: none"> • Read or listen to descriptions that contain problems • Identify problems • Sit with members of the group
Make a hypothesis	<ul style="list-style-type: none"> • Provide opportunities for students to brainstorm in making hypotheses • Guiding students in determining hypotheses that are relevant to the problem and prioritizing which hypotheses are the priority of the investigation. 	<ul style="list-style-type: none"> • Make hypotheses as temporary answers to problems that have been formulated by themselves
Design an experiment	<ul style="list-style-type: none"> • Provide opportunities for students to determine the steps that are in accordance with the hypothesis that will be done. • Guiding students to sort out problem-solving steps. 	<ul style="list-style-type: none"> • Discuss in determining and sorting the steps in the experiment
Conduct an experiment to obtain information	<ul style="list-style-type: none"> • Guiding students to get other information through experiments • Guiding students in carrying out experiments 	<ul style="list-style-type: none"> • Discuss in finding new information or knowledge through experiments
Collect and analyze data	<ul style="list-style-type: none"> • Guiding students in collecting and processing data from experimental results • Provide opportunities for each group to convey the results of the data collected • Give reinforcement and direct students to check/examine hypotheses made by students at the beginning of the activity whether the hypothesis is proven or not 	<ul style="list-style-type: none"> • Collect and process data from experimental results • Present the results of the discussion activities in front of the class • Record the strengths explained by the teacher

The results of the study also prove that there is an interaction between learning used and the students' initial ability to scientific literacy. Inquiry-discovery learning with initial abilities and conventional learning with initial abilities will interact with scientific literacy in substance pressure material.

Learning is an external thing that can affect the ability of students SL. In addition

to external factors, the internal is also very influential with everything that is in the students that support learning such as intelligence, talent, five sensory motor skills, and thinking schemes. Students' intelligence such as students' initial ability to physics is certainly influential because there has been a study before the experiment was conducted (Risqiana, N., Hidayat, A., Soepriyono, 2015).

Table 5. Students' Answers to HOTS and SL Aspects

Questions	Student's Answer	Aspect
<p>When you want to do a practicum to prove the sinking, floating and partially immersing events, you will definitely choose simple tools and materials by inserting eggs into a glass of water. When you put an egg into a glass of water, the glass will sink (like in the picture) because the density of water is smaller than the density of the egg. If you put an egg into a glass containing a salt solution, how is the egg's position/presence in the glass? Explain?</p>		<p>HOTS</p>
<p>Aldo is doing a practicum about Archimedes' law. The practicum was carried out to prove the sinking, floating and partially immersing event. He observed this by inserting eggs into water containing a salt solution. Tools and ingredients that must be prepared are glass (3 pieces), eggs (3 grains), spoons, and salt. The steps he did were the three glasses filled with a little water. Glass 1 contains water without a mixture of salt, glass 2 contains water and salt as much as one spoon then stir until evenly distributed, while glass 3 contains water and salt as much as three spoons then stirred until evenly distributed. The final step he did was to insert the egg into three glasses, and then he observed the existence of the egg. The presence of eggs in glass 1 sinks, glass 2 floats, and glass 3 floats.</p>		<p>SL</p>

The results of the statistical test data analysis show that SL students with high initial ability who are taught with inquiry-discovery learning are higher than students taught with conventional learning. Based on the results of interviews with several students with high initial abilities who learned to use inquiry-discovery learning,

they got good grades because they had carried out the practicum on the material being tested and watched the video of material application and did a lot of exercises during the learning process, which is in the form of literacy. Therefore, it helps them to get used to working on literacy questions. The results of

interviews with students with high initial abilities also said that they had the intention to learn on their own and had more curiosity; this was seen during the learning process.

The results of statistical test data analysis also showed that the scientific literacy of students with low initial ability who were taught with inquiry-discovery learning was higher than students taught with conventional learning. Based on the results of interviews with some students with low initial abilities who learned to use inquiry-discovery learning said that they got better grades from the pre-test because they had carried out the practicum and watched the video of material application learned and enough exercises, even though they still have not achieved minimal mastery in the posttest scores. The results of interviews with students with low initial abilities also said that they did not like science lessons, especially physics.

The results of this study are similar to research (Mawardini, Permanasari, & Sanjaya, 2015), which shows that the achievement of the average scientific literacy of high group students is better than the students in the medium and low groups, and the students in the medium group are better than the low group students. Inquiry-discovery learning invites students to search for concepts by practicing and emphasizes learning through experience (Tompo et al., 2016).

The success of inquiry-discovery learning occurs because the direct role of students in exploring the material through the practicum with directed steps in this learning and can make students more independent and responsible. This is consistent with the advantages of inquiry-discovery learning that is student-centered, and knowledge will last longer or be easier to remember (Vlassi & Karaliota, 2013). Based on this, this learning can help students obtain good learning outcomes because the knowledge or knowledge they

gain can last a long time and is easy to remember.

CONCLUSIONS AND SUGGESTIONS

Based on the results of data analysis and discussion, it can be concluded that the high-order thinking skills of students taught with inquiry-discovery learning are higher than students taught with conventional learning. There is no interaction between inquiry-discovery learning and higher-order thinking skills in terms of initial abilities. Higher-order thinking skills of high initial abilities students who were taught by inquiry-discovery learning are higher than students taught with conventional learning. Higher-order thinking skills of low initial abilities students taught by inquiry-discovery learning are higher than students taught by conventional learning. Scientific literacy of students who were taught with inquiry-discovery learning is higher than students taught with conventional learning.

There is an interaction between inquiry-discovery learning to scientific literacy in terms of initial abilities of students' scientific literacy with high initial abilities that were taught with inquiry-discovery learning. They achieved higher than students taught with conventional learning. Furthermore, scientific literacy students with low initial abilities who are taught with inquiry-discovery learning are higher than students taught with conventional learning.

Thus, inquiry-discovery learning models can be recommended in increasing HOTS and SL students. Teachers are expected to measure other activities of students in improving learning and learning outcomes of students' physics

REFERENCES

- Batlolona, J. R., & Haumahu. (2016). *Aktivitas Siswa Dalam Pembelajaran Fisika Pada Konsep Listrik Dinamis Dengan Menerapkan Media Interaktif Siswa Kelas X SMA Kristen YPKM*

- Ambon [Student Activity in Learning Physics on the Concept of Dynamic Electricity by Applying Interactive Media to Cla. In Seminar Nasional Pekan Ilmiah Fisika (PIF) XXVII (pp. 88–91).
- Belton, D. J. (2016). Teaching process simulation using video-enhanced and discovery/inquiry-based learning: Methodology and analysis within a theoretical framework for skill acquisition. *Education for Chemical Engineers*, 17(2002), 54–64. <https://doi.org/10.1016/j.ece.2016.08.003>
- Bloom, B. S. (1956). *Taxonomy of educational objectives, Handbook I: The cognitive domain*. New York: McKay.
- Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review*, 31, 21–32.
- Çepni, S., Ayvacı, H. Ş., & Bacanak, A. T.-K. M. (2004). Fen Eğitimine Yeni Bir Bakış, Fen Teknoloji-Toplum. Trabzon: Top-Kar Matbaacılık.
- Clark, D. (2010). Bloom's taxonomy of learning domains: The three types of learning. *Big Dog & Little Dog's Performance Juxtaposition*.
- Costa, A. L. (1985). *Developing Minds : A Resource Book for Teaching Thinking*. West Street Alexandria, Virginia: ASCD.
- Dillon, J., & Scott, W. (2002). Editorial – perspectives on environmental education-related research in science education. *International Journal of Science Education*, 24(11), 1111–1117. <https://doi.org/10.1080/09500690210137737>
- Fatmawati, I.N & Utari, S. (2015). Penerapan Levels of Inquiry untuk Meningkatkan Literasi Sains Siswa SMP Tema Limbah dan Upaya Penanggulangannya. *Jurnal Edusains*, 7(2), 152–159.
- Firman, H. (2007). Laporan Analisis Literasi Sains Berdasarkan Hasil PISA Nasional Tahun 2006. Jakarta: Pusat Penilaian Pendidikan Balitbang Depdiknas.
- Fives, H., Huebner, W., Birnbaum, A. S., & Nicolich, M. (2014). Developing a Measure of Scientific Literacy for Middle School Students. *Science Education*, 98(4), 549–580. <https://doi.org/10.1002/sce.21115>
- Forehand, M. (2011). *BloomsTaxonomy.pdf*. Bloom's Taxonomy-Emerging Perspective on Learning, Teaching, and Technology. <https://doi.org/10.4135/9781412957403.n51>
- Gormally, C., Brickman, P., & Lut, M. (2012). Developing a test of scientific literacy skills (TOSLS): Measuring undergraduates' evaluation of scientific information and arguments. *CBE Life Sciences Education*, 11(4), 364–377. <https://doi.org/10.1187/cbe.12-03-0026>
- In'am, Akhsanul; Hajar, S. (2017). An approach, 10(1), 55–70.
- Jonassen, D. H. (1991). Objectivism vs. constructivism: Do we need a new philosophical paradigm? *Educational Technology: Research and Development*, 39(3), 5–14.
- Kemdikbud. (2018). Rata-rata Nilai UN SMP 2018 alami penurunan. <https://news.detik.com/berita/4042222/kemendikbud-nilai-rata-rata-un-smp-2018-alami-penurunan>
- Klahr, D., & Nigam, M. (2004). The equivalence of learning paths in early science instruction: Effects of direct instruction and discovery learning. *Psychological Science*, 15(10), 661–667. <https://doi.org/10.1111/j.0956-7976.2004.00737.x>
- Loverude, M. E., Kautz, C. H., & Heron, P. R. L. (2003). Helping students develop an understanding of Archimedes' principle. I. Research on student understanding. *American*

- Journal of Physics, 71(11), 1178–1187.
<https://doi.org/10.1119/1.1607335>
- Madhuri, V. G., Kantamreddi, S. V., & Prakash Goteti, N. L. (2012). Promoting Higher Order Thinking Skills Using Inquiry-Based Learning. *European Journal of Engineering Education*, 37(April 2013), 117–123.
<https://doi.org/10.1080/03043797.2012.661701>
- Mawardini, A., Permanasari, A., & Sanjaya, Y. (2015). Profil Literasi Sains Siswa Smp Pada Pembelajaran Ipa Terpadu Tema Pencemaran Lingkungan Snf2015-Iv-49 Snf2015-Iv-50, IV(1996), 49–56.
- Meijerman, I., Storm, G., Moret, E., & Koster, A. (2013). Development and student evaluation of an inquiry-based elective course on drug discovery and preclinical drug development. *Currents in Pharmacy Teaching and Learning*, 5(1), 14–22.
<https://doi.org/10.1016/j.cptl.2012.09.009>
- Miri, B., David, B. C., & Uri, Z. (2007). Purposely teaching for the promotion of higher-order thinking skills: A case of critical thinking. *Research in Science Education*, 37(4), 353–369.
<https://doi.org/10.1007/s11165-006-9029-2>
- OECD. (2001). *Knowledge and Skills for Life – First Results from PISA 2000*. Paris: OECD.
- OECD. (2004a). *Learning for Tomorrow's World – First Results from PISA 2003*. Paris: OECD.
- OECD. (2006). *Development Co-operation Report 2005*, OECD
- OECD. (2010). *Development Co-operation Report 2010*. Paris: OECD.
- OECD (2014). *Measuring Innovation in Education: A New Perspective*, OECD Publishing. Paris: OECD.
- PISA 2006 Programme for International Student Assessment. (2006). Piten, S., Rakkapao, S., & Prasitpong, S. (2017). Cambodian students' prior knowledge of projectile motion. *Journal of Physics: Conference Series*, 901(1).
<https://doi.org/10.1088/1742-6596/901/1/012116>
- Polly, D., Ausband, L., Polly, D., & Ausband, L. (2014). Skills through WebQuests, (January 2015), 37–41.
<https://doi.org/10.1080/10402454.2009.10784628>
- Richardson, V., & Renner, J. W. (1970). A Study of the Inquiry-Discovery Method of Laboratory Instruction. *J. Chem. Educ.*, 47(1), 77–79.
<https://doi.org/10.1021/ed047p77>
- Risqiana, N., Hidayat, A., Soepriyono, K. H. (2015). Pengaruh Pembelajaran Fisika Model Problem Based Learning (PBL) terhadap Kemampuan Literasi Sains Siswa Ditinjau dari Kemampuan Awal [The Effect of Physics Learning on Problem Based Learning Model (PBL) on Students' Science Literacy Ability Viewed from In. In *Prosiding Pertemuan Ilmiah*. Malang: Universitas Kanjuruhan Malang.
- Saab, N., Van Joolingen, W. R., & Van Hout-Wolters, B. H. A. M. (2005). Communication in collaborative discovery learning. *British Journal of Educational Psychology*, 75(4), 603–621.
<https://doi.org/10.1348/000709905X42905>
- Sund, R. B., & Trowbridge, L. W. (1973). *Teaching science by inquiry in the secondary school*. Merrill Publishing Company.
- Taale, K. D. (2011). Improving physics problem-solving skills of students of Somanya Senior High Secondary Technical School in the Yilo Krobo District of Eastern Region of Ghana. *Journal of Education and Practice*, 2(6), 8–21.
- Tompo, B., Ahmad, A., & Muris, M. (2016). The development of

- discovery-inquiry learning model to reduce the science misconceptions of junior high school students. *International Journal of Environmental and Science Education*, 11(12), 5676–5686.
- Turgut, H. (2007). Scientific Literacy for All. Ankara University, *Journal of Faculty of Educational Sciences*, 40(2), 233–256. https://doi.org/10.1501/Egifak_0000000176
- Vlassi, M., & Karaliota, A. (2013). The Comparison between Guided Inquiry and Traditional Teaching Method. A Case Study for the Teaching of the Structure of Matter to 8th Grade Greek Students. *Procedia - Social and Behavioral Sciences*, 93, 494–497. <https://doi.org/10.1016/j.sbspro.2013.09.226>
- Wartono, W., Diantoro, M., & Bartlolona, J. R. (2018). Influence of Problem Based Learning Learning Model on Student Creative Thinking on Elasticity Topics A Material. *Jurnal Pendidikan Fisika Indonesia*, 14(1), 32–39. <https://doi.org/10.15294/jpfi.v14i1.10654>
- Wartono, W., Hudha, M. N., & Batlolona, J. R. (2018). How are the physics critical thinking skills of the students taught by using inquiry-discovery through empirical and theoretical overview? *Eurasia Journal of Mathematics, Science and Technology Education*, 14(2), 691–697. <https://doi.org/10.12973/ejmste/80632>
- Wilks, S. (1995). *Critical & creative thinking: Strategies for classroom inquiry*. Heinemann Educational Publishers.
- Yahya, A. A., Toukal, Z., & Osman, A. (2012). Bloom ' s Taxonomy – Based Classification for Item Bank. *Modern Advances in Intelligent Systems and Tools*, 431, 135–140.
- Yuenyong, C. (2013). Enhancing Scientific Literacy in Thailand. *Global Studies of Childhood*, 3(1), 86–98. <https://doi.org/10.2304/gsch.2013.3.1.86>
- Zohar, A. (2004). Higher order thinking in science classrooms: Students' learning and teachers' professional development (Vol. 22). Springer Science & Business Media.
- Zoller, U., Dori, Y. J., & Lubezky, A. (2002). Algorithmic, LOCS and HOCS (chemistry) exam questions: Performance and attitudes of college students. *International Journal of Science Education*, 24(2), 185–203. <https://doi.org/10.1080/09500690110049060>

AN IDENTIFICATION OF PHYSICS PRE-SERVICE TEACHERS' SCIENCE PROCESS SKILLS THROUGH SCIENCE PROCESS SKILLS-BASED PRACTICUM GUIDEBOOK

Darmaji*¹, Dwi Agus Kurniawan², Ai Suryani³, Ayu Lestari⁴

^{1,2,3,4}Physics Study Program of Education and Teacher Training Faculty, Jambi University
Jl. Lintas Jambi- Muaro Bulian, Muaro Jambi, Jambi, Indonesia.

*Correspondence address: Darmaji@unja.ac.id

Received: June 14th, 2018. Accepted: October 12nd, 2018. Published: October 29th, 2018

Abstract: This research was conducted to identify the science process skills of the physics education students of Jambi University in prism refraction practicum after using the basic physics practicum guidebook II. This research is a quantitative descriptive method. The study was conducted with a sample of 91 students. Data collection techniques were carried out using a science process skill observation sheet which was supported by interviews and documentation. Data were analyzed using descriptive statistics. The results showed that most students are highly skilled in implementing science process skills-based practicum with the following percentages: observing by 48.35%, classifying by 38.46%, measuring by 39.56%, predicting by 58.64%, compiling data tables by 51.65%, making graph by 58.24%, planning the experiment by 61.54%, and conducting the experiment by 45.05%. The students were also quite skilled in constructing hypotheses and defining variables with the percentage of 57.14% and 39.56%, respectively. The results of the study are expected to be used as a consideration for study programs and other faculties at Jambi University as well as other universities to conduct related studies.

© 2018 Physics Education, UIN Raden Intan Lampung, Indonesia.

Keywords: science process skills, physics education students, practicum

INTRODUCTION

The success of the learning process is influenced by the quality and way of teaching a teacher. Quality teachers not only have knowledge but also have skills. One of the skills a teacher must possess is science process skills. According to (Mutisya, Rotich, & Rotich, 2013), a teacher must have science process skills. It is a skill used by scientists when conducting scientific investigations (Lindrawati & Rohandi, 2015).

Science process skills can be developed by conducting practical activities. In developing process skills, practicum methods can be used. Practicum activities can be used as activities to improve or develop students' scientific skills including psychomotor aspects (Deviyanti, Ashari, & Kurniawan, 2016). In order for the practicum to be carried out to be effective in developing students' science process

skills, a practicum guide is needed that can support the students' science process skills (Misbah, Mustikawati, M. Feyzarri'at, 2018).

Science process skills serve to encourage students to develop the knowledge they have received (Idiege, Joseph, *Nja, Cecilia, Ugwu, & N3, 2017). Science process skills consist of basic science process skills and integrated process skills (Agustina & Saputra, 2016). The basic and integrated process skills are very relevant and in accordance with science subjects in secondary schools (Jack, 2013).

Science process skills of a pre-service physics teacher are required to support learning activities. According to (Lindrawati & Rohandi, 2015), Science process skills should be owned by pre-service physics teachers, so that when they are becoming a real teacher, they can have

an adequate understanding of science process skills and be able to apply it in the activities of learning in the classroom. If the physics teacher does not have the science process skills, then the teacher will not be able to develop the student's science process skills. In addition, learning will tend to be passive and students cannot construct their knowledge independently.

Considering the urgency of mastering the science process skills for physics education students, the Physics Education Study Program of Jambi University has developed a science process skills-based Basic Physics II practicum guidebook. Therefore, the researchers are interested in conducting research to find out basic science process skills and integrated science process skills of the pre-service

physics teacher at the University of Jambi. The difference in this research with previous research conducted by (Sari & Zulfadewina, 2018) is the subject of this research and the description of science process skills seen after students use the scientific process skills-based practicum guidebook.

METHOD

This research employs a quantitative descriptive method. "Descriptive research on quantitative research involves a careful description of educational phenomena" (Gall, Gall, & Borg, 2003)

Following is the research graph in Figure 1, and the research design in Table 1,

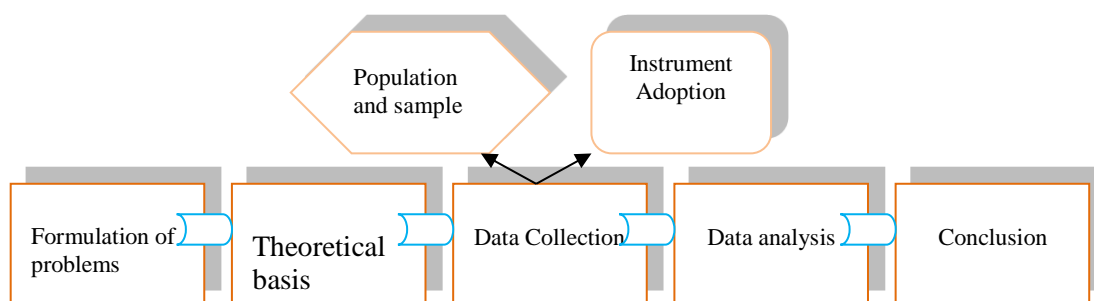


Figure 1. Modified Research Graph from Sugiyono 2014

Table 1 Research Plan

Class	Treatment	Post-test
Experimental	Science Process Skills-based practicum guidebook	Observation

Based on Table 1, the students were given practicum guidebook based on science process skills, and then they were observed. In this study the sample used was less than 100, according to (Sugiyono, 2016) the data collection technique is suitable to use if the sample to be studied is less than 100 people, then total sampling technique can be used. The number of samples was 91 physics education students who took basic physics courses II.

The data collecting technique used was observed using the Observation Sheet instrument. An effective observation sheet is used to measure the science process skills (Nasrodin, Hindarto, & E, Supeni, 2015). Observation sheet was made to refer to the observed indicators, including observing, classifying, measuring, predicting, compiling data tables, making hypotheses, making graphs, defining variables, conducting experiments, and designing experiments.

Students' science process skills data were analyzed through descriptive statistics using SPSS. Then to find out the mastery of science process skills, the students were grouped into four categories, as shown in Table 2.

Table 2. Students' science process skills mastery scale

No	Interval	Category
1	$25,00 \leq x \leq 43,75$	Poor
2	$43,75 < x \leq 62,50$	Low
3	$62,50 < x \leq 81,25$	High
4	$81,25 < x \leq 100,00$	Excellent

Description: x = Mastery score of science process skills.

RESULTS AND DISCUSSION

Results

The results of the descriptive analysis of the data gathered on the science process skills-based practicum guidebook on prism refraction material shown are shown in Table 3, and the distribution of the mastery is shown in Table 4.

Table 3. Descriptive Analysis of Basic Science Process Skills

Indikator	Mean	Std. Deviation
Observing	78,44	18,58
Classifying	76,09	22,02
Measuring	72,12	20,33
Predicting	77,60	29,84

Based on table 3, it is known that observing aspect has the highest average score with an average score and standard deviations respectively: 78.44 and 18.58. The indicator that has the smallest average score is measuring with an average score of 72.12 and std deviation of 20.33. Students' science process skills distribution is divided into four categories, poor, low, high, and excellent.

Table 4. Distribution of the Basic Science Process Skills

Indicators	Category	Percentage
Observing	Poor	6,59
	Low	9,89
	High	35,16
	Excellent	48,35
Classifying	Poor	8,79
	Low	19,78
	High	32,97
	Excellent	38,46
Measuring	Poor	9,89
	Low	19,78
	High	30,77
	Excellent	39,56
Predicting	Poor	20,88

Indicators	Category	Percentage
	Low	4,40
	High	16,48
	Excellent	58,24

Based on Table 4 it is known that the basic science process skills have already mastered by students. This is known from the average score mastery of the science process skills for each indicator in all categories are all excellent. Predicting is an indicator that is mastered by students with a percentage of 58.24%.

Table 5. Descriptive Analysis of Science Process Skills Data Integration

Indikator	Mean	Std. Deviation
Compiling data table	78,19	29,48
Making graphs	86,26	20,16
Collecting and processing data	70,14	15,81
Making hypothesis	75,82	21,87
Planning an experiment	81,41	17,26
Conducting an experiment	77,68	19,42

Based on Table 5, it is known that the indicator of making graphs has the highest average score of 86.26 and std. deviation of 20.16. While obtaining and processing data is an indicator that has the smallest average score of 70.14 and std. deviation of 15.81.

Table 6. Distribution of Integrated Science Process Skills

Indikator	Kategori	Persentase
Compiling data table	Poor	4,40
	Low	13,19
	High	30,77
	Excellent	51,65
Making graphs	Poor	6,59
	Low	0,00
	High	35,16
Making hypothesis	Excellent	58,24
	Poor	10,99
	Low	3,30
Defining Variable	High	57,14
	Excellent	28,57
	Poor	6,59
Variable	Low	31,87
	High	39,56

Indikator	Kategori	Persentase
Planning an experiment	Excellent	21,98
	Poor	5,49
	Low	4,40
	High	28,57
Conducting an experiment	Excellent	61,54
	Poor	7,69
	Low	13,19
	High	34,07
	Excellent	45,05

Based on Table 6, it is known that the indicator of making a hypothesis and defining variables are categorized as high while four other indicators are categorized as excellent. The indicator that is mastered by the students is planning experiments with an average percentage of 61.54%.

Discussion

Observation is the main skill of all science process skills aspects so it must be mastered first to be able to master the other (Puspita, Sicilia, 2016). In this study, the observing skill is highly mastered by the students with a percentage of 48.35% and an average score of 78.44. Observation activities were carried out by students directly when the practicum takes place and indirectly by observing the images contained in the guidebook.

Students have a very good skill of classifying with a mastery percentage of 38.48% and an average score of 76.09. Classifying skill is a skill often carried out by students so it is not difficult for them to master this skill well (Rahman, 2017). Classifying is the ability to identify similarities and differences in various observed objects (Sani, 2016). Classification activities carried out by students included grouping the same or opposite quantities, such as classifying the angle of deviation (D), the angle of incoming light (i), and the angle of refraction (r).

Measuring is the second basic skill that must be mastered. This is because after students observed the tool and how to use the tool, they will begin to take measurements. Measuring is an activity

that requires students to use a measuring tool and require students to do calculations to determine the measurement results (Rauf, Rasul, Mansor, Othman, & Lyndon, 2013). Based on the result of the analysis, the students have an excellent skill in measuring with a percentage of mastery of 39.56% and an average score of 72.12. Based on the results of observations, students in addition to making measurements in a structured manner they also did it carefully. Science process skills make the students more careful in carrying out experiments and interested in what is done (Ambarsari, Santosa, & Maridi, 2013).

The next science process skill mastered by the students is predicting with a percentage of 58.24% and an average score of 77.60. Predicting is to anticipate the consequences of a new situation or change past experience and previous observations (Wiwin & Kustijono, 2018). In this study, predictions were made before students conducted experiments so that they had were not influenced by previous experiments. Science process skills-based learning requires students to have good initial knowledge (Deta, Suparmi, & Widha, 2013). Based on the results of interviews with several students, information was obtained based on the identification of variables/laws related to the experiment. "... I make predictions based on the identification of existing formulated variables and based on refraction law ..." (interview conducted on 2 May 2018).

In general, physics education students have mastered basic science process skills well. These results identify that the use of practicum guidebook effectively increases the students' science process skills mastery. In accordance with the results of the research conducted by (Sari & Zulfadewina, 2018), mastery of basic science process skills without using a science process skills-based practicum

guidebook is still in the fairly good category.

Basic science process skills are skills that must be mastered by every student. Science and non-science require basic scientific process skills ... (Akinbobola & Afolabi, 2010). Students of pre-service physics teacher who do not have basic science process skills will have difficulty in developing their knowledge. Mastery of science process skills can affect the mastery of concepts in the cognitive domain (Desstya, 2015). In addition, students who do not master basic science process skills will not master the integrated science process skills. Integrated process skills can be obtained after basic skills are mastered by students (Rauf et al., 2013).

Science process skills can make students more literate about science, according to the statement (Espinosa, Monterola, & Punzalan, 2013) science process skills make students more knowledgeable in science. Students who have science process skills will have a positive attitude towards science and will also help them improve their scientific literacy. When students carry out scientific investigations, science process skills can also help in constructing the knowledge acquired during the activities.

Integrated science process skills are obtained after mastering basic science process skills. In this study, integrated science process skills were analyzed, namely on the making graphics, making hypotheses, compiling data tables, defining variables, planning experiments and conducting experiments aspects.

The compiling data table indicator from 91 physics students of Jambi University shows that they are excellent on this indicator with a percentage of 51.65%. The students are also doing an excellent job in the making graphs indicator with a percentage of 58.24%. This is certainly a good thing for a physics teacher candidate because making and understanding graphics is a basic ability for a scientist.

The hypothesis is a statement based on assumptions and has not been proven. Usually, hypotheses are used in determining theory and law. According to (İdris & Halil, 2016), The Hypothesis is a statement based on assumptions whose truth has not been proven. The making hypotheses indicator reveal that the students are skilled in making experimental hypotheses with a percentage of 57.14%.

The next indicator is defining variables. It can be seen that 39.56% of the students are skilled in identifying variables in the practicum. So, in this indicator, the students have been able to identify the dependent variable, the independent variable, and the control variable in the experiment. According to (Dönmez & Azizoglu, 2010), identifying variables is to see changes in variables that are related to other variables. For the planning, an experiment indicator, 61.54% of students belong to the excellent category in planning practicum activities.

The next indicator, which is conducting experiments, according to (Rezba et al., 1995) states that experiments include using the materials needed to create a mechanism that matches the practicum objectives, changes and control variables to reach data, record and evaluate data to analyze it, draw conclusions and provide reports on experiments conducted. The students are in the excellent category for the conducting experiments indicator with a percentage of 45.05%. This is because based on the results of an interview; the students are able to carry out practical activities well by just following the instructions in the practicum guidebook used.

The results of this study are expected to be used as a consideration in broadly applying practicum guidebook based on science process skills, especially in physics education study programs.

CONCLUSION AND SUGGESTION

Based on the results of the study, the implementation of science process skills-based Basic Physics II on prism refraction material can increase the basic science process skills and the integrated science process skills of physics education students of Jambi University. The most prominent basic science process skills are prediction with a percentage of 58.40%, while the most prominent integrated science process skills are planning an experiment with a percentage of 61.54%.

The researchers suggest further research on the relationship of mastery of science process skills with the mastery of physics concepts, creative thinking skills, and problem-solving skills.

REFERENCES

- Agustina, P., & Saputra, A. (2016). Analisis Keterampilan Proses Sains (Kps) Dasar Mahasiswa Calon Guru Biologi Pada Matakuliah Anatomi Tumbuhan (Studi Kasus Mahasiswa Prodi P . Biologi Fkip Ums Tahun. *Seminar Nasional Pendidikn Sains*, 71–78.
- Akinbobola, A. O., & Afolabi, F. (2010). Analysis of Science Process Skills in West African Senior Secondary School Certificate Physics. *American-Eurasian Journal of Scientific Research*, 4(5), 234–240.
- Ambarsari, W., Santosa, S., & Maridi. (2013). Penerapan Pembelajaran Inkuiri Terbimbing Terhadap Keterampilan Proses Sains Dasar Pada Pelajaran Biologi Siswa Kelas VIII SMP Negeri 7 Surakarta. *Jurnal Pendidikan Biologi*, 5(1), 81–95.
- Deta, U. A., Suparmi, & Widha, S. (2013). Pengaruh Metode Inkuiri Terbimbing Dan Proyek, Kreativitas, Serta Keterampilan Proses Sains Terhadap Prestasi Belajar Siswa. *Jurnal Pendidikan Fisika Indonesia (Indonesian Journal of Physics Education)*, 9(1), 28–34.
- <https://doi.org/10.15294/jpfi.v9i1.2577>
- Deviyanti, L., Ashari, & Kurniawan, E. S. (2016). Pengembangan Panduan Praktikum Fisika Berbasis Research Based Learning untuk Mengoptimalkan Domain Kognitif dan Psikomotorik Siswa di SMA Negeri 5 Purworejo, 9(2), 43–48.
- Espinosa, A. A., Monterola, S. L. C., & Punzalan, A. E. (2013). Career-Oriented Performance Tasks in Chemistry: Effects on Students' Critical Thinking Skills. *Education Research International*, 2013, 1–10. <https://doi.org/10.1155/2013/834584>
- Gall, M. D., Gall, J. P., & Borg, W. R. (2003). *Educational Research: An Introduction* (7th ed.). Boston: Pearson Educational Inc.
- Idiege, Joseph, K., *Nja, Cecilia, O., Ugwu, & N3, A. (2017). Development of Science Process Skills among Nigerian Secondary School Science Students and Pupils : An Opinion, 1(2), 13–21.
- Idris, D., & Halil, K. (2016). Determination of Prospective Preschool Teachers' Science Process Skills. *Journal Of European Education*, 6(1), 32–42. <https://doi.org/10.18656/jee.65104>
- Jack, G. U. (2013). The Influence of Identified Student and School Variables on Students ' Science Process Skills Acquisition. *Journal of Education and Practice*, 4(5), 16–23.
- Lindrawati, B., & Rohandi. (2015). Keterampilan Proses Sains Calon Guru Fisika, (April), 2013–2016.
- Misbah, Mustikawati, M. Feyzarif'at, M. D. P. (2018). Pengembangan Penunjuk Praktikum Fisika dasar I Berbasis 5M untuk Melatih Keterampilan Proses sains dan karakter WASAKA. *Jurnal Fisika FLUX*, 15(1), 26–29.
- Mutisya, S. M., Rotich, S., & Rotich, P. K. (2013). Conceptual Understanding of

- Science Process Skills and Gender Stereotyping : a Critical Component for Inquiry Teaching of Science in Kenya ' S Primary Schools. *Asian Journal of Social Sciences and Humanities*, 2(3), 359–369.
- Nasrodin, Hindarto, N., & E, Supeni, S. (2015). Analisis Kebiasaan Bekerja Ilmiah Mahasiswa Fisika Pada Pembelajaran Mata Kuliah Praktikum Fisika Dasar, 4(1), 1–6. Retrieved from <http://journal.unnes.ac.id/sju/index.php/upej%0AANALISIS>
- Puspita, Sicilia, A. (2016). Dalam Lks Biologi Kelas X Yang Digunakan Oleh Siswa Man Di Kota Yogyakarta the Analysis of Science Process Skills Developed in Lks Biology Class X, 5(1), 30–39.
- Rauf, R. A. A., Rasul, M. S., Mansor, A. N., Othman, Z., & Lyndon, N. (2013). Inculcation of science process skills in a science classroom. *Asian Social Science*, 9(8), 47–57. <https://doi.org/10.5539/ass.v9n8p47>
- Rezba, Spragule, Fiel, Funk, Okey, & Jaus. (1995). *Learning and Assessing Science Process Skill*. Dubuque, IA: Kendall/Hunt Publishing Company.
- Sari, P. M., & Zulfadewina. (2018). Profil Penguasaan keterampilan Proses Sains Mahasiswa program Studi Pendidikan Guru Sekolah dasar. *Jurnal Inovasi Pendidikan Dasar*, 3(2), 65–72. Retrieved from <http://jipd.uhamka.ac.id>
- Sugiyono. (2016). *Metode Penelitian: Kuantitatif, Kualitatif dan R&D*. Bandung: Alfabeta.
- Wiwin, E., & Kustijono, R. (2018). The use of physics practicum to train science process skills and its effect on scientific attitude of vocational high school students The use of physics practicum to train science process skills and its effect on scientific attitude of vocational high sch.

DEVELOPMENT OF THREE-TIER DIAGNOSTICS INSTRUMENTS ON STUDENTS MISCONCEPTION TEST IN FLUID CONCEPT

Irwansyah^{*1}, Sukarmin², Harjana³

^{1,2}) Postgraduate, Physics Education, Sebelas Maret University, Surakarta, Indonesia

³) Department of Physics, Faculty of Mathematics and Science, Sebelas Maret University, Surakarta, Indonesia
Jl. Ir. Sutami 36A Kentingan Jebres Surakarta 57126, Indonesia

*Correspondence address: irwansyah200893.is@gmail.com

Received: July 18th, 2018. Accepted: October 18th, 2018. Published: October 28th, 2018

Abstract: The purpose of this research was to know the validity and reliability of instrument three-tier diagnosis to identify the students' misconception in fluid concept. The stages of development research that used in this research were (1) The first research and collecting information, (2) planning and designing of development (3) validity and product evaluation. The instrument of the test was tested on 98 students of 3 schools. The instrument has been developed and categorized effectively because it has a valid category with the Aiken validity index value > from table V (0.75) and the reliability of the instrument has a value of 0.96 with a high category. The instrument of three-tier test that developed was able to identify the students' comprehension in students' concept and students' misconception. There are 27,58% students comprehend the concept, 45,29% students did not comprehend the concept, 24,74% students showed that misconception and 2,36% students experienced errors

© 2018 Physics Education, UIN Raden Intan, Lampung, Indonesia.

Keywords: Fluid, misconception, development, three-tier

INTRODUCTION

One of the main problems that appear in physics education is students' misconceptions. (Wijaya, Supriyono Koes, & Muhandjito, 2016). When the students learn about everything around them either through formal school education or non-formal education through daily experience, students tend to develop comprehension of something based on their own views. Because this concern, several researchers have done the research to describe the students' comprehension. The variety of comprehension types that are formed by students are called by several terms, such as "alternative conceptions", "misconception", "naïve beliefs", "children's ideas", "conceptual difficulties", "phenomenological primitives", "mental models" and many the others term (Gurel, Eryilmaz, & McDermott, 2015). Lack of comprehension through a concept can be

improved by further instruction and learning, while misconception is believed to able inhibiting the acceptance and development of knowledge and students' ability. (Hasan, Bagayoko, & Kelley, 1999). Misconception must be overcome because it can give negative effect in the further learning process. (Djanette & Fouad, 2014; Lucariello, Tine, & Ganley, 2014; Sholihat, Samsudin, & Nugraha, 2017). Based on this thing, it is necessary to identify the students' comprehension of whether the students have understood the concept well, students have not understood the concept well or the students faced misconception.

The misconception is the condition where the students' comprehensions are different from the experts' comprehension. (Resbiantoro & Nugraha, 2017; Wijaya et al., 2016). Misconception can be also identified as the concept that contrary to theories that are scientifically accepted and generally accepted (Gurel et

al., 2015). Misconception can be identified in some methods such as using instrument diagnostic test that used to identified the students' misconception is Three-tier instrument (Zukhruf, Khaldun, & Ilyas, 2016). Three-tier tests are considered to have advantages in distinguishing the lower students' comprehension and students that faced fault incomprehension or misconception (Gurel et al., 2015).

Three-tier test instrument can identify students' comprehension of the concept and students do not need many times (Wijaya et al., 2016; Wisudawati, 2015). Besides the Three-tier test instrument can distinguish that students comprehend the concept, misconception, guesswork (do not have self-confidence), and do not the concept (Abbas, 2016). Besides it can identify the students' misconception, the three-tier test instrument also able to identify the students that comprehend the concept or less comprehend the concept (Aini, Ibnu, & Budiasih, 2016). The three-tier instrument is that used in the second level. The test participants are still given an alternative answer and sometimes the test participant just guesses and it is difficult to know the difficulties cause that experienced by the students. (Suwanto, 2013). In this research, the researcher wants to develop the three-tier test instrument that able to identify the students' difficulties in the learning that is by using the three-tier instrument with the open-minded reason. In preparing the instrument or test instrument need to be done accurately based on the rule that determined by education measurement and curriculum (Prihatni, Kumaidi, & Mundilarto, 2016; Siregar, 2014). The instrument that used an instrument of collecting data must be done validity besides to acquire suggestion and improvement that purpose to give assessment through items in the instrument (Suryani, Kartowagiran, & Jailani, 2017). Validity is evidence and

theory through the interpretation of the test score based on the purpose of test usage (Pruyn, Watsford, & Murphy, 2016).

Diagnostic Formative Assessment

Assessment can be said as an act of collecting data in order to make decisions based on information obtained in the testing phase. Some of the assessment characteristics in learning such as the following: (1) Assessment is started by collecting some information about students in the learning; (2) In the assessment activity is done by analyzing and interpretation through data and information are that collected; (3) Interpretation results decisions about learning; (4) There is a follow-up to the decisions produced; (5) Assessment Assessment is carried out on an ongoing basis (Kusairi, 2012). Some knowledge about formative assessments include: (1) Formative assessment is a process carried out in learning; (2) Formative assessment results are not only used by teachers but also by students; (3) Formative assessment provides feedback on student learning and the learning process carried out by the teacher; (4) Feedback provided by formative assessment will be useful for students and teachers to make arrangements so that learning and learning can achieve curriculum goals (Kusairi, 2013). With formative assessment in the form of objective tests, it can help students who have low learning outcomes to learn the subject matter as a whole (Parsa, 2015). Formative diagnostic assessment is an instrument prepared to find out the learning outcomes that aim to identify or diagnose learning outcomes so that feedback occurs on the results of the use of formative diagnostic assessment.

METHOD

The Research Procedure

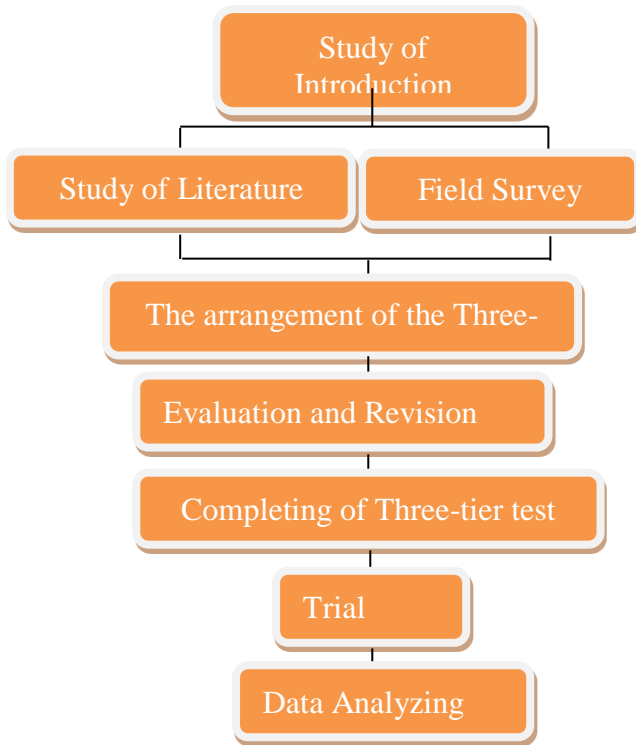


Figure 1. The Research Procedure

This research is a type of research that aims to analyze the validity, reliability, level of difficulty, differentiation, deception index of students' misconception diagnosis instruments and analyze students' learning difficulties that cause the students do not understand the concept or students that faced misconception in the fluid concept. The research is started with preliminary study through literature review and empirical research (Field Survey). The result of the literature review showed that an instrument was said to be good if it has validity, reliability, level of difficulty, differentiation and a good deception index. The research begins in December 2017 until March 2018. The initial drafting of the instrument, validation, and test is conducted in December 2017 until February 2018. The instrument trials are conducted from February to March 2018. The research was conducted in SMA and

Madrasah aliyah in the Karanganyar region of Java Middle, with high, medium and low categories based on the results of 2014, 2015 and 2016 national examinations. The subjects of this research were 98 students of class XI IPA consisting of 1 class of SMA NI Karanganyar, 1 class of SMA Gondangrejo, and 1 class of MA N Gondangrejo. Before the instrument was used to identify student misconceptions, a Focus Group Discussion (FGD) was carried out by involving experts in the fields of Physics, Physics Education, measurement and Physics Education practitioners. Based on the FGD, there are several instruments that need to be revised. After the revision is complete, the instrument can be used to identify student misconceptions, but first, it is necessary to analyze the validity, reliability, differentiation, level of difficulty and index of the deception.

Tests of validity, reliability, level of difficulty, distinguishing power and the test index of the test instruments to identify student misconceptions involved 1 class from each school with a total of 98 students. In the testing phase of the instrument, it is intended to obtain information about the feasibility, adaptability, and functioning of the test instrument on field conditions. In addition, the trials carried out can also provide information about the validity, reliability, differentiation, level of difficulty and deception index of an instrument. The validity of an instrument does not apply generally to all measuring objectives. A test generally only produces a valid measure for a particular measurement goal.

Validity of the contents of a test instrument can be done by looking at the suitability of the indicators in the grid with the operational definition of the test instrument and with the operational definition of constructing instruments, determination of content validity can be

done through focus group discussions (PGD) conducted by at least 5 experts and practitioners in measured field. An instrument will be said to be valid if it has an Aiken validity index greater than V table. According to the V table compiled by Aiken, a question is said to be valid with the number of validators 8 people at least the question has a validity index of 0.75 (Aiken, 1985).

Based on the validity of the test items, the value of 0.74 indicates good and acceptable validity (Mohamad, Sulaiman, Sern, & Salleh, 2015; Yasin, Yunus, Rus, Ahmad, & Rahim, 2015). Aiken's validity is formulated by the equation:

$$V = S / [n * (c - 1)] \text{ Where } S = \sum ni(r - \ell_0)$$

Where:

V: Aiken validation index

C: Number of categories or criteria

ℓ_0 : The lowest category

ni : Number of assessors who choose criteria i

r : Criteria to i

n : Number of all assessors

In addition to the validity of an instrument, the reliability of an instrument is also much needed in the preparation of an instrument, this is because the reliability of an instrument shows the consistent validity of an instrument (Mohamad et al., 2015; Yasin et al., 2015). The reliability of an instrument is a determination of the results of a test, or if a change occurs, then the change can be said to be meaningless or significantly, Reliability itself can be said as the instrument's freedom of error and can produce a consistent result (Priyambodo & Marfuatun, 2016) The reliability of an instrument can be obtained through the results of testing instruments to test participants, in addition by testing the test instruments, information on the difficulty of the items, the item distinguishing power, and the index of the items about an instrument (Yaminah, Saputro, &

Utami, 2016). A test instrument is said to be reliable if the instrument items are consistent in measuring a person so that the results of measurements are performed on the same subject even at different times. There is no agreement in general what is the minimum coefficient of an instrument so that the instrument can be said to be reliable, but for a test to be used to decide about students, it must have a reliability coefficient of 0.70 (Fitriatun & Sukanti, 2016). Determination of the reliability of the assessment instrument developed in this study is to use the equation or formula Cronbach Alpha as follows (Fitriatun & Sukanti, 2016):

$$\alpha = \frac{k}{k-1} \left(1 - \frac{\sum Si^2}{S^2} \right)$$

Where:

K = Number of test items

S_i^2 = Variant total test score

$\sum S_i^2$ = Number of all item variants forming test

Table 1. Interpretation of reliability values refers to Guilford's opinion

Score α	Reliability
< 0,70	Low
\geq 0,70	High

Cronbach Alpha is generally used when we measure tests that have standard multiple-choice items or in the form of essays. Cronbach Alpha in principle includes measuring homogeneity in which it focuses on two important aspects, namely the content aspect and the heterogeneity aspect of the test. If the test item is heterogeneous, it means measuring more than one characteristic, traits or attributes and will cause the alpha coefficient to be lower. Conversely, if the test is more homogeneous then the alpha coefficient price will be higher which means the test is more consistent (Shirali, Shekari, & Angali, 2017).

Reliability is the stability of the score obtained by the same person when tested again with the same test in different

situations or from a measurement of other measurements, so that reliability can be said as the level of consistency of the two measurements of the same thing. By using a reliable test tool, a person will have a constant score if given the same test even at different intervals, for which a good test instrument must also have a good test item difficulty level.

The level of difficulty of a question can show the level of quality of a test item. Test items can be stated as items that are good if the items are not too difficult and not too easy, in other words, the degree of difficulty of an item is moderate or sufficient. Good questions are questions that are not too easy and not too difficult, questions that are too easy do not stimulate students to improve their efforts to solve them and vice versa if the problem is too difficult will cause students to despair and not have the enthusiasm to try again. Equations are used to determine the level of difficulty with the correct proportion of answers (Fitriatun & Sukanti, 2016):

$$P = \frac{\sum x}{S_m N}$$

Where:

- P = The proportion answers correctly or the level of difficulty
- $\sum x$ = The number of test participants who answered correctly
- S_m = Maximum Score
- N = Number of test takers

Table 2. Difficulty level categories (Arikunto, 2013) (Nova, 2016) (Jihad, 2013)

Score of P	question category
$P \leq 30$	Difficult
$0,30 < P \leq 0,70$	Medium
$0,70 < P \leq 1,00$	Easy

Distinguishing power is one of the points that must be considered in the preparation of instruments or questions in the analysis of learning outcomes. Analysis of the differentiation of items was conducted to determine the difference power which can be seen from the

discrimination index value for each item. The differentiating power of a problem is the ability of a question to distinguish between students who are clever (highly capable) with students who are stupid (low ability). The distinguishing factor of a test functions to determine whether or not a question can distinguish groups in aspects measured according to differences in the group, in principle the distinguishing index is calculated on the basis of group division into two parts, namely the upper group which is a group of capable test takers high with the lower group, namely the low-ability group of test takers. Different power analysis can use equations:

$$rbis = \frac{Y_b - Y_s}{SD} \cdot \frac{nb \cdot bs}{un \sqrt{n^2 - n}}$$

$$rpbis = \frac{X_b - X_s}{SD} \sqrt{pq}$$

Where:

- X_b, Y_b = The average score of students who answer correctly
- X_s, Y_s = The average score of students who answer incorrectly
- SD = Standard Deviation
- N_b, n_s = Number of students who answered correctly, Number of students who answered incorrectly
- p = Proportion of the correct answer for all answers
- q = 1-p
- u = Ordination of a normal curve

The distinguishing criteria are interpreted using the following references:

Table 3. Classification of differentiation (D) (Arikunto, 2013; Nova, 2016)

Distinction index (D)	Category
$D \leq 0,20$	Poor
$0,20 < D \leq 0,40$	Satisfactory
$0,40 < D \leq 0,70$	Good
$0,70 < D \leq 1,00$	Excellent

The answer pattern in a question is known by calculating the number of tests who chose each option provided (Fitriatun

& Sukanti, 2016). A deception index can be said to be good or has performed its function well if it has such attractiveness that the test participants feel hesitant and hesitant so that in the end, they become fooled to choose a distractor as the correct answer. In general, what applies to the evaluation of learning outcomes is that distractors have been able to carry out their duties well if the distractors have at least been chosen by 5% of all test participants (Fitriatun & Sukanti, 2016). Distractor efficiency (DE) is calculated based on the number of NFD in an item and ranges from 0 - 100%. NFD is choices other than keys when chosen not often by respondents (<5%), and does not carry out their functions (D'sa & Visbal-Dionaldo, 2017; Mahjabeen et al., 2018).

Table 4. Questions Category based on Distinction index Factor (Fitriatun & Sukanti, 2016)

Non-functional distractors Item	Items
0	Very Good
1	Good
2	Enough
3	Less Good
4	Not Good

The instruments used in this research used conceptual diagnostic tests consisting of three levels or three-tier tests. The three-level diagnostic test instrument used in this research consisted of 28 items from 11 fluid concepts. Research to analyze students' misconceptions about fluid concepts is carried out in several stages, the initial stage of data collection, data processing, description and discussion of findings in the study. Data analysis uses the concept of analysis compiled by Kaltakci (Kamilah & Suwarna, 2016).

Table 5. Misconception Analyzing

The first stage	The second stage	The third stage	Categories
Correct	Correct	Believed	Understand the concept
Correct	Correct	Not believed	Not understand the concept

Correct	Incorrect	Believed	Positive False or Misconception
Correct	Incorrect	Not believed	Not understand the concept
Incorrect	Correct	Believed	Negative false or error
Incorrect	Correct	No believed	Not understand the concept
Incorrect	Incorrect	Believed	Misconception
Incorrect	Incorrect	Not believed	Not understand the concept

RESULTS AND DISCUSSION

Validity

An instrument that has been prepared in draft form before used it must be validated. The purpose of validation is to get feedback, criticism, and suggestions for improvement in accordance with the expertise of each validator. Expert validation aims to provide an assessment of the instruments that have been prepared. The assessment carried out by the validator can be in the form of conformity with the indicators that have been prepared, the suitability of the material, conformity of the choice of answers, the suitability of the language or conformity of the instrument as a measuring instrument.

An instrument has that prepared to be validated by 4 experts and 4 teachers, the data were analyzed by using Aiken equation. Based on the validity analyzing was getting the data that 28 questions that were prepared and had the valid category where for the Aiken validity index more than V table for 8 validators is 0.75. Based on the validity analyzing was getting the data that:

Table 6. Validity Analyzing Items

Items Number	Category
1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28	Valid
-	Invalid

Based on the results of the analysis of the validity of the items it was found that 28 questions were stated in the valid

category where for the Aiken validity index results for 8 validators higher than V tables or higher than 0.75. If the item is valid then the question is feasible to use.

Reliability

The reliability analysis of the items was carried out on 28 questions that had good validity, based on the results of the reliability analysis using the Cronbach Alpha formula with the help of the Quest program, it was obtained data that:

Table 7. Reliability analysis of test items

Types of Reliability	Score of Reliability	Category
Reliability item	0,96	High

Reliability analysis of the questions was carried out on 28 valid questions. Based on the results of the reliability analysis using the Cronbach Alpha formula, the reliability of the questions was 0.96 with a high category.

Difficulty level

Difficulty level analysis of test items was carried out on 28 questions that had been tested for validity. Based on the analysis of the difficulty level of the test items, it was found that:

Table 8. Analysis of the difficulty level of test items

Test items	Category
2,3,5	Easy
1,4,6,7,8,10,11,12,13,15,16,17,18,19,21,22,23,27,28	Medium
9,14,24,25,26	Difficult

Table 9. Percentase of the difficulty level of test items

Category	Percentase
Easy	10,71 %
Medium	71,42 %
Difficult	17,85 %

Based on the results of the data analysis of the difficulty level of the test items shown in the table, it can be seen

that from 28 test questions that have been tested, information is obtained that the difficulty level of the test questions is divided into three categories, namely easy, moderate, and difficult. Questions that have an easy level of difficulty are shown no 2,3,5 or with a percentage of 10.71%, questions that have a level of difficulty with the category being shown no.1, 4, 6, 7, 8, 10, 11, 12, 13, 15, 16, 17, 18, 19, 21, 22, 23, 27, 28 or with a percentage of 71.42% and questions that have a level of difficulty with difficult categories are shown no 9,14,24,25,26 or with a percentage amounting to 17.85%.

Differentiating Power

Differential power analysis was conducted to determine the quality of the items in distinguishing between the upper groups who answered correctly and the lower groups who answered correctly. Distinguishing power analysis was carried out on 28 items that had good validity. Based on the distinguishing analysis, data were obtained that:

Table 10. Distinguishing power Analyzing

Items number	Category
1,3,5,7,14,24,25	Bad
2,4,6,10,11,13,15,18,20,21,27,28	Sufficient
8,9,12,16,17,19,22,23,26	Good

Table 11. Percentase of Distinguishing power Analyzing

Category	Percentase
Bad	25 %
Sufficient	42,85 %
Good	32,14 %
Very good	0 %

Based on the results of the analysis of distinguishing data shown in the table, it can be seen that out of 28 questions compiled and tested on students, information was obtained that the differentiating problem was divided into 3 categories, namely bad, sufficient and good. Test items that have a differentiation with a bad category are

numbered 1,3,5,7,14,24,25 or with a percentage of 25%, test items that have distinguishing features from the category are simply indicated number 2,4,6, 10,11,13,15,18,20,21,27,28 or with a percentage of 42.85% and test items that have distinguishing features with good categories shown in numbers 8,9,12,16,17,19, 22,23,26 or with a percentage of 32.14%.

Deception Index

The deception index analysis was carried out to find out how the functioning of the alternative answers to the errors given to the multiple-choice test items. Based on the analysis of the alternative index, the answers to the test items were found that:

Table 12. Analyzing of deception alternative answer

Alternative Answer	Category
2 / (b,c,d), 5/(b,c,d), 8/(a,c,d)	$\leq 0,05$ (Kurang Baik)

Table 13. Persentase Analyzing of deception alternative answer

$\leq 0,05$ (less good)	$\geq 0,05$ (good)
6,42%	93,57%

Based on the results of the analysis of the alternative answers to the deception data shown in the table, it is known that from 28 test items with 5 alternative answers on each test item, it was found that alternative answers b, c, and d on test items number 2, b, c and d on Test items number 5 and a, c and d on item number 8 have not had good or not selected deception at least 5% of the total test takers.

Conception of Students

Based on the results of student misconception analysis of the fluid concept using the three-tier test instrument, the data obtained that:

Table 14. Persentase of students' concept comprehension level about the fluid concept

Level of comprehension concept	Persentase
Understand the concept	27,58
Not understand the concept	45,29
Misconception	24,74
Error	2,36

Table 14 showed that from 98 students in SMA XI IPA grade was gotten data that 27,28% students understood the fluid concept. 45,29% students have not understood the fluid concept, 24,74% students have misconceptions and 2,36% students have an error. Based on the analyzing of data identified students' misconception, there are many students that faced misconception. The difference between students that did not understand and the students and students faced misconception lies in the students' belief about their answer was given. If the students believed through their answer is given but their answer was wrong so that the students were categorized as a misconception, even though if the students did not believe with their answer given so that the students were categorized that they did not understand the concept.

Misconceptions that occur in students are not limited simply because their answers are wrong, however, based on an analysis of understanding the concepts of students with three-tier test instruments with open reasons or students not given alternative answers, it is found that students find the difficult to give reasons for their answers given it to the first level question. It shows the difficulty of students in communicating in conveying what they understand.

CONCLUSION AND SUGGESTION

The results of the validation by eight validator experts found that the test items developed were included in the valid category. Based on the results of the

analysis of the diagnostic test instrument, it was found that the 28 test items used in this study had the reliability of 0.96 with a high category so that the instruments prepared were reliable and feasible to be used as test kits. The level of difficulty of items consists of 3 items with easy categories, 19 items with medium categories and 5 items with difficult categories. The differentiation of test items consisted of 7 items with a bad category, 12 items with enough categories and 9 items in a good category, for the fraudulent index the alternative answers that had not been selected were at least 5% of the total test participants, namely alternatives B, C and D on item number 2, B, C and D in points 5 and A, C and D in number 8.

The next research for the researchers suggested that the test sample diagnostic test instruments use more varied schools so that the diagnostic test instruments compiled have better validity and reliability. Item Questions developed should be made more in-depth in identifying misconceptions experienced by students so that the information obtained by the teacher will be more complete. In addition, diagnostic instruments to identify student misconceptions should be arranged in the form of four-tier tests for open reasons.

REFERENCES

- Abbas, M. L. H. (2016). Pengembangan Instrumen Three Tier Diagnostic Test Miskonsepsi Suhu dan Kalor. *Ed-Humanistics*, 01(02), 83–92.
- Aiken, L. R. (1985). Three coefficient for analyzing the reliability and validity of rating. *Educational and Psychological Measurement*. <https://doi.org/10.1177/0013164485451012>
- Aini, R. G., Ibnu, S., & Budiasih, E. (2016). Identifikasi Miskonsepsi dalam Materi Stoikiometri pada Siswa Kelas X di SMAN 1 Malang Melalui Tes Diagnostik Three-Tier. *Jurnal Pembelajaran Kimia*, 01(2), 50–56.
- D'sa, juliana linnette, & Visbal-Dionaldo, maria liza. (2017). Analysis of Multiple Choice Questions: Item Difficulty, Discrimination Index Analysis of Multiple Choice Questions: Item Difficulty, Discrimination Index and Distractor Efficiency, (July). <https://doi.org/10.5958/0974-9357.2017.00079.4>
- Djanette, B., & Fouad, C. (2014). Determination of University Students' Misconceptions about Light Using Concept Maps. *Procedia - Social and Behavioral Sciences*, 152, 582–589. <https://doi.org/10.1016/j.sbspro.2014.09.247>
- Fitriatun, A., & Sukanti. (2016). Analisis Validitas, Reliabilitas dan Butir Soal Latihan Ujian Nasional Ekonomi Akuntansi di MAN Maguwaharjo. *Jurnal Kajian Pendidikan Akuntansi Indonesia*, 8(3), 1–11.
- Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2015). A review and comparison of diagnostic instruments to identify students' misconceptions in science. *Eurasia Journal of Mathematics, Science and Technology Education*, 11(5), 989–1008. <https://doi.org/10.12973/eurasia.2015.1369a>
- Hasan, S., Bagayoko, D., & Kelley, E. L. (1999). Misconceptions and the Certainty of Response Index (CRI). *Physics Education*, 34(5), 294–299. <https://doi.org/10.1088/0031-9120/34/5/304>
- Kamilah, D. S., & Suwarna, I. P. (2016). Pengembangan Three-Tier Test Digital Untuk Mengidentifikasi Miskonsepsi Pada Konsep Fluida Statis. *Edusains*, 8(2), 212–220.
- Kusairi, S. (2013). Analisis Asesmen

- Formatif Fisika Sma Berbantuan Komputer. *Jurnal Penelitian Dan Evaluasi Pendidikan*, 16(0), 68–87. <https://doi.org/10.21831/PEP.V16I0.1106>
- Lucariello, J., Tine, M. T., & Ganley, C. M. (2014). A formative assessment of students' algebraic variable misconceptions. *Journal of Mathematical Behavior*, 33(1), 30–41. <https://doi.org/10.1016/j.jmathb.2013.09.001>
- Mahjabeen, W., Alam, S., Hassan, U., Zafar, T., Butt, R., Konain, S., & Rizvi, M. (2018). Difficulty Index, Discrimination Index and Distractor Efficiency in Multiple Choice Questions, (March), 310–315.
- Mohamad, M. M., Sulaiman, N. L., Sern, L. C., & Salleh, K. M. (2015). Measuring the Validity and Reliability of Research Instruments. *Procedia - Social and Behavioral Sciences*, 204(November 2014), 164–171. <https://doi.org/10.1016/j.sbspro.2015.08.129>
- Parsa, i made. (2015). Pengaruh Bentuk Penilaian Formatif dan Hasil, XI(1), 79–90.
- Prihatni, Y., Kumaidi, K., & Mundilarto, M. (2016). Pengembangan Instrumen Diagnostik Kognitif Pada Mata Pelajaran Ipa Di Smp. *Jurnal Penelitian Dan Evaluasi Pendidikan*, 20(1), 111. <https://doi.org/10.21831/pep.v20i1.7524>
- Priyambodo, E., & Marfuatun. (2016). Validity and Realibility of Chemistry Systemic Multiple Choices Questions (CSMCQs). *International Journal of Evaluation and Research in Education*, 5(4), 306–309.
- Pruyn, E. C., Watsford, M. L., & Murphy, A. J. (2016). Validity and reliability of three methods of stiffness assessment. *Journal of Sport and Health Science*, 5(4), 476–483. <https://doi.org/10.1016/j.jshs.2015.12.001>
- Resbiantoro, G., & Nugraha, A. W. (2017). Miskonsepsi Mahasiswa Pada Konsep Dasar Gaya Dan Gerak Untuk Sekolah Dasar. *Jurnal Pendidikan Sains (JPS)*, 5(2), 80–87.
- Shirali, G., Shekari, M., & Angali, K. A. (2017). Assessing Reliability and Validity of an Instrument for Measuring Resilience Safety Culture in Sociotechnical Systems. *Safety and Health at Work*, 9(3), 296–307. <https://doi.org/10.1016/j.shaw.2017.07.010>
- Sholihat, F. N., Samsudin, A., & Nugraha, M. G. (2017). Identifikasi Miskonsepsi dan Penyebab Miskonsepsi Siswa Menggunakan Four-Tier Diagnostic Test Pada Sub-Materi Fluida Dinamik: Azas Kontinuitas. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, 3(2), 175–180. <https://doi.org/10.21009/1.03208>
- Siregar, S. (2014). *Statistik Parametrik untuk Penelitian Kuantitatif*. Jakarta: Bumi Aksara.
- Suryani, H., Kartowagiran, B., & Jailani. (2017). Development and Validity of Mathematical Learning Assessment Instruments Based on Multiple Intelligence. *Jurnal Penelitian Dan Evaluasi Pendidikan*, 21(1), 93–103.
- Suwarto. (2013). Model-model Instrumen Diagnostik. *Widyatama*, 22(1), 64–70.
- Wijaya, C. P., Supriyono Koes, H., & Muhardjito. (2016). The diagnosis of senior high school class X MIA B students misconceptions about hydrostatic pressure concept using three-tier. *Jurnal Pendidikan IPA Indonesia*, 5(1), 14–21. <https://doi.org/10.15294/jpii.v5i1.5784>
- Wisudawati, A. W. (2015). Pengembangan Instrumen Three –

- Tier Test Untuk Mengidentifikasi Representasi Tingkat Mikroskopis Perubahan Wujud Air Sebagai Alternatif Assesment Integrasi Islam-Sains (A Preliminary Study). Seminar Nasional Kimia Dan Pendidikan KImia VII.
- Yamtinah, S., Saputro, S., & Utami, B. (2016). Content Validity and Scoring of Two-Tier as Measuring Instrument of Science Process Skills for Knowledge Aspects in Chemistry Learning. *Prosiding ICTTE FKIP UNS 2015*, 1(1), 911–916.
- Yasin, R. M., Yunus, F. A. N., Rus, R. C., Ahmad, A., & Rahim, M. B. (2015). Validity and Reliability Learning Transfer Item Using Rasch Measurement Model. *Procedia - Social and Behavioral Sciences*, 204(November 2014), 212–217. <https://doi.org/10.1016/j.sbspro.2015.08.143>
- Zukhruf, K. D., Khaldun, I., & Ilyas, D. S. (2016). Remediasi Miskonsepsi Dengan Menggunakan Media Pembelajaran Interaktif Pada Materi Fluida Statis. *Jurnal Pendidikan Sains Indonesia*, 04(02), 56–68.

SCIENTIFIC LITERACY: HOW IS IT EVOLVED TO PRE-SERVICE PHYSICS TEACHER?

Muhammad Minan Chusni*¹, Rizki Zakwandi², Aan Hasanah³, Adam Malik⁴, Adeng Muchtar Ghazali⁵, Mujib Ubaidillah⁶

^{1, 2, 4}Department of Physics Education, UIN Sunan Gunung Djati, Jl. A.H Nasution No 105, Bandung, Indonesia

³UIN Sunan Gunung Djati, Jl. A.H. Nasution No 105, Bandung, Indonesia

⁵UIN Sunan Gunung Djati, Jl. A.H Nasution No. 105, Bandung, Indonesia

⁶IAIN Syekh Nurjati Cirebon, Indonesia

*Corresponding Address; minan.chusni@uinsgd.ac.id

Received: July 30th, 2018. Accepted: October 24th, 2018. Published: October 28th, 2018

Abstract: Scientific literacy is the ability to use scientific knowledge, identify problems, and draw conclusions based on evidence, in order to understand and make decisions about nature and changes that occur in nature as a result of human activity. This study aims to determine the development of physics teacher candidates' scientific literacy. This is important to prepare the physics teachers in the future. The method used was ex-post facto. The subjects of this research were all students of physics education Department of UIN Sunan Gunung Djati Bandung from the first to the last semester. The data collection used was essayed tests which contained the context of science, the content of science, the process of science, and the attitude of science. Data analysis was done qualitatively and quantitatively. Based on the results of this study, it indicates that the scientific literacy ability possessed by physics teacher candidate students experiencing a continuous development in terms of the context of science, science content, the process of science, and attitude to science. The result of this research may be applied by the Physics Department to make a decision or rule on how to improve the physics student' literacy level.

© 2018 Physics Education, UIN Raden Intan, Lampung, Indonesia.

Keyword: Physics teachers, professional teacher, scientific literacy

INTRODUCTION

Scientific literacy has long received attention from the academic field. Scientific literacy is a very important ability for everyone to solve problems. People who have the literacy ability is able to read and understand graphs, tables, diagrams, and able to apply mathematical skills in their life (Vieira & Tenreiro-Vieira, 2016). While someone who has scientific literacy is a person, who uses scientific knowledge and skills to make decisions to understand life and to participate in social activities (Luke, 2018; Restivo, 2017).

The scientific literacy is directly correlated with building a new generation that has strong scientific thinking and attitude (Linder, Airey, Mayaba, & Webb, 2014). It can effectively communicate science and research results to the general

public (Arohman, Safudin, & Priyandoko, 2016). The United States National Science Education Standard states that the nation has set a goal for all students to be able to reach the level of scientific literacy (C. Y. Chang, Chang, & Yang, 2009; Wright, Franks, Kuo, McTigue, & Serrano, 2016)

Scientific literacy learning has become widespread as one of the most important in science education. The scientific literacy assumptions consist of the ability to think metacognitive, read and write scientific texts, and to apply elements of scientific argumentation (Orr & Kukner, 2015). According to Butler and Winne in Wallace that metacognitive knowledge needs to be developed by students in order for their learning to be more effective (Bovill, Cook-Sather, Felten, Millard, & Moore-Cherry, 2016; Wallace, 2004). Reading and writing skills are also very important

in literacy, according to Holliday in Wallace, by reading we could know the skill of outlining the ideas and information obtained from the text being read, whereas by getting used to writing will train the ability to express ideas with what is in their hearts in their own language (Roos, 2014). As for applying scientific argumentation, according to Pittrinch in Wallace can be applied after accustomed to writing and reading scientific texts (Johnson-Glenberg, Megowan-Romanowicz, Birchfield, & Savio-Ramos, 2016; Wallace, 2004).

Learning in science education literacy according to Doyle describes three versions: (a) student-centered, where learning is designed to be in the personal meaning and experience of the child, (b) the subject matter, the lesson is designed to align with professional work and discipline, (c) learning center in world activities real where it will be an experience for every individual. To achieve the goal of science literacy, teachers and science educators should concentrate on instructional design for student learning or on student performance (August & Shanahan, 2017; S. N. Chang & Chiu, 2005).

The Ministry of National Education has developed a curriculum policy study in science subjects with facts about PISA results on the average literacy conditions of Indonesian students. So far, the acquisition of Indonesian students' literacy index is still very low. This is in line with Indonesia's rating according to the Program for International Students Assessment (PISA), which occupies the 62nd position of 69 countries evaluated (Iswadi, 2016).

This study was conducted based on the Curriculum Centre of the National Education Research and Development Agency on the Future Science Curriculum. Based on such study resulted in science learning related to science literacy. Some of the things recommended in the

academic script are: (1) Science learning should be able to foster students' self-esteem, (2) science learning must be accompanied by the development of skills and skill skills and scientific skills, so that science learning not only teaches concepts, (3) Science learning should make students able to develop their reasoning ability and can plan to conduct scientific investigation, (4) Science learning should be able to revitalize science process skill for students, teachers and prospective teachers as the main mission of Teaching and Learning Process of science (Islami, Nahadi, & Permanasari, 2016). Simply, the research aim is to show the level of student literacy of physics content and to give consideration to be applied by the department.

METHOD

The approach used in this research was descriptive quantitative approach with special study characteristic. The method used in this research was an ex-post facto method. This research explains the influence of literacy ability for physics teacher candidate. Researchers took 41 students of Physics Education Department of UIN Sunan Gunung Djati Bandung as the randomly selected subject. The data in this research was obtained from the instrument of scientific literacy with four aspects of literacy namely process, concept, context, and attitude. The subject matter in this research was gear and spring matter that has been learned by the student in senior high school or basic physics in university. The instrument was validated by the specialist, and the reliability was calculated using Spearman-Brown methods. An assessment was done by using four-levels rubric according to the true level of the answer (Zakwandi, Rochman, Nasrudin, Yuningsih, & Putra, 2018). The data was then analyzed by a quantitative approach to get the profile of student ability and to predict the literacy level of the student in the last years. Before

that, the data has been checked through statistical approach such as reliability or normality of the data. Reliability has the same function as the standard deviation is to show the distribution of the result.

RESULTS AND DISCUSSIONS

The data in this study was collected from the instrument of scientific literacy. Before the data was used to make a conclusion of the result, the data was checked through the validity and reliability test and give the result as the coefficient of reliability with the value 0,92 with the very high interpretation (Crowder, 2017) and the validity of each number of question is:

Table 1. The validity of instrument literacy of each question

No	Number of Question	Index	Qualification
1	1 (Process)	0.55	Middle
2	2 (Concept)	0.75	High
3	3 (Context)	0.70	High
4	4 (Attitude)	0.78	High
5	5 (Process)	0.88	Very High
6	6 (Concept)	0.79	High
7	7 (Context)	0.82	Very High
8	8 (Attitude)	0.85	Very High

Based on table 1 we get the information that the instrument of literacy used in this research was reliable and possessed a high-level degree of validity. So we can to use the data from this instrument to make a conclusion and generalization of the students' levels of literacy in Physics Education Department (Chatfield, 2018).

The result of this study indicates that the scientific literacy possessed by the students of physics teacher candidate experiencing a continuous development during the learning process. Based on the data obtained, the student ability increases significantly.

Table 2. Student average score in mechanic's phenomenon.

No	Year	Average
1	2017	1.35
2	2016	2.07
3	2017	2.65

Table 2 shows the level of students' scientific literacy ability at the beginning (first years) to the end (third year). Based on the table, we have the data of the improvement of the students' scientific literacy with the coefficient of 1, 40 each year. The data indicate that the students' level in the first years was low, the students in the second years was in the moderate scientific literacy ability and the student in the third years was in the high-level category. In addition, the data obtained shows that the overall average of students in the aspect of scientific literacy was still in the moderate category with the achievement of 2.02 on a scale of 0 to 4 (Towns & Ashby, 2014). This provides an illustration that the implementation of learning that had been done to help students to develop their scientific literacy level was still not enough since society requires them to be highly literate. Based on the assumption, the increase of student literacy could be used to predict that the Physics Education Program students would have a high level of literacy, thus it can be assumed that the graduates are already at a high level. However, this still needs to be improved further because of the score is still in the unsafe level (Drew & Thomas, 2018).

Table 3. Students' scientific literacy Levels on Gear and spring matter

No	Year	Average	
		Gear	Spring
1	2017	1.77	0.92
2	2016	2.43	1.70
3	2017	2.73	2.56

Based on Table 3, the difference in student literacy level was observed from the material tested. In this study, the material used as research was the material

related to gear, chain, and spring. Based on the data obtained then it appears that the subjects of the research were more literate on the material related to wheel and chain compared with the spring material. This is because of the subjects were in touch directly with the wheels and chains more than the springs (Proyowidodo & Luik, 2014). In the real-life application, the wheel and chain are represented by Ferris-wheel whereas spring material is represented by a sledgehammer. Based on the data obtained, the level of students' literacy on the material related to wheel and chain was in the intermediate level with the score of 2.31 while the material related to springs was in the low level with the score of 1.73 from a 0-4 scale. If it is reviewed further on the basis of each scientific literacy aspect (process, concept, context, and attitude), it shows more specific results. Table 4 shows the level of students' literacy on each aspect of literacy in each material tested. In every aspect of students' scientific literacy also shows higher levels in the wheel and chain material compared to spring material. In the aspect of data process, the students were more familiar with the process of moving or working principle of Ferris-Wheel than a sledgehammer. This is due to the experience of the average student who had been on a Ferris-Wheel, and only a few of the students have ever used a sledgehammer (Rainey, Maher, Coupland, Franchi, & Moje, 2018). Based on these results it can be shown that one way to increase the level of literacy is by presenting the real form of a physics concept. The results showed that students have the highest level of literacy on the process in both materials while for the lowest score are in the attitude aspect. This indicates that the student still can't give a proper view in addressing the application of the physics concept. This is true also related to the acquisition of literacy index on the concept aspect in each material

where the students only get the score of 2.18 on wheel and chain material and 1.76 for the spring material (Soobard & Rannikmae, 2011).

Table 4. Student literacy levels each aspect on each matter study

No	Aspect	Index	
		Gear	Spring
1	Process	2.69	2,09
2	Concept	2.18	1.76
3	Context	2.48	1.54
4	Attitude	1.89	1.64

This is slightly different in the context aspect in which the students have a fairly good score on wheel and spring material. This may indicate that the students were able to predict how the impact of the application will be. The overall cumulative result of the student literacy index is shown in Table 5.

Table 5. Student literation index of each aspect literacy

No	Aspect	Index	Qualificati on
1	Process	2.39	Moderate
2	Concept	1.97	Low
3	Context	2,01	Moderate
4	Attitude	1.71	Low
	Average	2.02	Moderate

Table 5 shows that the level of student' literacy is at a moderate level. The obtained literacy index based on the literacy aspect shows that the new students get the highest score (Dong, Chai, Sang, Koh, & Tsai, 2015). This thorough discussion indicates that the average students' literacy index obtained is still at the moderate level and even very close to the low literacy level in the range of 1.01 - 2.00. This does not fully reflect how the implementation of the learning is done (Asyhari & Asyhari, 2017). Furthermore, the development of students' literacy index in every aspect of literacy is shown in Figure 1.

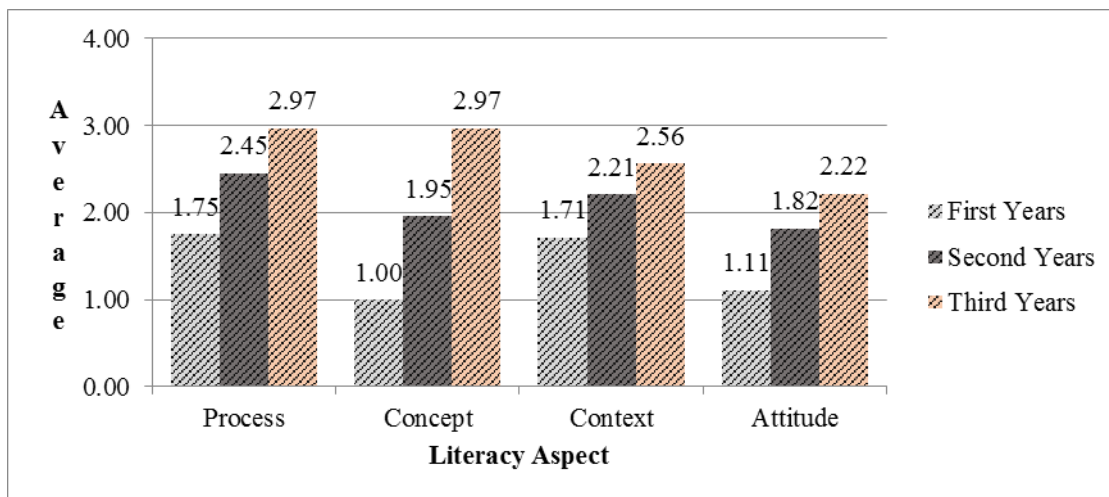


Figure 1. Student Literacy Levels each aspect of science literacy.

Figure 1 shows that the students' scientific literacy index of each aspect has increased from the first year to the third year. The most significant increase occurred in the concept aspect where the first-year students gained a score of 1.00 while in the third-year students gained a score of 2.97. which has the same value with the index on the aspect of the process. The smallest increase occurred in the context aspect (0.85 from initial ability). However, this can be masked by a relatively high initial willingness of 1.71 (Supeno, Supeno, Subiki, & Rohma, 2018). The next smallest increase was in the attitude aspect that increased by 1.11 from the initial ability into 1.11. Overall, it can be seen that the lesson learned can significantly improve the student literacy index. Especially in the concept and process aspects which shows the increase of 1.97 and 1.22 from the initial capability. Based on the data, it can be described how the learning process was undertaken to improve student conceptual understanding (Connor et al., 2017).

CONCLUSION

Student literacy skills related to the application of physics concepts on wheel and chain and spring material have improved along with the learning experience. Both on the whole and on the literacy aspect, students' scientific literacy

skills increased significantly. A high level of improvement occurred in the conceptual mastery aspects reaching threefold compared to the students' ability in the first year. While the lowest increase occurred in the aspects of content that is only 85% compared to the first year. However, this is covered with a high initial ability. The overall level of student literacy is at a moderate level (years 1 - 3) with an index of 2.02 on a scale of 0 - 4. This can indicate that the level of students' literacy still needs to be improved.

REFERENCES

Arohman, M., Safudin, & Priyandoko, D. (2016). Kemampuan Literasi Sains Siswa pada Pembelajaran Ekosistem. In *Prosiding Seminar Biology* (pp. 90–92). Retrieved from <http://www.jurnal.fkip.uns.ac.id/index.php/prosbio/article/view/9480/0>

Asyhari, A., & Asyhari, A. (2017). Literasi Sains Berbasis Nilai-Nilai Islam dan Budaya Indonesia. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 6(1), 137. <https://doi.org/10.24042/jpifalbiruni.v6i1.1584>

August, D., & Shanahan, T. (2017). Developing literacy in second-language learners: Report of the National Literacy Panel on Language-Minority Children and

- Youth. Routledge.
- Bovill, C., Cook-Sather, A., Felten, P., Millard, L., & Moore-Cherry, N. (2016). Addressing potential challenges in co-creating learning and teaching: overcoming resistance, navigating institutional norms and ensuring inclusivity in student–staff partnerships. *Higher Education*, 71(2), 195–208. <https://doi.org/10.1007/s10734-015-9896-4>
- Chang, C. Y., Chang, Y. H., & Yang, F. Y. (2009). Exploring Secondary Science Teachers' Perceptions of the Goals of Earth Science Education in Taiwan. *International Journal of Science Education*, 31(17), 2316.
- Chang, S. N., & Chiu, M. H. (2005). The Development of Authentic Assessments to Investigate ninth Graders' Scientific Literacy: In The Case of Scientific Cognition Concerning The Concepts of Chemistry and Physics. *International Journal of Science and Mathematics Education*, 3.
- Chatfield, C. (2018). *Introduction to Multivariate Analysis*. Routledge. <https://doi.org/10.1201/9780203749999>
- Connor, C. M., Dombek, J., Crowe, E. C., Spencer, M., Tighe, E. L., Coffinger, S., ... Petscher, Y. (2017). Acquiring science and social studies knowledge in kindergarten through fourth grade: Conceptualization, design, implementation, and efficacy testing of content-area literacy instruction (CALI). *Journal of Educational Psychology*, 109(3), 301–320. <https://doi.org/10.1037/edu0000128>
- Crowder, M. (2017). *Statistical Analyse of Reliability Data*. Routledge. Retrieved from content.taylorfrancis.com
- Dong, Y., Chai, C. S., Sang, G.-Y., Koh, J. H. L., & Tsai, C.-C. (2015). Exploring the Profiles and Interplays of Pre-service and In-service Teachers' Technological Pedagogical Content Knowledge (TPACK) in China. *Journal of Educational Technology & Society*. *International Forum of Educational Technology & Society*. <https://doi.org/10.2307/jeductechsoci.18.1.158>
- Drew, S. V., & Thomas, J. (2018). Secondary science teachers' implementation of CCSS and NGSS literacy practices: a survey study. *Reading and Writing*, 31(2), 267–291. <https://doi.org/10.1007/s11145-017-9784-7>
- Islami, R. A. Z. El, Nahadi, N., & Permanasari, A. (2016). Membangun Literasi Sains Siswa Pada Konsep Asam Basa Melalui Pembelajaran Inkuiri Terbimbing. *Jurnal Penelitian Dan Pembelajaran IPA*, 2(2), 110–120. <https://doi.org/10.30870/JPPi.V2i2.662>
- Iswadi, H. (2016). Sekelumat dari Hasil PISA 2015 yang Baru Dirilis. Retrieved from http://www.ubaya.ac.id/2014/content/articles_detail/230/Overview-of-the-PISA-2015-results-that-have-just-been-Released.html
- Johnson-Glenberg, M. C., Megowan-Romanowicz, C., Birchfield, D. A., & Savio-Ramos, C. (2016). Effects of Embodied Learning and Digital Platform on the Retention of Physics Content: Centripetal Force. *Frontiers in Psychology*, 7, 1819. <https://doi.org/10.3389/fpsyg.2016.01819>
- Linder, A., Airey, J., Mayaba, N., & Webb, P. (2014). Fostering Disciplinary Literacy? South African Physics Lecturers' Educational Responses to their Students' Lack of Representational Competence. *African Journal of Research in Mathematics, Science and*

- Technology Education, 18(3), 242–252.
<https://doi.org/10.1080/10288457.2014.953294>
- Luke, A. (2018). The social construction of literacy in the primary school. In *Critical Literacy, Schooling and Social Justice* (1st ed., pp. 28–74). New York: Routledge.
- Orr, A. M., & Kukner, J. M. (2015). Fostering a creative mindset in content area pre-service teachers through their use of literacy strategies. *Thinking Skills and Creativity*, 16, 69–79.
<https://doi.org/10.1016/J.TSC.2015.02.003>
- Proyowidodo, G., & Luik, J. (2014). Communicating disaster mitigation literacy to coastal communities in Pacitan, Indonesia. *American International Journal of Research in Humanities, Arts and Social Sciences*, 5(2), 245–248.
- Rainey, E. C., Maher, B. L., Coupland, D., Franchi, R., & Moje, E. B. (2018). But What Does It Look Like? Illustrations of Disciplinary Literacy Teaching in Two Content Areas. *Journal of Adolescent & Adult Literacy*, 61(4), 371–379.
<https://doi.org/10.1002/jaal.669>
- Restivo, S. (2017). The Social Construction of Mathematics. In *Sociology, Science, and the End of Philosophy* (pp. 253–281). London: Palgrave Macmillan UK.
https://doi.org/10.1057/978-1-349-95160-4_7
- Roos, J. M. (2014). Measuring science or religion? A measurement analysis of the National Science Foundation sponsored science literacy scale 2006–2010. *Public Understanding of Science*, 23(7), 797–813.
<https://doi.org/10.1177/0963662512464318>
- Soobard, R., & Rannikmae, M. (2011). Assessing student's levels of scientific literacy using interdisciplinary scenarios. *Science Education International*, 22(2), 133–144.
- Supeno, S., Supeno, S., Subiki, S., & Rohma, L. W. (2018). Students' Ability In Solving Physics Problems on Newtons' Law of Motion. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 7(1), 59–70.
<https://doi.org/10.24042/jipfalbiruni.v7i1.2247>
- Towns, E., & Ashby, S. (2014). The influence of practice educators on occupational therapy students' understanding of the practical applications of theoretical knowledge: A phenomenological study into student experiences of practice education. *Australian Occupational Therapy Journal*, 61(April), 344–352.
<https://doi.org/10.1111/1440-1630.12134>
- Vieira, R. M., & Tenreiro-Vieira, C. (2016). Fostering Scientific Literacy and Critical Thinking in Elementary Science Education. *International Journal of Science and Mathematics Education*, 14(4), 659–680.
<https://doi.org/10.1007/s10763-014-9605-2>
- Wallace, C. S. (2004). Framing New Research in Science Literacy and Language Use: Authenticity, Multiple Discourses, and the "Third Space. In *Framing New Research in Science Literacy and Language Use: Authenticity, Multiple Discourses, and the "Third Space* (p. 902).
- Wright, K. L., Franks, A. D., Kuo, L.-J., McTigue, E. M., & Serrano, J. (2016). Both Theory and Practice: Science Literacy Instruction and Theories of Reading. *International Journal of Science and Mathematics Education*, 14(7), 1275–1292.
<https://doi.org/10.1007/s10763-015-9661-2>

Zakwandi, R., Rochman, C., Nasrudin, D., Yuningsih, E. K., & Putra, S. (2018). Profil Literasi Fisika Siswa Madrasah Terhadap Mitigasi Bencana Erosi Batang Sinamar. *Jurnal Pendidikan Islam Belajea*, 3(1), 47–58. <https://doi.org/http://dx.doi.org/10.29240/bjpi.v3i1.279>

DEVELOPMENT OF PROBLEM SOLVING-ORIENTED WORKSHEET OF PHYSICS LEARNING IN SENIOR HIGH SCHOOL

Muhammad Syahrul Kahar*¹, Ismail Suardi Wekke², Muhamad Ruslan Layn³

^{1,3} Mathematics Education Department, Universitas Muhammadiyah Sorong, Papua, Indonesia

² State Islamic College of Sorong, Papua, Indonesia

*Corresponding address: muhammadsyahrulkahar@gmail.com

Received: July 2nd, 2018. Accepted: October 20th, 2018. Published: October 28th, 2018

Abstract: This study aimed at identifying how did the improvement in the problem-solving ability of learners work in improving the ability of learners in constructing the materials obtained after the development of LKPD (Learner's Worksheet) in classroom learning. This research used Research and Development (R & D) approach using the Kemp model. Data collections were done through problem-solving tests, validation analysis, and correlation test. The indicators of this study included the effectiveness of the developed learner's worksheet and the increased ability of problem-solving that was seen from the learning results obtained. The results showed that the average increase in the learning outcomes of the learners was equal to 79.44 with a difference in the scores of learning outcomes where $t_{count} = 32.806 > t_{table} = 1.734$, with a significance level of 0.000. Also, the improvement of learning outcomes on the response of learners gives significant influence with a score of 0.338 with a significance level of 0.085. Based on these results the development, the problem-solving oriented students' worksheet is declared valid and effective based on the results of validation tests by experts and the results of the implementation of classroom learning. These results impact the students' learning outcomes. It is expected that in the learning process with different materials, the worksheet can be applied in improving students' ability to solve problems. It is suggested for a research to collaborate the worksheet with other models and, media that can be linked to the problem-solving aspects, so that in its implementation, students have the confidence to succeed, be more active, and interested in problem-solving given.

© 2018 Physics Education, UIN Raden Intan, Lampung, Indonesia.

Keywords: Learning of physics, learner's worksheet, problem-solving

INTRODUCTION

Physics learning is a subject that requires quite a lot of relatively high intellectualize so that most learners have difficulty in learning. They assume that physics learning is a fairly difficult lesson because it requires not only mathematical calculation but also the understanding of concepts (Keller et al., 2017). Therefore, the researchers apply problem solving-oriented learning model.

Some research results in various countries such as Sweden and Japan show that the average implementation of learning that has been carried out is not directed to the students' critical thinking and the ability to solve problems. This is

evidenced by the students' inability to connect material taught with the phenomena that exist in their environment. The students' competence in the material provided has not been maximally achieved. Also, another thing that is very influential is the use of strategies in implementing learning to make students active without losing focus on the material provided. These results are also consistent with reports from the two countries which explain that students whose teachers often use a variety of approaches or strategies have a higher level of achievement on problem-solving compared to teachers who only explain in conventional ways (Asami-Johansson, 2015).

Based on the elaboration of the findings in the two countries, Indonesia is facing similar problems. It can be seen at the research site that in the implementation of learning in schools, the teacher only implements learning by explaining the material without carrying out the collaboration of various learning strategies and media, thus impacting the competencies possessed by students. The matter gives a change in mindset for students towards the willingness and interest in participating in the lesson.

In overcoming the problems that exist in the classroom, there needs to be an implementation of learning that is oriented towards problem-solving. The ability to solve problems within certain limits can be established through the field of study and the disciplines. The issue of how to teach 'problem solving' will never be overcome without considering the type of problem to be solved, suggestions and forms of the program prepared, and a student's innate variables. Similarly (Ceberio & Franco, 2016) explained that the problem solving oriented learning process could improve the ability of students to make hypotheses and analyze the results of the practice found.

Problem-solving strategies, in principle, use real-world problems as a context for learners to learn about critical thinking and problem solving and to acquire essential knowledge and concepts from the subject they learn. Darma (2018) states that in carrying out a learning using problem solving-oriented learning model that directs the learning outcomes on problem-solving abilities, it is possible for students to be able to describe information in accordance with their abilities and skills in processing the information obtained.

In according to (Purnamawati, Ertikanto, & Suyatna, 2017) stated that the process of learning with the teacher is a series of reciprocity between student activities and teaching activities. In order

for the learner's learning process to be effective, the teacher must act as a facilitator that provides an environment for the learning process to take place effectively and efficiently. To be a good facilitator, the teacher must master the concepts and principles of the learning process. While (Fathurrahman et al., 2018) and (Kahar, 2017) stated that in physics learning activities, teachers rarely train learners with skills. Practical activities are also rarely done on the grounds of limited time to learn conceptually and inadequacy of laboratory facilities and infrastructure, so the potential ability of learners is less trained.

When the development of learners' potency, especially their creativity of thinking during learning, is not optimal, it will result in learning that is not optimal as well. Therefore, a real effort is needed, one of which is to improve the learning process that occurs in the classroom through the use of different learning models and approaches. Thus, it needs a strategy that includes aspects of the development and implementation of tools or learning media to improve interest in learning and increase its outcomes (Kahar, 2018).

This strategy and development show students that every subject of physics is necessarily a way of thinking they must understand, not just by letting them learn from the teacher or the book, but the teacher must provide for them an opportunity to apply the knowledge they have in the real world. One of the learning tools developed is the learner's worksheet (LKPD) which supports to develop the strategy of problem solving-oriented learning. Similarly (Rahayu et al., 2017) explained that the implementation of students worksheet in learning oriented to various learning methods could improve some aspects of students' abilities such as learning motivation, and classroom learning activities.

This is in line with (Kahar et al., 2018) which explained that a learning approach

using a worksheet could construct learners' understanding. The construction of the worksheet development is classified into five stages including clarification of issues, opinion disclosure, evaluation and selection, implementation, and creative performance. (Noor et al., 2017) Also stated that the development of learning tools could show the improvement of the ability of learners determined by the ability to think, especially to solve the problems of life they face. Furthermore (Powell et al., 2017) stated that the use of learning media could provide cognitive implications for students in improving problem-solving abilities.

This problem solving-oriented learning strategy can be a good solution for learners in dealing with physics lessons. The use of a model or method of learning by the characteristics of the material taught allows teachers to communicate well with learners and add their insight thinking, so they can learn the whole concept well (Fitriah, 2013). Similarly, (Tanti et al., 2017) expressed that the use of various models of learning that focus on the formation of models and media in physics learning through contextual problem solving can provide opportunities for learners to actively engage in problem-solving, and can assist them in developing learning media and other media related to the subject of physics.

One of the models and learning approaches that can make learners become more active and grow their meta-cognition skill, learning think mathematically, and interest in learning is by using the Problem Solving model (Schoenfeld, 2016). Similarly (Putri et al., 2017) stated that the development of learning-oriented critical thinking skills could improve the ability of students in problem-solving for the material being taught and the implementation of these learning runs effectively and efficiently.

This allows the learners to follow physics learning more contextually, can

apply the concept well, to absorb learning carefully (Kahar, 2018). Also, the learning process that uses worksheets can provide more contextual learning related to the daily lives. The implementation is expected to be able to have an impact on students in improving their learning outcomes (Barniol & Zavala, 2016)

The development is also focused on the subject of fluid that can support more dominant discussion about materials related to the learners' daily life. Firdaus & Wilujeng (2018) explain that the development of inquiry-oriented worksheets was able to improve the students' ability and also able to improve students' critical thinking skills in solving the given questions. This can also have an impact on the learning activities carried out by students during learning.

Based on the above description, it is not appropriate to teach the subject of fluid or other materials that were collaborated into applicative aspects of learning solely by lecturing methods in the classroom. It should be taught by inviting learners to observe what they will learn and understand why the material is essential to them. Therefore, the purpose of this study was to evaluate how does the improvement of the problem-solving ability of the learners work after the development of the problem solving-oriented worksheet. In according to (English, Hudson, & Dawes, 2013) stated that the problem-solving process was able to construct students' skills in collaborating with the context of knowledge that was obtained.

Based on the results of the research stated above, the implementation and development of a learning media by applying an approach can provide significant results in improving learning outcomes. Still, based on the previously mentioned research, there has not been any development of worksheets that are oriented to the students' ability to solve problems. Therefore, the researcher intends to develop a worksheet that is

problem-solving oriented because in physics learning, especially in the fluid material, it is possible to stimulate the students to solve every problem stated in the worksheet.

Therefore, the achievement of the above-mentioned research objectives, students are expected to be able to identify models, methods, and strategies that were applied in every classroom learning, in order to improve their achievement and learning outcomes during the learning process. Also, they are also able to understand better the material obtained with the help of models, methods or tools in the form of LKPD applied in learning.

METHOD

The research method employed is research and development (R & D), where the design of research and development of learners' worksheet was done by referring to the development of the Kemp model. This development model consisted of several stages are (1) identification of learning problems, (2) material analysis, (3) analysis of specific learning objectives, (4) designing learning strategies, (5) establishing learning methods, and (6) developing evaluation instruments (Kemp, 1995). The revision stage can be done based on advice's given as stated in figure 1.

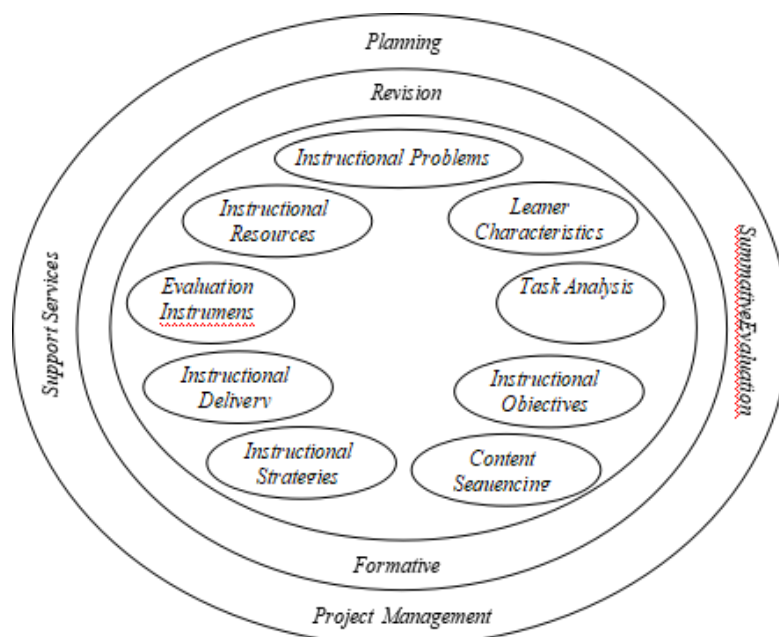


Figure 1. The cycle of development of the kemp learning model worksheet

This research was conducted at SMA Muhammadiyah Al-Amin, Sorong. The sample was 18 students of the second semester of the eleventh grade of Class XI MIA. The number of the samples was quite small since the overall students of the school were also limited.

The instruments used to collect the data in this study were the expert validation sheet and the problem-solving test. The expert validated the developed worksheet. The results of the validation can be in the form of suggestions and opinions which

then be used to revise the worksheet. There were two validators consisted of lecturers and practitioners (teacher). The instruments used to collect data are as follows:

Expert Validation

Expert validation was used by the team of validators to validate worksheets and research instruments that had been designed. The result of this validation was in the form of validators' suggestions and

opinions were used to revise such devices and instruments.

Problem-solving test

To identify the achievement of the physics learning of learners, they were given a multiple-choice test. This multiple-choice test consisted of 20 items that were used after the research to the same class (Suharsimi, 2006). It was intended to identify the achievement of the problem-solving skills of learners by referring to their physics learning outcomes after being taught using a problem-solving worksheet. Also, the achievement of learning they obtained, once collaborated on their responses, was analyzed using a correlation test.

To analyze data of the development of problem solving-oriented worksheet, descriptive statistical analysis technique was used. The data analyzed were:

Data analysis based on experts' validation

Data that had been validated by experts were analyzed by considering their inputs, comments, and suggestions. The results of the analysis were presented as guidelines for revising the worksheet used in the study.

Activities carried out in the process of analyzing the validity were by finding the total mean of the mean of (\bar{X}) for all aspects using the formula of

$$\bar{X} = \frac{\sum_{j=i}^n \bar{A}_i}{n}, \quad (1)$$

Information:

- \bar{X}_{The} = total mean of all aspects
- \bar{A}_i = mean of the i^{th} aspect
- n = amount of aspects

Furthermore, the total mean (\bar{X}) was assessed based on the interval rate determined as follows:

- $3.5 < M \leq 4$ Very valid
- $2.5 < M \leq 3.5$ Valid
- $1.5 < M \leq 2.5$ Quite valid
- $M \leq 1.5$ Not valid

The criteria used to decide that the learner's worksheet had a sufficient degree of validity were, among others, the mean value of validity for the overall aspects was at least being in a valid category. Otherwise, a revision was necessary to do based on the suggestion of the validators or by reviewing the aspects that were considered to be lacking.

RESULTS AND DISCUSSION

The results of the research are (1) Analysis of expert test on the learner's worksheet; and (2) Field test analysis.

The initial product developed is a learner's worksheet (Figure 1) in physics learning at SMA Muhammadiyah Al-Amin. Before trial, it is necessary to validate by experts by the field of research to validate the resulting product. Validation is done by providing an initial draft of the learner's worksheet with an evaluation sheet for each physics expert and teacher. An evaluation sheet is a questionnaire that contains aspects of assessment and quality, suggestions, and comments from experts and teachers of physics of SMA Muhammadiyah Al-Amin about the worksheet. The results of the evaluation are in the form of values of the aspect of the quality of the learning worksheet by using scale 1 to 4.

This developed worksheet has received feedback from some experts so that it can be more qualified and achieve the expected goals. The assessment developed includes four main elements.

The four elements include Format, Content, Language, and Benefits/ Usability. The experts in the assessment of the worksheet developed are (1) Rahmatullah Bin Arsyad, S.Pd., M. Pd (Lecturer of Muhammadiyah University of Sorong) and (2) Nurlia Malawat, S. Si (Physics Teacher). The data presented are the result of the experts' assessment of the worksheet product that was developed. The results so vary according to the assessors. The assessment presented in

order to see how far the quality of the product was developed. Firstly, the format shows that the mean score obtained is 3.75. When viewed from the rating category described in the previous section, then the mean score is included in the category of 'Very Good.' Secondly, the content shows that the mean score earned is 3.5 then the mean score is considered as 'Very Good.' Thirdly, Language shows that the mean score earned is 4.0 then the mean score is in the category of 'Very Good.' Fourthly, Benefit/Usability of the worksheet shows that the mean score earned is three then the mean score is categorized as 'Excellent'. More details were seen in Figure 2.

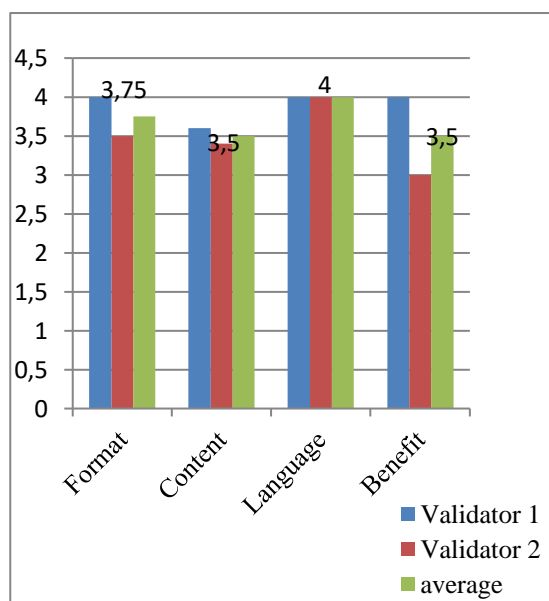


Figure 2. Experts' validation chart

The results of the scoring data obtained from the experts can show that the worksheet product belongs to the category of 'Very Good.' This proves that the experts averagely give a high assessment of the developed worksheet product. Therefore, it concluded that the development of student worksheets in SMA Muhammadiyah Al-Amin, Sorong, can be used for every trial conducted. This is consistent with research by (Alina et al., 2016) who explained that validation of the worksheet has an impact on the learning outcomes of the students in the classroom.

The result of the normality test of the learners' outcomes seen in figure 3.

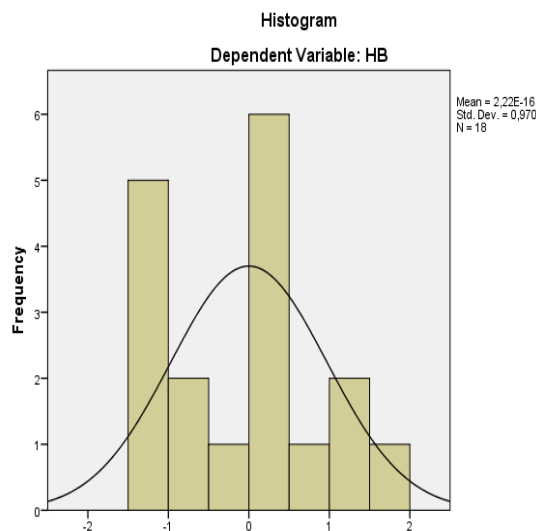


Figure 3. Normality test chart

The figure above shows that the results obtained by the learners when following the learning process have a normal distribution. Based on these data, the results of the descriptive analysis done show that the score obtained by the learners in following the learning on the Fluid subject showing the results of problem-solving is 79.44. This indicates that the learners, averagely, can understand the learning materials when a problem-solving-oriented learning process is implemented based on the process of practicum in the classroom and the laboratory.

This is also supported by another research by Seyhan (2015) that shows the students' problem-solving abilities are very dependent on the perception of the subject matter that has been learned. In addition, with the improvement of the ability, the students are able to be more active in honing their thinking skills caused by the application of good learning methods. The results of the descriptive analysis indicate that the scores of problem-solving of the learners are as shown in table 1.

Table 1. Descriptive analysis of the scores of problem-solving of the learners

	N	18
Mean		79,44
Median		80,00
Modus		65,00
Standard Deviation		10,27
Skewness		0,12
Minimum Score		65,00
Maximum Score		95,00

This analysis proves that the achievement of the results obtained by the learners during the learning of physics in the classroom experienced a significant improvement with the maximum score of 95 and the minimum score of 65. The results of t-test done using one sample tests how that the score of $t_{count} = 32.806 > t_{table} = 1.734$ with the significance degree of 0.000. Those show that the development of learners' worksheets affects improving problem-solving skills. The results obtained agree with (Sadipour et al., 2017) explaining that the oriented learning model of students' academic performance was able to provide better learning achievement, motivation, and problem-solving abilities.

In addition to the analysis mentioned above data, simple regression test results between students' learning outcomes and their responses in the next learning using worksheets can describe as well. This shown in Table 2.

Table 2. Correlation Test between Learning Outcomes to Student's Response

		Outcomes	Response
Pearson Correlation	Outcome	1,000	0,338
	Response	0,338	1,000
Sig. (1-tailed)	Outcome	-	0,085
	Response	0,085	-
N	Outcome	18	18
	Response	18	18

From the table above, it can be seen that the score of learning achievement and the response of learners obtained have a significant correlation to the response of

learners with Pearson correlation coefficient of 0.338 and significance level of 0.085. These results indicate that the level of achievement of the development of problem solving-oriented learner's worksheet shows a significant improvement in the implementation. Similarly (Barniol & Zavala, 2016) who explained that understanding to students could be improved through worksheets, to produce active learning. On the other hand (Stozhko et al., 2015) also suggests that project-based learning can develop students' problem-solving skills which are assisted by the use of learning media such as using worksheets, IT and so on.

Compared to other countries, such as Japan, the advantages in applying problem-solving learning by collaborating with various methods or approaches in implementing learning include: (1) students are more active and often express their ideas; (2) students have the opportunity to use their knowledge and skills extensively; (3) this method can give low-achievement students the opportunity to respond in their own way; (4) students are motivated to take lessons and (5) build a desire to find a problem (Asami-Johansson, 2015). In addition, the results of the study by Seyhan (2015) reveals that at the level of perception of problem-solving abilities, other process skills, and logical thinking abilities are more effective in compared to another conventional teaching methods. In addition, the learning outcomes obtained by students towards problem-solving abilities are quite significant.

On the other hand, these results prove that the response of learners has a significant relationship with their learning outcomes in which their ability to solve problems has increased. This is also supported by (Fhadhila, Ertikanto, & Rosidin, 2018) which stated that the learner's worksheet effectively improves the average of the learning outcomes, in which the achievement of the development

objectives is in the category of 'Good'. This is seen from the feedback given by the learners during the learning process with the results indicating a linkage to the effectiveness of the development of the worksheet.

Based on the results of the analysis of the data obtained, it found that the achievement of the learning process in the class got good results. This can be seen from the aspect of the device used. The achievement in question is to develop a valid, practical, and effective worksheet. To know the validity, each worksheet was assessed by two people. The results of the assessment of the two validators show that from the worksheet used in the developed learning, it was concluded that the worksheet is valid and practical.

The validity was illustrated by the results of the assessment of two validators where the developed learner's worksheet meets the criteria of validity with the average value of validity of 3.68 and is in the category of 'very valid.' This shows that from the aspect that was assessed and measured in the implementation of validation, it was seen that the learner's worksheet used is suitable for use in the learning process, so it was expected that this validation would have an impact on the improvement of learners' learning outcomes. In according to (Alina et al., 2016) the validity of worksheets provides a good response in the implementation of the learning process in the classroom.

The scores obtained indicate that the learners while following the lesson responded positively and were interested in the implementation of the learning process using problem solving-oriented worksheet in the classroom. Differences in the results obtained were due to the previous learning process different from the process of learning-oriented problem solving using the learner's worksheet, where each learner shows considerable interest in solving the problem. This is in line with research conducted by (Khairani

& Febrinal, 2016) which stated that testing the potential impact of the use of learning media can provide convenience to learners in understanding the lesson in the classroom.

The application of the oriented learning process enables the learners to be able to implement the results obtained and connect each learning material with daily life. In addition, it also describes the level of ability of learners in completing the problem-solving test, where the results of the testability of learners obtained on average are in the category of completeness, but the minimum score obtained learners fall into the category does not reach the minimum mastery criteria (KKM) which became the basis of the assessment of learning outcomes. There were just four students who can obtain that score. This indicates that there is still a small percentage of learners who still need special treatment in the learning process. In according to (Keller et al., 2017) stated that teachers must have pedagogic abilities in delivering material contextually to increase motivation and learning achievement.

Guidance and interest in the implementation of physics learning need to be encouraged again to improve their abilities. On the other hand, according to (Rahayu et al., 2017) the development of problem solving-oriented learning strategy using a worksheet can be a new model for learners in developing their thinking skills and honing other skills. This strategy encourages them to think more creatively. Therefore, learning based on problem-solving aspect and development of the learner's worksheet which is carried out by the process of practicum able to train learners to construct their knowledge and investigate a concept, as well as able to reflect the concept that was understood.

This is in line with the statement of (Puspitasari & Munawi, 2018) which explained that the implementation of an approach, method, and model of learning

could stimulate changes in the mindset of learners in solving the problem. Similarly (Lan, Hsiao, & Shih, 2018) explained that the implementation of a design in learning-oriented towards the use of instructional media was able to provide meaningful learning for students. Furthermore (Kahar, 2017) also explained that the problem-solving ability could give impact to the students in their ability of mathematical thinking in solving problems in their everyday life.

In according to (Panaoura et al., 2017) explained that problem-oriented learning could improve student learning outcomes and can also help improve understanding of physical concepts. On the other hand (Diani, Yuberti & Syarlisjisman, 2018) explained that learning based on problem-based learning could provide positive interaction for students so that the learning process carried out by students can run effectively, efficiently and be able to understand the material being taught. Another result of research (Amin & Mahmud, 2016) also explains that the development of a learning media through visual media or worksheets were able to have a significant impact on improving students' problem-solving abilities which include concept map ability and mathematical abilities.

CONCLUSIONS AND SUGGESTIONS

Some conclusions can be made based on the results of the research: the development of problem-solving oriented student worksheets is declared valid and effective based on the results of validation by the experts and the results of the implementation of classroom learning.

Furthermore, in learning by using problem-solving oriented worksheets, it is obtained the average learning outcomes of 79.44 with the results of the analysis of $t_{\text{count}} = 32.806 > t_{\text{table}} = 1.734$ with the significance degree of 0.000. On the other hand, in the implementation of worksheets oriented to problem-solving shows the

influence on students' responses to learning with a score of 0.338 with a significance level of 0.085.

The implication by these results has an impact on improving student learning outcomes so that it was expected that learning process with different materials can be applied in improving students' ability to solve problems. It is expected that in the learning process with different materials, the worksheet can be applied in improving students' ability to solve problems. It is suggested for a research to collaborate the worksheet with other models and, media that can be linked to the problem-solving aspects, so that in its implementation, students have the confidence to succeed, be more active, and interested in problem-solving given.

ACKNOWLEDGMENT

Thanks to the Directorate of Research and Community Service and the Directorate General of Research and Development Reinforcement of the Ministry of Research, Technology and Higher Education who have provided funding assistance in 2018.

REFERENCES

- Alina, Dining Nika; Purnomo, Tarzan; Kuntjoro, S. (2016). Validitas Lks Ekosistem Mangrove Berbasis Sets Pada Materi Ekosistem Untuk Sma Di Wilayah Pesisir Surabaya. *Berkala Ilmiah Pendidikan Biologi*, 5(3), 189–193.
- Amin, B. D., & Mahmud, A. (2016). The Development of Physics Learning Instrument Based on Hypermedia and Its Influence on the Student Problem Solving Skill. *Journal of Education and Practice*, 7(6), 22–28. Retrieved from <http://libproxy.library.wmich.edu/login?url=https://search.proquest.com/docview/1826527141?accountid=15099>
- Asami-Johansson, Y. (2015). Designing

- Mathematics Lessons Using Japanese Problem Solving Oriented Lesson Structure: A Swedish case study. In Linkoping Universitet.
- Barniol, P., & Zavala, G. (2016). A tutorial worksheet to help students develop the ability to interpret the dot product as a projection. *Eurasia Journal of Mathematics, Science and Technology Education*, 12(9), 2387–2398. <https://doi.org/10.12973/eurasia.2016.1271a>
- Ceberio, M., Manuel Almudi, J., & Franco, A. (2016). Design and Application of Interactive Simulations in Problem-Solving in University-Level Physics Education. *Journal of Science Education and Technology*, 25(4), 590–609. <https://doi.org/10.1007/s10956-016-9615-7>
- Darma; I, K, Candiasa; I, M, Sadia; I, W, D. N. (2018). The effect of problem-based learning model and an authentic assessment of mathematical problem-solving ability by using the numeric ability as the covariable The effect of problem-based learning model and an authentic assessment of mathematical problem-solving ability. *Journal of Physics: Conf. Series*, 1040.
- Diani, R., & Syarlisjiswan, M. R. (2018). Web-Enhanced Course Based On Problem-Based Learning (PBL): Development Of Interactive Learning Media For Basic Physics II. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 07(April), 105–116. <https://doi.org/10.24042/jipfalbiruni.v7i1.2849>
- English, L. D., Hudson, P., & Dawes, L. (2013). Engineering-Based Problem Solving in the Middle School: Design and Construction with Simple Machines. *Journal of Pre-College Engineering Education Research*, 3(2), 43–55. <https://doi.org/10.7771/2157-9288.1081>
- Fathurrahman, M; Ibrahim, Ibrahim; Kahar, M S; Arsyad, R; Rawi, R. D. P. (2018). Development of Learning Media Based on MOODLE Integrated with Blended Learning in Mathematics Learning Process at SMA Muhammadiyah Al – Amin Sorong. Development of Learning Media Based on MOODLE Integrated with Blended Learning in Mathematics Learning Proc. In IOP Conference Series: Earth and Environmental Science (pp. 1–6).
- Fhadhila, F., Ertikanto, C., & Rosidin, U. (2018). Developing Student Worksheet of Temperature and. *Jurnal Ilmiah Pendidikan Fisika Al-BiRuNi*, 07(April), 21–32. <https://doi.org/10.24042/jipfalbiruni.v7i1.2318>
- Firdaus, M., & Wilujeng, I. (2018). Pengembangan LKPD Inkuiri Terbimbing Untuk Meningkatkan Keterampilan Berpikir Kritis dan Hasil Belajar Peserta Didik. *Jurnal Inovasi Pendidikan IPA*, 4(1), 26–40. <https://doi.org/http://dx.doi.org/10.21831/jipi.v4i1.5574> Copyright
- Fitriah, E. (2013). Implementasi Model Creative Problem Solving Bervisi Sets Dalam Meningkatkan Keterampilan Proses Sains Dan Kreativitas Siswa Sma Berbasis Pesantren. *Jurnal Scientiae Educatia*, 2(2).
- Kahar, M. S. (2017). Analisis Minat Belajar Mahasiswa Terhadap Penggunaan Alat Peraga Neraca Cavendish. *SEJ (Science Education Journal)*, 1(2), 73. <https://doi.org/10.21070/sej.v1i2.1177>
- Kahar, M. S. (2018). Motivation Analysis Learning in The Implementation of Physics Practicum. *Jurnal Ilmiah Pendidikan MIPA*, 8(1), 1–6. Retrieved from <http://journal.lppmunindra.ac.id/index.php/Formatif/article/view/2285/1858>

- Kahar, M. S., Fathurrahman, M., Amri, I., & Pristianto, H. (2018). Development of Cavendish Balance of Aids Based on Blender Application in Learning Physics Development of Cavendish Balance of Aids Based on Blender Application in Learning Physics. In IOP Conference Series: Earth and Environmental Science (pp. 1–5).
- Keller, M. M., Neumann, K., & Fischer, H. E. (2017). The impact of physics teachers' pedagogical content knowledge and motivation on students' achievement and interest. *Journal of Research in Science Teaching*, 54(5), 586–614. <https://doi.org/10.1002/tea.21378>
- Kemp; Jerrold; E. (1995). *Instruction Design: A Plan for Unit and Course Development*. Belmont: Feron.
- Khairani, Majidah; Febrinal, D. (2016). Pengembangan Media Pembelajaran Dalam Bentuk Macromedia Flash Materi Tabung Untuk Smp Kelas IX. *Jurnal Ipteks Terapan Research of Applied Science and Education*, 10(12), 95–102. <https://doi.org/10.22216/jit.2016.v10i2.440>
- Lan, Y., Hsiao, I. Y. T., & Shih, M. (2018). Effective Learning Design of Game-Based 3D Virtual Language Learning Environments for Special Education Students. *Educational Technology & Society*, 21(3), 213–227.
- Noor, Muhammad; Zainuddin, & Miriam, S. (2017). Pengembangan Perangkat Pembelajaran Ipa Fisika Melalui Model Pengajaran Langsung Dengan Metode Problem Solving. *Berkala Ilmiah Pendidikan Fisika*, 5(3), 328–339.
- Panaoura, A., Michael-Chrysanthou, P., Gagatsis, A., Elia, I., & Philippou, A. (2017). A Structural Model Related to the Understanding of the Concept of Function: Definition and Problem-Solving. *International Journal of Science and Mathematics Education*, 15(4), 723–740. <https://doi.org/10.1007/s10763-016-9714-1>
- Powell, L. E., Wild, M. R., Glang, A., Ibarra, S., Gau, J. M., Perez, A., ... Slocumb, J. (2017). The development and evaluation of a web-based programme to support problem-solving skills following brain injury. *Disability and Rehabilitation: Assistive Technology*. <https://doi.org/10.1080/17483107.2017.1389999>
- Purnamawati, D., Ertikanto, C., & Suyatna, A. (2017). Keefektifan Lembar Kerja Siswa Berbasis Inkuiri untuk Menumbuhkan Keterampilan Berpikir Tingkat Tinggi. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 6(2), 209. <https://doi.org/10.24042/jipfalbiruni.v6i2.2070>
- Puspitasari, M. D. M., & Munawi, H. A. (2018). Perubahan Pola Berpikir Mahasiswa Pada Fenomena Perpindahan Panas Secara Konveksi. *Berkala Ilmiah Pendidikan Fisika*, 6(2), 142. <https://doi.org/10.20527/bipf.v6i2.4909>
- Putri, Sri Diana, Djamas, D. (2017). Pengembangan Perangkat Pembelajaran Fisika Berbasis Keterampilan Berpikir Kritis dalam Problem-Based Learning. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 6(1), 125. <https://doi.org/10.24042/jpifalbiruni.v6i1.648>
- Rahayu, T., Syafril, S., Wati, W., & Yuberti, Y. (2017). The Application of STAD- Cooperative Learning in Developing Integrated Science on Students Worksheet. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 6(2), 247. <https://doi.org/10.24042/jipfalbiruni.v6i2.1933>
- Sadipour, I., Ghavam, S. E., Farrokhi, N., & Sameti, N. (2017). A Model to Predict Academic Performance based on the

- Components of Emotional Intelligence, Problem Solving Skills and Achievement Motivation among Students of Smart and Ordinary School. *International Journal of Environmental & Science Education*, 12(5), 1353–1369.
- Schoenfeld, A. H. (2016). Learning to Think Mathematically: Problem Solving, Metacognition, and Sense Making in Mathematics (Reprint). *Journal of Education*, 196(2), 1–38. <https://doi.org/10.1177/002205741619600202>
- Seyhan, H. G. (2015). The effects of problem-solving applications on the development of science process skills, logical thinking skills and perception on problem-solving ability in the science laboratory. *Asia-Pacific Forum on Science Learning and Teaching*, 16(2), 1–31.
- Stozhko sny@usue.ru, N., Bortnik, B., Mironova, L., Tchernysheva, A., & Podshivalova, E. (2015). Interdisciplinary project-based learning: technology for improving student cognition. *Research in Learning Technology*, 23(1063519), 1–13. <https://doi.org/10.3402/rlt.v23.27577>
- Suharsimi, A. (2006). Dasar-Dasar Evaluasi Pendidikan. In Jakarta: Bumi Aksara (p. 168).
- Tanti, T., Jamaluddin, J., & Syefrinando, B. (2017). Pengaruh Pembelajaran Berbasis Masalah terhadap Beliefs Siswa tentang Fisika dan Pembelajaran Fisika. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 6(1), 23. <https://doi.org/10.24042/jpifalbiruni.v6i1.603>

THE DEVELOPMENT OF VIRTUAL LABORATORY LEARNING MEDIA FOR THE PHYSICAL OPTICS SUBJECT

Arif Billah*¹, Arif Widiyatmoko²

¹Institut Agama Islam Negeri (IAIN) Salatiga, Indonesia

²Graduate student of Graduate School for International Development and Cooperation, Hiroshima University, Japan

*corresponding author: arifbillahbadr@iainsalatiga.ac.id

Received: July 2nd, 2018. Accepted: October 21st, 2018. Published: October 28th, 2018

Abstract: This study aims to produce virtual laboratory interactive learning media that is effective and practical for the subject of physical optics. It uses the Research and Development (R & D) method. The material in the learning media includes dispersion, diffraction, interference, and polarization. Users of this product can be directly involved in observing, measuring and taking practical data. Product development has been validated by material expert, media expert, and practitioners (teachers). This product has also been tested in one-to-one, small groups, and field trial. Based on the results of the assessment by material expert, media expert, teachers, and field trial, this learning media software is categorized as “excellent” with a value of 4.63 for validity, “medium” with an n-gain value of 0.37 for effectiveness, and “excellent” with a value of 4.49 for practicality.

© 2018 Physics Education, UIN Raden Intan, Lampung, Indonesia

Keywords: learning media, physical optics, virtual laboratory

INTRODUCTION

Physics as a branch of natural science basically aim to study and provide information about laws, theories, principles, facts from various natural phenomena. Common constraints in physics learning are that students required to master concepts, formulas and calculations, graphs and diagrams, and practicum presented simultaneously (Liliarti & Kuswanto, 2018).

The aforementioned learning process is strongly supported by the activities in the laboratory. Experimental physics learning: (1) is a core component of physics as a discipline (Wilcox & Lewandowski, 2018); (2) can train student skills in problem-solving in accordance with learning in the classroom (Danielsson, 2014); and (3) can increase the activity and learning outcomes of physics (Poniman, 2016). Physics experiment activities also make teachers able to observe student learning behavior in paying attention, understanding concepts, understanding

procedural instructions, and measuring experimental results (Purba & Hwang, 2018). Thus, physics experiments or practicum contributes to realize a successful physics learning. The success of learning activities in this laboratory must be supported by the selection of the right tools and materials (Bernhard, 2018).

Based on the results of observations in the field, the supporting components of laboratory-based physical optics learning are still inadequate. This observation was carried out in five high schools in the Semarang City of Indonesia. The low level of physics learning activities especially the subject of laboratory-based physical optics is due to (1) inadequate equipment availability; (2) unavailability of materials; (3) lack of laboratory personnel at schools; (4) longer working time in labs compared to the time for conventional learning; and (5) difficulties in visualizing abstract physics concepts.

THEORETICAL FRAMEWORK

Limitations and constraints on the use of laboratories as a place for experimental activities or practicum can be solved by using other learning strategies, one of which is to use computer media. Computers can be used as learning support media because they are able to do: (1) simultaneous presentation, processing, and calculation of data (text, numeric, image, audio, visual); (2) program data into interactive and animated simulations. This potential is very supportive in the development of teaching aids and physics learning media in the form of multimedia software containing audio, visual, simulation, and interactive animation.

The use of computer simulations contributes positively to the success of physics learning (Amadeu & Leal, 2013); Virtual lab experience and computer-based visualization allow students to interact with scientific concepts that are difficult to observe directly (Chiu, Dejaegher, & Chao, 2015); it makes learning interesting and allows students to actively manipulate graphical visualization of complex phenomena (Moser, Zumbach, & Deibl, 2017); and provides opportunities for students to plan, organize, and control learning with a high level of flexibility (Arista & Kuswanto, 2018). Modeling and simulation of laboratory experiments can help students overcome obstacles in cost (Ahmed & Hasegawa, 2014), time, and security (Kurniawati & Fatisa, 2016). Through interviews, students positively think about their experiences in virtual lab-based learning (Aşıksoy & Islek, 2017).

The positive impact of computer use as a physics experimental media simulation (virtual lab), among others, is able to: (1) improve students' ability to understand basic science (Escobar, Sánchez, Beltrán, La Hoz, & González, 2016); (2) improve students' abilities in planning and implementing problem solving solutions (Gunawan, Harjono, Sahidu, & Herayanti, 2017); (3) improve scientific literacy

skills (Jannati, Setiawan, Siahaan, & Rochman, 2018); (4) support distance learning (González, Escobar, Sánchez, De La Hoz, & Beltrán, 2017); (5) make practical activities cheaper and can help teachers explain the concept of electronic circuits (Emhadelima, 2015); and (6) make learning time more efficient, support independent learning, and can be used to measure mastery of material (Masril, Hidayati, & Darvina, 2018). The students stated that they were learning faster, more interesting and fun (Ünlü & Dökme, 2015).

Based on the field study and the literature above, it is necessary to develop a Virtual Laboratory Learning Media for Physical Optics. Researchers chose the subject of physical optics because in this material, there are several abstract concepts and facts from field studies.

METHOD

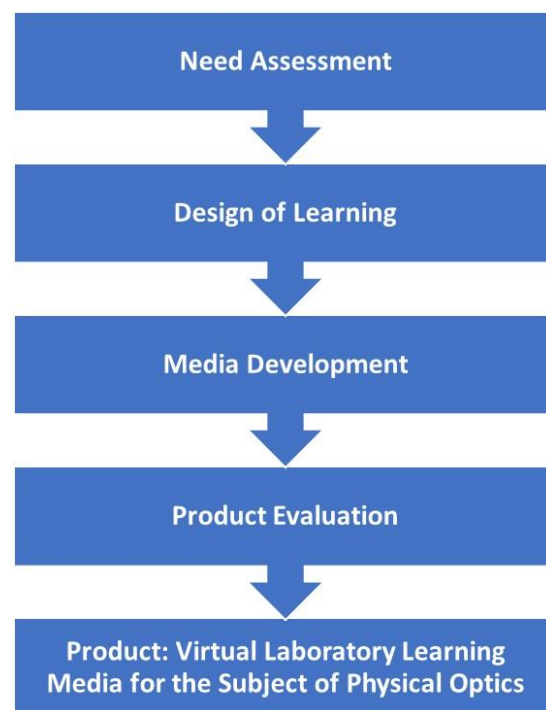


Figure 1. Development Procedure of Virtual Laboratory Learning Media for the Subject of Physical Optics.

This type of research is Research and Development (R & D), therefore this research is product oriented. The product

developed was in the form of Virtual Laboratory Learning Media for Physical Optics for high-school students of XII grade. The development procedure in this study is explained in Figure 1.

The data obtained are qualitative and quantitative data. Qualitative data is obtained from questionnaires given to material experts, media experts, teachers and students. The number of students involved was three students at the one-to-one test stage, 12 students in the small-group test stage, 38 students for the experimental group, and 38 students for the control group.

Qualitative data is used to obtain the validity and practicality of the product. Quantitative data is obtained from test scores in the form of multiple choices. Quantitative data is needed to test the effectiveness of product implementation. The instruments used were questionnaires, interview guides, student activity observation sheets, and test questions. The research data is also sourced from suggestion notes about product quality.

The quantitative data analysis technique used in this study is descriptive statistics with the criteria of “excellent”, “very good”, “good”, “fair”, and “poor” which are converted into quantitative data on a scale of 5 starting from 1 up to 5. The steps in analyzing data include: (a) collecting raw data, (b) scoring, and (c) conversions shown in Table 1.

Table 1. Assessment criteria

Value	Criteria	Value Interval
A	Excellent	$X > (X_i + 1.8S_{bi})$
B	Very Good	$(X_i + 0.6S_{bi}) < X \leq (X_i + 1.8S_{bi})$
C	Good	$(X_i - 0.6S_{bi}) < X \leq (X_i + 0.6S_{bi})$
D	Fair	$(X_i - 1.8S_{bi}) < X \leq (X_i - 0.6S_{bi})$
E	Poor	$X \leq (X_i - 1.8S_{bi})$

The indicators of the success of product research developed are: (1) valid if the results of the evaluation from the validate get the minimum criteria of “good”; (2) effective if the N-gain value is in the “medium” category; and (3) the practical results of the validate’s assessment obtained at least “good” criteria.

RESULTS AND DISCUSSION

Results

The contents of this product are not only for virtual laboratory applications but also for providing theoretical material equipped with images, animations, and videos. It aims to enable students to learn independently. Virtual laboratories are designed to be interactive virtual laboratory simulations so students can be directly involved in observation, measurement, and data collection of virtual lab results.

The main menu contains Learning Objectives, Materials, Virtual labs, and Evaluations. The main material consists of: (1) Dispersion, (2) Diffraction, (3) Interference, and (4) Polarization. In each material menu, there are sub menus: (1) Introduction, (2) Materials, (3) Simulations, (4) Videos, and (5) Quizzes. Examples of this page display are shown in Figure 2.



Figure 2. The display of the material menu

The virtual laboratory menu contains (1) Light Dispersion on the Prism, (2) Single-Slit Diffraction, and (3) Double Slit Interference (Top View), and (4) Double Slit Interference (Side View). An example of a virtual laboratory page is shown in Figure 3.

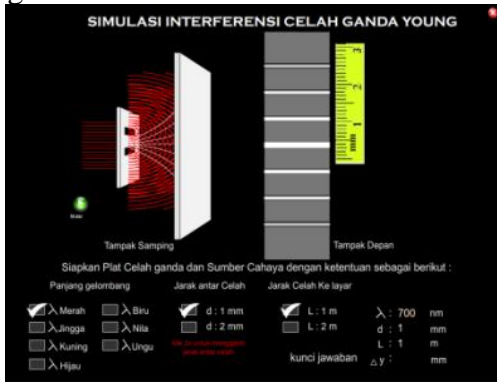


Figure 3. Virtual Laboratory page for Double slit Interference

Evaluation contains two random questions. Each package has 20 multiple-choice questions. The opening page for evaluation is shown in Figure 4.

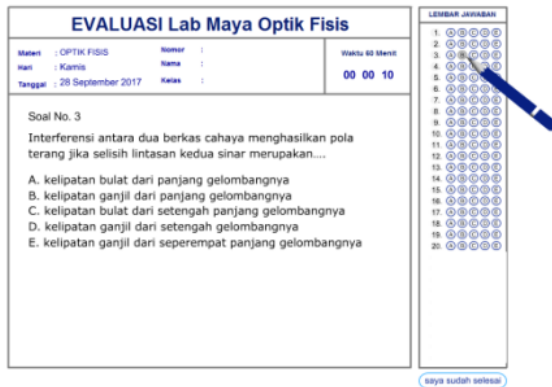


Figure 4. Evaluation Opening Page

The average pre-test, post-test, N-gain values of the one-to-one and small-group trials are shown in Table 2.

Table 2. Results of one-to-one and small group trials

Group	Pre-test	Post-test	n-gain
One-to-one	3,33	16,67	0,80 (80,41%)
Small group	3,00	13,67	0,63 (63,35%)

The mean values of the pre-test, post-test, and n-gain of the experimental and control groups are shown in Table 3.

Table 3. Field test results

Group	Pre-test	Post-test	n-gain
Experiment	3,29	13,34	0,37 (36,94%)
Control	3,16	10,39	0,27 (26,54%)

The average n-gain of the experimental group and the control group in the medium category. This data is shown in Figure 5.

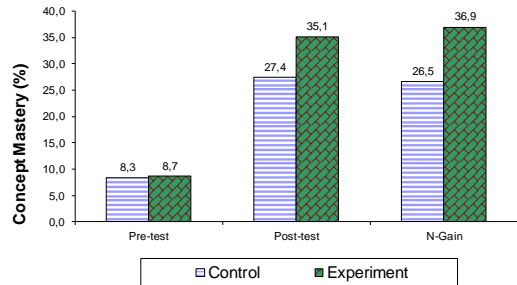


Figure 5. Comparison of Average Scores of Pre-test, Post-test, and N-gain Concept Mastery for Both Groups

The results of the normality test are shown in Table 4.

Table 4. The result of the normality test of data concept mastery

Group	χ^2_{count}	χ^2_{table}	Conclusion
Experiment: N-gain	2.111	7.815	Normally distributed
Control: N-gain	1.058	7.815	Normally distributed

The homogeneity test is carried out using the F test (equation of two variants). This data is shown in Table 5.

Table 5. The result of the homogeneity test of data concept mastery

Variance of Experimental Group	Variance of Control Group	F_{count}	F_{table}	Conclusion
103.05	102.08	1.01	1.85	The sample variance is in a homogeneous state

The technique used in this hypothesis test is a parametric statistical technique (t-test). This is because the data from both groups are normal and homogeneously distributed. The results of the hypothesis test analysis are shown in Table 6.

Table 6. The hypothesis test results of student concept mastery with t-test one tail of both groups

Aspect	s	t _{count}	t _{table}	Conclusion
N-gain	11.447	0.009	1.6657	Hypothesis Ho accepted

Table 6 shows that the results of hypothesis testing with a one-way t-test (t-tailed) are $t_{count} < t_{table}$. This shows that there are significant differences between new and old teaching methods. New teaching methods are more effective than old teaching methods.

The results of the product validity assessment are shown in Table 7.

Table 7. Results of product validity assessment

Aspects	Validators	Values	Criteria
Feasibility of content	Material expert	4.60	Excellent
	Teacher	4.88	Excellent
Feasibility of presentation	Material Expert	4.30	Excellent
	Teacher	4.74	Excellent
Average		4.63	Excellent

The results of the product practicality assessment are shown in Table 8.

Table 8. The product practicality assessment results

Aspects	Validators	Values	Criteria
Quality and reliability	Media expert	4.73	Excellent
	Teacher	4.76	Excellent
Ease of Use	Media expert	4.18	Very good
	Teacher	4.55	Excellent
Design/shape	Media expert	4.00	Very good
	Teacher	4.80	Excellent
Influence on Individuals	Media expert	4.00	Very good
	Teacher	4.90	Excellent
Average		4.49	Excellent

Discussion

Interactive multimedia-based virtual-learning lab in this study combines several elements of interactive simulation, learning material, and evaluation. The products resulted from this study are packaged in interactive learning CDs that can be run directly or can be installed. This product can function as an independent learning media.

The average value given by material experts and teachers on the validity of the product is 4.63. Based on the results of this assessment, it can be concluded that the product meets the validity criteria with the criteria of “excellent”. The average value given by media experts and teachers on product practicality is 4.49. Based on the results of this assessment, it can be concluded that the product meets the practical criteria with the criteria of “excellent”.

The results of the product assessment through the one-to-one test are “excellent”, there is an average increase in the post-test score. This is indicated by a normalized gain of 0.8 or 80.41%, so it can be concluded that the increase in mastery of concepts at the one-to-one test stage is in the “high” category.

The results of product assessment through small-group tests are “excellent”, indicated by a normalized gain of 0.63 or 63.35%, so it can be concluded that the increase in mastery of concepts in small-group tests is in the “medium” category.

In the field trial stage, in the experimental group, the product obtained a “high” category with a normal gain of 0.37 or 36.94%, so it can be concluded that the increase in mastery of the concepts in this test was “medium”, while the control group, without using the product, the normalized gain value is 0.27 or 26.54%. Based on the description, it can be concluded that the product of this study is effective.

In the research data, the experimental group shows that through the help of this product students easily understand difficult and abstract concepts, as well as physical optical material and this product, can be used anywhere and anytime. This is because the product is equipped with interactive simulations and animations that can visualize abstract concepts that become more concrete so that the learning process becomes more meaningful for students.

The characteristics that are the hallmarks of this product are: (1) Learning objectives, materials, labs, and evaluations have been integrated into a single software package; (2) Material contains the initial menu, description of material, simulation, video, and quiz; (3) The introductory menu can be used as apperception learning and pre-test; (4) Material is described through full text and color images to attract students' attention; (5) Simulation in the form of interactive and communicative moving images; (6) In the material menu. There are videos about material and laboratory reviews; (7) The teacher can use it as a learning media, which includes pre-test, post-test, and evaluation; (10) Students can use it as an independent learning material and can repeat any sections of the learning material they want; and (11) This virtual laboratory can be used anywhere and anytime.

While the weaknesses of this product are: (1) cannot display objects in 3D; (2) can only run on Microsoft Windows operating systems; and (3) no usage history.

Data from the mastery of students' concepts in the experimental and control groups were obtained from evaluations using the same problem as many as 20 items. The mean pre-test values in the experimental and control groups were 8.7% and 8.3%. It means there is no difference in the mastery of concepts between the two groups before the application of the product. This is because the two groups were evenly distributed, and the two groups had never received similar learning.

Both groups were given different treatments. The experimental group uses products, and the control group uses lecture learning. The mean value of the post-test experimental group was 35.1%, and the control group was 27.4%. This shows a significant difference in the mastery of physical optics concepts. The N-gain value of the experimental group

was 36.9% with the category "medium" and for the control group was 26.5% with the category "low". Thus, mastery of the concept of the experimental group students with the application of virtual lab products is higher than the control group.

The results of the observation showed that students in the experimental group were happier, more enthusiastic, more creative and motivated. Observation data indicates that students' curiosity increased, as evidenced by the increasing activity of expressing ideas, opinions, or very dominant questions, namely 93.1%. This proves that the application of products in learning has increased student learning motivation.

Another thing that was found during the observation was that the teacher's role declined in learning. So, the teacher plays the role as a facilitator, directs and motivates students in learning. In the control group, it was found that student enthusiasm tended to be lower than the experimental group, this was seen in expressing opinions, asking questions, or doing practical activities.

The most significant difference between the two groups is the duration of lab activity. During the learning process, the experimental group took less time than the control group. This shows that the use of media virtual lab learning is more efficient in terms of time. Based on the description above, it can be concluded that the use of virtual lab learning media on the subject of physical optics is more effective and efficient.

Learning by using this product can improve the mastery of students' concepts. The virtual lab learning media can visualize abstract concepts more concretely so that the learning objectives and learning processes become more meaningful. With meaningful learning, students will achieve learning outcomes that are more optimal or better than before.

CONCLUSION

Based on the results of the study, it can be concluded that the product development in the form of virtual lab learning media on the subject of physical optics is (1) valid, the average value is 4.63 with the category “excellent”; (2) effective, N-gain from the experimental group, which is 0.37 or 36.94% with the category “medium”; and (3) practical, the average value is 4.49 with the category “excellent”.

REFERENCES

- Ahmed, M. E., & Hasegawa, S. (2014). An Instructional Design Model and Criteria for Designing and Developing Online Virtual Labs, 4(3), 355–371.
- Amadeu, R., & Leal, J. P. (2013). Advantages of using computer simulations in physics learning. *Enseñanza de Las Ciencias*, 31(3), 177–188. Retrieved from <http://www.rieoei.org/deloslectores/1640Carrio.pdf>
- Arista, F. S., & Kuswanto, H. (2018). Virtual physics laboratory application based on the Android smartphone to improve learning independence and conceptual understanding. *International Journal of Instruction*, 11(1), 1–16.
- Aşiksoy, G., & Islek, D. (2017). The impact of the virtual laboratory on students’ attitudes in a general physics laboratory. *International Journal of Online Engineering*, 13(4), 20–28.
- Bernhard, J. (2018). What matters for students’ learning in the laboratory? do not neglect the role of experimental equipment! *Instructional Science*. <https://doi.org/10.1007/s11251-018-9469-x>
- Chiu, J. L., Dejaegher, C. J., & Chao, J. (2015). The effects of augmented virtual science laboratories on middle school students’ understanding of gas properties. *Computers and Education*, 85, 59–73.
- Danielsson, A. T. (2014). In the physics class: University physics students’ enactment of class and gender in the context of laboratory work. *Cultural Studies of Science Education*, 9, 477–494.
- Emhadelima. (2015). The use of virtual media laboratory to increase students’ motivation on direct current circuits materials at class X of MAN I Pekanbaru. *Al-Ta’lim Journal*, 22(3), 254–265.
- Escobar, J. H., Sánchez, H., Beltrán, J. R., La Hoz, J. De, & González, J. D. (2016). Virtual experimentation in electromagnetism, mechanics, and optics: Web-based learning. *Journal of Physics: Conference Series*, 687(1).
- González, J. D., Escobar, J. H., Sánchez, H., De La Hoz, J., & Beltrán, J. R. (2017). 2D and 3D virtual interactive laboratories of physics on Unity platform. *Journal of Physics: Conference Series*, 935(1).
- Gunawan, Harjono, A., Sahidu, H., & Herayanti, L. (2017). Virtual laboratory to improve students’ problem-solving skills on electricity concept. *Jurnal Pendidikan IPA Indonesia*, 6(2), 257–264.
- Jannati, E. D., Setiawan, A., Siahaan, P., & Rochman, C. (2018). Virtual laboratory learning media development to improve science literacy skills of mechanical engineering students on basic physics concept of material measurement. *Journal of Physics: Conference Series*, 1013(1).
- Kurniawati, Y., & Fatisa, Y. (2016). Evaluasi Program Pemodelan Dan Simulasi Laboratorium Kimia Pada Mahasiswa Calon Guru. *Edusains*, 8(2), 201–211.
- Liliarti, N., & Kuswanto, H. (2018). Improving the competency of

- diagrammatic and argumentative representation in physics through Android-based mobile learning application. *International Journal of Instruction*, 11(3), 106–122.
- Masril, M., Hidayati, H., & Darvina, Y. (2018). The Development of Virtual Laboratory Using ICT for Physics in Senior High School. *IOP Conference Series: Materials Science and Engineering*, 335(1).
- Moser, S., Zumbach, J., & Deibl, I. (2017). The effect of metacognitive training and prompting on learning success in simulation-based physics learning. *Science Education*, 101(6), 944–967.
- Poniman. (2016). Upaya Peningkatan Aktivitas dan Hasil Belajar Fisika dengan Metode Praktikum pada Siswa Kelas XI IPA MAN 1 Kalianda Lampung Selatan. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 05(2), 257–264.
- Purba, S. W. D., & Hwang, W. Y. (2018). Investigation of learning behaviors and achievement of simple pendulum for vocational high school students with Ubiquitous-Physics app. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(7), 2877–2893.
- Ünlü, Z. K., & Dökme, İ. (2015). 7th Grade Students' Views on Combining the use of Computer Simulations and Laboratory Activities in Science Teaching. *Procedia - Social and Behavioral Sciences*, 191, 1173–1177.
- Wilcox, B. R., & Lewandowski, H. J. (2018). A Summary of research-based assessment of students' beliefs about the nature of experimental physics. *American Association of Physics Teachers*.

5E-LEARNING CYCLE STRATEGY: INCREASING CONCEPTUAL UNDERSTANDING AND LEARNING MOTIVATION

Febrianto Putra*¹, Ika Yunita Nurkholifah², Ani Rusilowati³, Bambang Subali⁴

^{1,2,3,4}Department of Physics Education, Post Graduate Program, Universitas Negeri Semarang, Indonesia

*Correspondence address: febriantoputra326@gmail.com

Received: July 24th, 2018. Accepted: October 19th, 2018. Published: October 28th, 2018

Abstract: 5E learning cycle strategy was students center oriented learning model. The learning process becomes more meaningful, which are prioritized authentic experience of students, made students become actively participating, able to critical thinking skills and creatively. The phases of the learning cycle 5E consist of engagement, exploration, explanation, elaboration, and evaluation. The purpose of the research was increased learning motivation and conceptual understanding improved by discovery learning due to the 5E learning cycle strategy. The research was conducted at SMA Teuku Umar Semarang. The research has used a qualitative approach. The type of research is classroom action research (CAR). The data analysis technique used a percentage of the learning motivation and the students' understanding concept. The percentage applied discovery learning by both of the first CAR cycle is 78% and the second CAR cycle is 92%. The conceptual understanding was shown better in the second CAR cycle. The effectiveness discovery learning can be interpreted from the normalized gain. The score of the normalized gain is 0.52. The category of the normalized gain is a medium gain. Students' motivation was increased by both the first cycle is 62% and the second cycle is 82%. Based on the decision of the research, it can be concluded that the 5E learning cycle process can influence increased students learning motivation and students understanding the concept not only heat concept but also heat transfer concept.

© 2018 Physics Education, UIN Raden Intan, Lampung, Indonesia.

Keywords: conceptual understanding, learning cycle, learning motivation.

INTRODUCTION

Understanding the concept is constructing meaningful of learning message, either orally, in writing or graphics in the learning process with learning media. (Hutahaean, Harahap, & Derlina, 2017). Physics lesson has the potential course for made developing the ability to understand the concept vehicle (Mahardika, Faizah, & Indrawati, 2017). The conceptual understanding was included in the cognitive process consist of (1) to interpreting, (2) to point out, (3) to classify, (4) to summarize, (5) to conclude, (6) to compare, and (7) to explain (Hutahaean et al., 2017).

The critical thinking is one of the skills that was developed. it can be seen from the ability of conceptual understanding and problem-solving. The student's ability in problem-solving is built on an

understanding of a concept. (Hartono, 2013; Ulina, 2017). The identification of the ability going to be developed in the physics lesson which are (1) the ability of scientific reasoning, (2) the ability to interpret representations of science such as images, equations, mathematical, and graphs, (3) the ability of the scientific process, (4) the ability to solve problems, (5) communication skills (Ulina, 2017).

Based on the identification of some ability in learning, then conducted a preliminary study of the condition of learning in class XI SMA Teuku Umar Semarang. The method used observation of student learning activities and interviews. Observations by describing the problems experienced, which are (1) students were able to present a good level of memorization of the objectives that it receives, but in fact do not understand it;

(2) students would not be able to connect between understanding the concept of the actualization of understanding of the concept. (3) Students have difficulty understanding the concept of physics.

Results of a preliminary study using interviews to senior high school physics teacher in class XI at SMA Teuku Umar Semarang produce a description as follows: (1). Students understand the concepts being taught but the examination is a low score, because of the mathematical skills in physics solving is a low category. (2). Students not only have the intrinsic motivation in the good category but also interested in learning physics. (3). Students should be given in the form of extrinsic motivation punishment so that students interested in practicing tasks assigned by the teacher. 4). Appropriate equipment, physics lab in physics laboratory SMA Teuku Umar Semarang in either category, but the quantity of less practical tools primarily on practical tools that are fundamental.

Problems arise when expectations do not match with reality (Sugiyono, 2017). Identify the problem by observation of the student and the teacher, the exposure of the problems that occur in the classroom. In general, there are two problems, which are (1) conceptual understanding of students was poorly, (2) active participation of students in the learning process needs to be improved. Many students learn physics have misconceptions about the lesson, even though before they starting to learn it. Students should be able to both learn and apply the physics concept in the daily. Conceptual knowledge is a critical point for the generation and selection of appropriate procedures in solving problems (Kola, 2017). Conceptual understanding allows students to transfer an explanation of the phenomenon to the different situations (Kola, 2017).

Research needs to be applied an ongoing classroom action to find a solution to the problem of improving the quality of

learning (Arikunto, Suhardjono, & Supardi, 2017). Teachers should familiarize students to think critically by assigning them to experiment, to seek explanations and finding solutions the problems, and to make inquiries about the matter to be discussed in the next section to understand the concept (Hartono, 2013). The effectiveness, efficiency, and standardization of teaching that is not offset by the teacher in the learning process make learning it does not achieve maximum results. (Furoidah, Indrawati, & Subiki, 2013). The physics course was developed learning process according to the scientific approach and interactive learning (Ramdhani, Usodo, & Subanti, 2017).

The learning process in accordance with the rules of the scientific approach focused on the activity of students in the classroom and interactive learning so that students can actively investigating and scientific attitude in solving the problem (Pratiwi & Supardi, 2014). Science learning strategies that develop in the 21st century has a framework that combines content knowledge, pedagogical knowledge, and knowledge of technology according to the scientific approach (Sarwi, 2016). Both professional teacher and pre-service teacher should understand and apply the approach to the learning process, academic content, pedagogical content, and evaluation/assessment, which is imbued with the essence of physics. Support and demand for innovation have a relation to the organization of learning and organizational innovation (Hsiao, Chang, & Chen, 2014).

Several factors can affect the quality of learning innovations such as teachers, students, learning materials, facilities, learning management, student, and the learning environment (Arikunto et al., 2017). Some models were varied learning can affect the motivation of students and students' understanding of the concept, but in fact, nowadays most teachers still use

practical guide to learning with conventional models, so that the learning motivation and understanding of the concept seen clearly the low category (Ali, 2018). Classroom action research required of the application of alternative learning models that can improve student learning activities in an effort to improve motivation and understanding of the concept. which are (1) cooperative learning, (2) inquiry learning, (3) problem-based learning, and (4) project-based learning, and (5) learning cycle (Diani, 2015; Indrasati, Indrawati, & Supriadi, 2014; Loibl & Rummel, 2014; Manalu, 2017; Schalk, Edelsbrunner, Deiglmayr, Schumacher, & Stern, 2018; Siswandi, 2015). Learning cycle 4E and 5E learning cycle and 7E learning cycle applied to improve learning achievement, problem-solving skills, and critical thinking skills in secondary school and senior high school levels (Hartono, 2013; Septiana, Harjono, & Hikmawati, 2018; Supriyatman & Amiruddin, 2014; Ulina, 2017; Wahyuni, Syamsu, & Muslimin, 2013). Based on the results of previous research, the invention will be developed to measure not only learning motivation but also students' understanding of the concept. The initial hypothesis that motivation to learn has a correlation with students' understanding of the concept, the more strength of the students' motivation will have lots of energy and enthusiasm to participate in learning activities and obtain maximum learning results actively. The learning motivation is the driving force and direction of student learning activities so that the learning achievement of learning can be achieved (Sardiman, 2012). Therefore, discovery learning with 5E learning cycle strategy is expected to increase students' motivation and understanding of concepts on temperature and heat material. The learning methods

used which are a discussion, demonstration, and practicum.

THEORETICAL FRAMEWORK

Learning Cycle

Model fun learning, student-centered and provide appropriate learning resources, one of the better model which is the Learning Cycle (LC) (Wahyuni et al., 2013). The learning cycle is a student-centered model, the learning process becomes more meaningful because it prioritizes real experience, and formed a student becomes active, critical and creative (Wahyuni et al., 2013), The phases of learning cycle 5E consist of engagement, exploration, explanation, elaboration, and evaluation (Sarac, 2018). The phases of the learning cycle according to Piaget learning theory and constructivism learning theory because of learning is the development of the cognitive aspects of the learning objectives is to enhance students' understanding. The phases of the learning cycle process require good scientific literacy (Ulina, 2017),

Science literacy used to develop knowledge and understanding, to achieve individual growth up and have a positive role in the wider community (Sulisworo & Sutadi, 2017), Use of the learning cycle provides opportunities for students to express their previous knowledge and the opportunity to refute, debate their ideas, this process results in cognitive imbalance, thus developing a higher level of thinking, and good approach to studying physics (Supriyatman & Amiruddin, 2014),

Figure 1 shown that learning cycle is one of the learning models with a constructivist approach which initially consists of three stages: exploration, invention, and discovery. Three of these stages is being turned into five stages developed by Robert Bybee (Septiana et al., 2018),

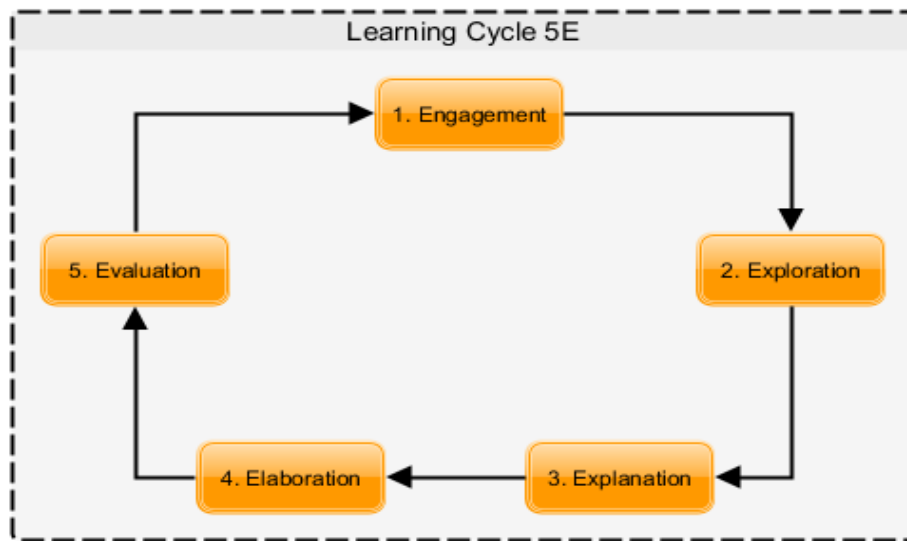


Figure 1. The phases of the 5E learning cycle

Learning cycle initially began as a three-phase model of the invention, the introduction of terminology and the implementation of the concept, and then expressed as 4E learning cycle consists of engagement, exploration, explanation, and extension. In subsequent years, has been developed as a model 5E learning cycle by adding additional evaluation phase by science education researchers Boddy, Watson, and Aubusson (Sarac, 2018),

The engagement phase, students enthusiastic about the lessons to be raised by providing daily physics phenomenon that corresponds to the topic and asks the students to argue about the phenomenon. Students will explore to prove their opinion about the physics phenomenon depends on the Exploration phase. The teacher presents a learning activity that gives students real experience with the concept of learning topics. Independence of the students in exploring and prove the hypothesis that they have made. The role of the teacher only as a guide and facilitator. Teacher as a facilitator in the CAR should be aware of their role in the classroom (Jan 2013),

The results were obtained from the phase of exploration, it will be explained students understand the concepts in this

phase. Teacher asks profound reason to encourage students to explain what they found. Meanwhile, in the elaboration phase, students are going to build more connections between what they know with what they should have learned. In the evaluation phase, students are evaluated to assess how well students understand the concepts of the lessons. Teachers assess what students have learned in various aspects during the learning process to determine how well students understand the concepts learned. Ratings are given either orally or in writing to measure the learning process (Tania & Murni, 2017),

Discovery Learning

Innovative learning approach had no impact in the classroom for teachers to follow the practical guidelines in teaching, those teachers can design learning and guided discovery learning using guided discovery learning heuristic learning (Janssen, Westbrook, & van Driel, 2014), Implementation of discovery model of learning can increase students' activity, increase understanding of the concept, and the students' critical thinking skills, as well as cognitive learning outcomes of students (Maulidar, Yusrizal, and Halim, 2016; Rosarina, Sudin, & Sujana, 2016). The

teacher's role as a mediator and facilitator in learning connected with learning innovations that have a relationship between an organization's learning and organizational innovation (Hsiao et al., 2014),

The role of teachers in the model of discovery learning as mentors by providing opportunities for students to learn participation actively, teachers can guide and direct the learning activities of students according to the learning objectives (Purnomo, Mujasam, & Joseph, 2014), Conditions such as these want to

change the teaching and learning activities are teacher-oriented to student-oriented.

Benefits guidance for concept discovery or invention situation has been clearly demonstrated in the teaching with discovery learning (Loibl & Rummel, 2014), Students are placed in self-determined learning situations and asked to find a model or concept underlying problems. Learners need guidance during this learning activity. Table 1 shows the phases of discovery learning and 5E learning cycle strategy (Hartono, 2013).

Table 1 Discovery learning process and 5E learning cycle strategy

No.	Discovery Learning	5E Learning Cycle Strategy
1	Their problems are solved.	Teachers identify students' understanding concept before the learning process.
2	The adjustment to the level of students' cognitive development.	Teachers explain the purpose of teaching and learning materials needed and motivate students to engage in critical thinking in choosing the solution of the problems faced.
3	Concepts or principles to be found by students through these activities need to be expressed and written clearly.	Teachers guide students to determine and set the tasks related to the problem.
4	Must be provided the tools and the necessary learning materials.	Teachers support students to collect appropriate information, conduct experiments, and seek explanations and solutions to problems.
5	The composition of the class is set so as to facilitate the free flow of thoughts student involvement in ongoing learning activities.	Teachers guide students in designing and preparing the lesson.
6	Teachers give students the opportunity to collect data.	Teachers help students to share their work with their peers, evaluate and compare their understanding with their prior knowledge.
7	Teachers gave the correct answer according to the data and information needed by students.	Teachers guide students to expand and reflect on concepts learned

METHOD

The study is classroom action research (CAR). CAR process taking place in four phases consist of planning, implementation, observation, and reflection. The research experiment was conducted in two cycles. The cycle or repetition is not clearly done from planning to reflection, but only the implementation and observation phase (Arikunto et al., 2017) see Figure 2. The number of cycles depends on the outcome

of reflection and learning achievement levels (see Table 5). The study was conducted in class XI IPA at SMA Teuku Umar Semarang, with a sample of 29 students of class XI. The research was conducted during four meetings with the allocation of one meeting time is a two-hour lesson.

Each action consists of a series of four activities: 1) Planning, the activity of designing in detail what and how the

actions to be taken. 2) The action is a core activity in the CAR, the actions of at least two cycles. 3) Observation is an act of gathering information that will be used to determine whether the action taken in accordance with the plan. 4) Evaluation

and reflection are an activity undertaken to determine the implementation shortfall CAR (Arikunto et al., 2017). table 2 and table 3 shown the description of the activity.

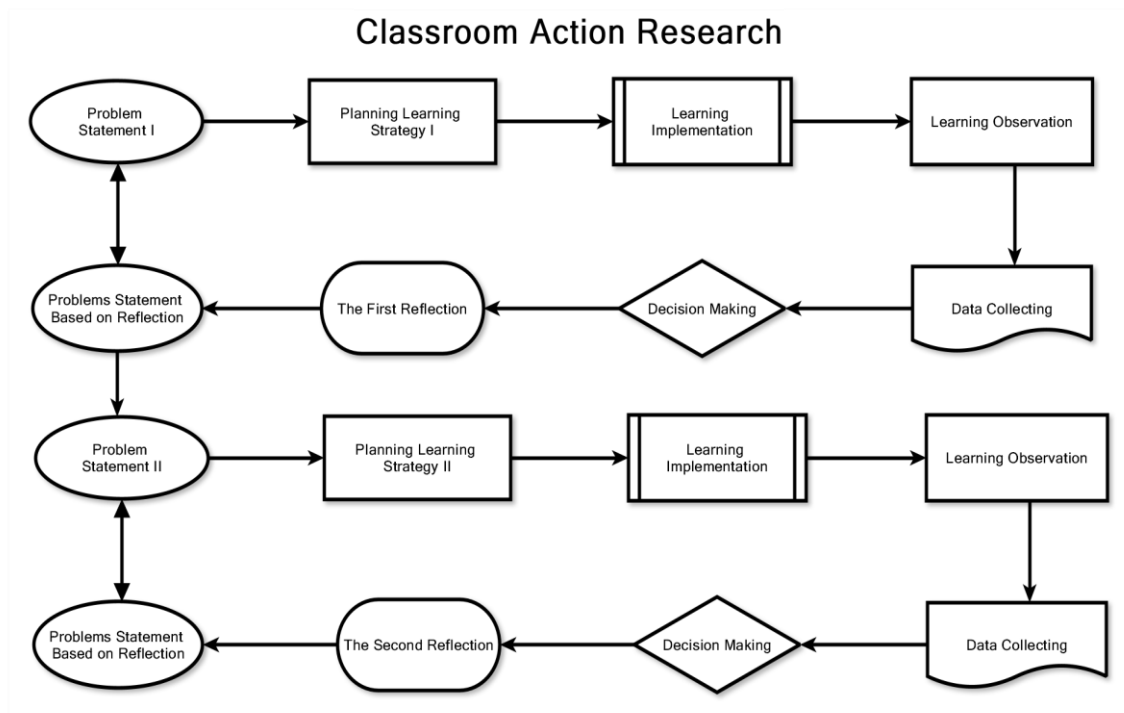


Figure 2. shown that the phases of classroom action research which are problems statement, planning learning strategy, learning implementation, learning observation, data collection, decision making, reflection, and problems statement based on the reflection learning process.

Table 2. The first cycle

Cycle Stages	Description of Event
Plan	<ol style="list-style-type: none"> 1. Based on the problem formulation will be applied discovery learning with demonstration method 2. Selected topics that correspond with the content that is the temperature, heat, and heat transfer. (2 meetings consist of one meeting each cycle, and will continue with the second cycle) selected sub-subject for the first cycle is black rules. 3. Creating RPP (study plan) was planned for the objectives in detail exposure. 4. Designed scenario execution of discovery learning improves in the first cycle. 5. Prepared physics course and instructional media will be used, as well as other documents, such as attendance, experimental tools calorimeter, student worksheets, study plan, student observation sheet, etc. 6. Designing instruments to observe the process of learning and learning outcomes as well as a guideline to analyze.
Action	<ol style="list-style-type: none"> 7. Setting up a colleague to act as an observer, and help document the activity. 1. Taught for 2 meet physics class following by the objectives about black rules. 2. Learning optimized to fit the predetermined scenario. 3. Documenting (collecting documents student activities, and other documents) and observe all the activities carried out in the learning process.

Observation	<ol style="list-style-type: none"> 1. Observations of classroom learning and response, as well as students using instruments that have been prepared. 2. Ask colleagues to observe the process of teaching the teachers using the observation sheet that has been designed. 3. Conducting formative tests to determine if the students understanding of the concept using the course of the sub-tests the rules black, while the interview is used to review the students' motivation and learning activity observation students sheet student used to observe adherence to discovery learning. In the first cycle, the observed aspect is to increase the understanding of the concept which is characterized by an increase in the score of posttest students.
Reflection	<ol style="list-style-type: none"> 4. Collecting all the observations and analyze them. 1. Describe the learning indicator has been reached. 2. Based on the analysis of observations (both process and learning outcomes) evaluating the learning indicator has not been reached. 3. Knowing the shortcomings of the application of the discovery learning in the classroom. for example, step instructional sequence that does not match, the format of the task is poor, or the performance of teachers is poorly teaching. 4. The results were compiled and summarized reflection as an input in the design second cycle.

Table 3. The second cycle

Cycle Stages	Description of the Event
plan	<ol style="list-style-type: none"> 1. Repetition designing lesson plans further subject of heat transfer consist of conduction, convection, and radiation (instead of repeating sub-topic of the black rules). 2. Return designed learning cycle implementation scenarios through discovery learning in the learning cycle II with regard to the outcome of reflection the first cycles. 3. Repetition preparing instructional materials and media to be used, as well as documents, such as attendance, experimental tools calorimeter, student worksheets, etc. 4. Repetition designing instruments to observe the process of learning and learning outcomes as well as a guideline to analyzing. 5. Setting up a colleague to act as an observer, and help document the activity.
Action	<ol style="list-style-type: none"> 1. Implementation learning in the second cycle with an advanced sub-topics heat transfer: conduction. 2. Documenting (collecting documents student activities). 3. Implementing learning in the second cycle with an advanced sub-topics heat transfer: conviction and radiation.
Observation	<ol style="list-style-type: none"> 1. Observe the implementation of discovery learning used student observation sheet that has provided and developed. The second cycle was observed the students' motivation aspect is shown from the activity of students in the learning process is done in the classroom, especially active participation in group investigation. 2. Collecting the data observations and analyzing data. 3. Observe the implementation of 5E learning cycle through discovery learning using observation sheet that has provided. The second cycle was observed the students' motivation aspect is shown from the activity of students in the learning process is done in the classroom, especially active participation in group investigation.
Reflection	<ol style="list-style-type: none"> 1. Based on observation, it can be concluded that results on observational analysis for corrective actions are reflected in the third cycle (if the indicator there is not yet reached). if the indicator has been achieved, then the set of observational data used for the preparation of research reports.

RESULTS AND DISCUSSION

Table 4 shows the results of the formative test on heat and temperature physics course. The data sample of the study was counting until 29 students. Both of the lower pre-test scores is 13, and the higher pre-test score is 66. the mean score initial condition in the first cycle is 29,3. it is shown that poorly condition. 5E learning cycle strategy was applied as a treatment to increase the student's pre-test score. after given the treatment that can be seen clearly increase the post-test scores. Both of the lower post-test scores is 47, and the higher post-test score is 93. the mean score final condition in the second cycle is 66.2.

The percentage applied the 5E learning cycle which is 78 % in the first cycle and 92 % in the second cycle. Based on the results achieved, both values meet the implementation of indicator already predetermined. The analysis of the level of success of the classroom action research due to the 5E learning cycle strategy has increased from the first cycle until the second cycle. Improved adherence to learning is the result of reflection carried out after the first cycle to correct deficiencies occurring in the first cycle and growing up in the first cycle to apply in the next action.

The results of the students' understanding of concepts based on the

cognitive process. This aspect is measured by tests conducted at the end of the cycle. furthermore, those students were made a meaning conceptual and seen either who have or who haven't completed. comparing until the end of each cycle to know that is an increase of conceptual understanding before given treatment, after the first cycle and the second cycle. The formative test results consist of both the first cycle was obtained an average score of 29.3 and the second cycle was obtained an average score of 66.2. Based on these data, it can be seen that the students' understanding of the concept increases either the first cycle or the second cycle. due to the students' understanding of physics concepts before being implemented learning cycle and thereafter learning has increased quite significantly. see table 5.

Implementation of discovery learning can improve the learning process and student achievement. Based on the results of previous studies in the first cycle, the percentage of achievement of student both the first cycle interested of 64.71% and increased in the second cycle into 82.35%. Improved learning achievement is shown from the aspect of knowledge in the first cycle of 61.77% and increased in the second cycle into 85.29% (Putra, Tandililing, & Arsyid, 2016),

Table 4. Data distribution pretest-posttest students

Data Pretest		Data Posttest		N-Gain
Interval	Frequency	Interval	Frequency	
13-22	15	47-55	7	0.52
23-32	1	56-64	6	
33-42	3	65-73	7	
43-52	6	74-82	4	
53-62	2	83-91	1	
63-72	1	92-100	4	

Based on the results of the learning process has been applied to the 5E learning cycle due to practical learning methods, demonstrations and discussions to increase students' activity in learning. Results of research conducted showed increased activity of students as seen from the observation of students in learning

activities. The observation students' activity according to several indicators were observed consist of readiness, enthusiasm, group investigation, problem-solving, doing exercise, and decision making with reflecting (table 5 shown student activities).

Table 5. Observations Student Activities

No.	Rated aspect	Initial Condition	CAR		Information
			Cycle 1	Cycle 2	
1	The readiness of students to receive course materials	60%	60%	73%	Increased
2	The enthusiasm of students in participating in group discussions	33%	53%	80%	Increased
3	Activities of students in group discussion activities	66%	66%	93%	Increased
4	Activities of students in solving problems	40%	53%	86%	Increased
5	Activities of students in doing exercises	53%	73%	73%	Increased
6	Student participation in activities reflecting on learning	66%	66%	86%	Increased

CONCLUSION

Students understanding of the concept have been increased. The learning cycle type 5E conducted on class XI IPA at SMA Teuku Umar by applying for heat and temperature physics course. 5E learning cycle strategy consisting of the phases, which are engagement, exploration, explanation, elaboration, and evaluation. Increasing student motivation in the learning process is characterized by the improved activity of students in the learning process as measured through assessment of student activity observed during the discovery learning process takes place. Based on the decision of the research it can be concluded that the learning cycle type 5E process can influence increased students learning motivation and students understanding the concept.

Determining the phases of classroom action research or further studies can be reached by looking at the gap between the real condition with ideal conditions for learning. CAR going to improve the climate of the classroom in a way change their methods means or learning strategies according to the characteristics of the material to improve student achievement. Implementation the learning cycle on

different types of matter physicists who have characteristics that match the learning cycle process.

REFERENCES

Ali, S. (2018). Pengaruh Model Pembelajaran dan Motivasi Belajar Fisika terhadap Hasil Belajar Fisika (Studi Eksperimen Peserta Didik pada Kelas VIII SMP Negeri 40 Bulukumba), 8(1), 15–28.

Arikunto, S., Suhardjono, & Supardi. (2017). Penelitian Tindakan Kelas. (Suryani, Ed.). Jakarta: Bumi Aksara.

Diani, R. (2015). Pengembangan Perangkat Pembelajaran Fisika Berbasis Pendidikan Karakter dengan Model Problem Based Instruction. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 4(2), 241–253. <https://doi.org/10.24042/jpifalbiruni.v4i2.96>

Furoidah, A. Z., Indrawati, & Subiki. (2013). Implementasi Model Discovery Learning Disertai Lembar Kerja Siswa dalam Pembelajaran Fisika Siswa di SMA. *Jurnal Pembelajaran Fisika*, 6(3), 285–291.

Hartono. (2013). Learning Cycle-7E Model To Increase Student ' S Critical Thinking On Science. *Jurnal*

- Pendidikan Fisika Indonesia (Indonesian Journal of Physics Education), 9(1), 58–66.
- Hsiao, H.-C., Chang, J.-C., & Chen, S.-C. (2014). The Influence of Support for Innovation on Organizational Innovation: Taking Organizational Learning as a Mediator. *The Asia-Pacific Education Researcher*, 23(3), 463–472. <https://doi.org/10.1007/s40299-013-0121-x>
- Hutahaean, R., Harahap, M. B., & Derlina, D. (2017). The Effect of Scientific Inquiry Learning Model Using Macromedia Flash on Student's Concept Understanding and Science Process Skills in Senior High School. *IOSR Journal of Research & Method in Education (IOSRJRME)*, 07(04), 29–37. <https://doi.org/10.9790/7388-0704012937>
- Indrasati, H., Indrawati, & Supriadi, B. (2014). Pengaruh Model Quantum Teaching Disertai LKS Berbasis Kartun Fisika terhadap Hasil dan Motivasi Belajar Siswa dalam Pembelajaran Fisika di SMA. *Jurnal Pembelajaran Fisika*, 5(1), 30–35.
- Jan, P. (2013). A New Scholarship of Classroom-based, Open, Communal Inquiry. *Teaching and Learning Inquiry: The ISSOTL Journal*, 1(1), 23–33. <https://doi.org/10.2979/teachlearningq.1.1.23>
- Janssen, F. J. J. M., Westbroek, H. B., & van Driel, J. H. (2014). How to make guided discovery learning practical for student teachers. *Instructional Science*, 42(1), 67–90. <https://doi.org/10.1007/s11251-013-9296-z>
- Kola, A. J. (2017). Investigating the Conceptual Understanding of Physics through an Interactive Lecture-Engagement. *Cumhuyet International Journal of Education*, 6(1), 82–96.
- Loibl, K., & Rummel, N. (2014). The impact of guidance during problem-solving prior to instruction on students' inventions and learning outcomes. *Instructional Science*, 42(3), 305–326. <https://doi.org/10.1007/s11251-013-9282-5>
- Mahardika, I. K., Faizah, M., & Indrawati. (2017). Peningkatan Aktivitas dan Hasil Belajar Fisika Siswa pada Kelas X APK SMKN 8 Jember Tahun Ajaran 2016-2017 dengan Model Learning Cycle (LC) Disertai LKS Multirepresentasi. *Jurnal Pembelajaran Fisika*, 6(2), 126–131.
- Manalu, A. (2017). Pengaruh Model Pembelajaran Kooperatif Tipe Group Investigation (GI) dengan Menggunakan Media Visual terhadap Pengetahuan Konseptual Siswa Kelas X Pada Materi Suhu dan Kalor. *Jurnal Inovasi Pembelajaran Fisika*, 1(1), 7–16.
- Maulidar, N., Yusrizal, & Halim, A. (2016). Pengaruh Penerapan Model Pembelajaran Guided Discovery terhadap Kemampuan Pemahaman Konsep dan Keterampilan Berpikir Kritis Siswa SMP pada Materi Kemagnetan. *Jurnal Pendidikan Sanis Indonesia*, 4(2), 69–75.
- Pratiwi, N. W., & Supardi, Z. A. I. (2014). Penerapan Model Pembelajaran Learning Cycle 5E pada Materi Fluida Statis Siswa Kelas X SMA. *Jurnal Inovasi Pendidikan Fisika (JIPF)*, 03(02), 143–148.
- Purnomo, H. Y., Mujasam, & Yusuf, I. (2014). Penerapan Model Guided Discovery Learning pada Materi Kalor terhadap Hasil Belajar Kognitif Peserta Didik Kelas VII SMPN 13 Prafi Manokwari Papua Barat. *Pancaran*, 5(2), 1–14.
- Putra, R. R., Tandililing, E., & Arsyid, S. B. (2016). Pengaruh Model Discovery Learning terhadap Pemahaman Konsep Siswa Materi Getaran dan Gelombang di SMP.

- Jurnal Pendidikan Dan Pembelajaran, 5(10), 1–11.
- Ramdhani, M. ., Usodo, B., & Subanti, S. (2017). Discovery Learning with Scientific Approach to Geometry. *Journal of Physics: Conference Series*, 895(1), 0120331–0120336. <https://doi.org/10.1088/1742-6596/895/1/012033>
- Rosarina, G., Sudin, A., & Sujana, A. (2016). Penerapan Model Discovery Learning Untuk Meningkatkan Hasil Belajar Siswa Pada Materi Perubahan Wujud Benda. *Jurnal Pena Ilmiah*, 1(1), 371–380.
- Sarac, H. (2018). The Effect of Learning Cycle Models on Achievement of Students: A Meta-Analysis Study. *International Journal of Educational Methodology*, 4(1), 1–18. <https://doi.org/10.12973/ijem.4.1.1>
- Sardiman. (2012). *Interaksi dan Motivasi Belajar Mengajar*. Bandung: Rajawali Pers.
- Sarwi. (2016). *Pembelajaran Inovatif Fisika Aktif dan Menyenangkan*. Semarang: UNNES PRESS.
- Schalk, L., Edelsbrunner, P. A., Deiglmayr, A., Schumacher, R., & Stern, E. (2019). Improved application of the control-of-variables strategy as a collateral benefit of inquiry-based physics education in elementary school. *Learning and Instruction*, 59(September 2018), 34–45. <https://doi.org/10.1016/j.learninstruc.2018.09.006>
- Septiana, I. S., Harjono, A., & Hikmawati. (2018). Pengaruh Model Learning Cycle 5E Berbasis Eksperimen terhadap Kemampuan Berpikir Kritis Fisika Peserta Didik Kelas XI SMAN 1 Gerung. *Jurnal Pendidikan Fisika Dan Teknologi*, 4(1), 7–15.
- Siswandi. (2015). Peningkatan Pemahaman Konsep Kalor dengan Metode Group investigation. *Jurnal Praktik Penelitian Tindakan Kelas Pendidikan Dasar Dan Menengah*, 5(3), 44–49.
- Sugiyono. (2017). *Metode Penelitian Pendidikan Pendekatan Kuantitatif, Kualitatif, dan R&D*. Bandung: Alfa Beta.
- Sulisworo, D., & Sutadi, N. (2017). Science Learning Cycle Method to Enhance the Conceptual Understanding and the Learning Independence on Physics Learning. *International Journal of Evaluation and Research in Education*, 6(1), 64–70.
- Supriyatman, & Amiruddin, K. (2014). Implementation of Physics Learning Material Based on the 4E Learning Cycle Method for Student SMP Negeri in Left Behind Area (Case Study in District Parigi Moutong). *International Journal of Scientific Engineering and Research (IJSER)*, 2(2), 8–12.
- Tania, B., & Murni. (2017). Penerapan Model Pembelajaran learning Cycle 5e untuk Meningkatkan Pemahaman Konsep Matematika Siswa SMPN 1 Pasie Raja. *Gravity: Jurnal Ilmiah Penelitian Dan Pembelajaran Fisika*, 3(1), 66–79.
- Ulina, N. S. (2017). Meningkatkan Keterampilan Berpikir Siswa Dengan Model Learning Cycle Dalam Pembelajaran Fisika di SMA Jakarta. *Jurnal Formatif*, 7(1), 49–55.
- Wahyuni, Z., Syamsu, & Muslimin. (2013). Penerapan Model Learning Cycle Tipe 5E dengan Media Visual Untuk Meningkatkan Hasil Belajar Fisika Pada Siswa Kelas Xc SMA Negeri 2 Dolo. *Jurnal Pendidikan Fisika Tadulako*, 1(1), 1–10.

ONE DIMENSIONAL MOTION WITH ICT BASED LEARNING: IMPROVING THE PHYSICS TEACHER CANDIDATES' SCIENCE PROCESS SKILLS AND ATTITUDES

Ade Yeti Nuryantini*¹, Ea Cahya Septia Mahen²

^{1,2}Department of Physics Education, Universitas Islam Negeri Sunan Gunung Djati Bandung, Indonesia

*Correspondence address: ade.yeti@uinsgd.ac.id

Received: July 24th, 2018. Accepted: October 21st, 2018. Published: October 28th, 2018

Abstract: Education nowadays is demanded to produce students who have beneficial skills of the 21st century in dealing with problems in the era of information and digital technology. Therefore, it is necessary to change the emphasis of learning patterns. In this paper, the results of the application of 21st-century skills in learning Basic Physics 1 in the Physics Education Study Program, UIN Sunan Gunung Djati Bandung using a scientific approach is presented. Learning activities were conducted based on low budget materials and ICT in the form of tracker software. The results showed that students were skilled in using tracker (90%), had science processing skills (excellent 5.2%, good 74.0%, and fair 20.8%), and fostered curiosity (92.0%), careful attitude (92.2%), caring for the environment (73.0%), honest (93.0%), and cooperative (97.0%).

© 2018 Physics Education, UIN Raden Intan Lampung, Indonesia.

Keywords: ICT, tracker, 21st-century skills

INTRODUCTION

One-dimensional motion is one of the materials taught in class for first-grade senior high school. In the revised 2013 curriculum, the basic competencies for one-dimensional motion material are analyzing physical quantities in straight motion with constant velocity and straight motion with constant acceleration (still) including its physical meaning and presents experimental results data and graphs to investigate the motion properties of objects that move straight at a constant velocity and move straight with constant acceleration (fixed) and their physical meaning. One-dimensional motion material is an important material and becomes the basis for further mechanics discussion (Rosenblatt & Heckler, 2011; Suyuti, Kusairi, & Sutopo, 2016).

One-dimensional motion is the motion of an object on a straight track. One-dimensional motion material is limited to the motion of objects in the horizontal (x-axis) and vertical (y-axis) paths. Straight motion on the x-axis is known as uniform

rectilinear motion (GLB). While straight on the y-axis, it is known as an accelerated uniform rectilinear motion (GLBB).

GLB and GLBB have their own characteristics. In the high school level, students must be able to analyze the characteristics of physical quantities. To help students finding their own concepts of GLB and GLBB, teachers must be creative in developing materials, managing the learning process, and using learning methods and models.

One of the efforts that can be taken by the teacher in learning the GLB and GLBB material is the use of ICT (Information, Communication, Technology) in the form of computer use (Arafiana & Setyarsih, 2014; Bonato & Gratton, 2017; Milner Bolotin & Antimirova, 2009; Wijayanto & Susilawati, 2015). In this article, the researchers focused on video analysis with the use of computers using tracker software in the learning process to analyze the characteristics of physical quantities on GLB and GLBB. Simulations using computers are closely related to forms of

constructivism learning, namely learning scientific discoveries (Jong & Joolingen, 1998).

Tracker is an application used to analyze video and modeling (Belloni et al., 2013; Brown & Cox, 2009; Wee, Chew, Goh, Tan, & Lee, 2012; Wee & Leong, 2015). Tracker is an open source application that can be accessed for free on the open source physics website. Tracker is made to be applied for physics learning purposes. To run the tracker application, other supporting applications are needed, namely Java 1.6 or higher, quick time, video converter, a video for windows (Wee et al., 2012). Tracker has the ability to manually and automatically track positions on time, speed, acceleration, mass center, and other kinematic quantities (Brown & Cox, 2009; Mariati, Betty, & Sehat, 2017; Tirtasari, Latief, Amahoru, & Azizah, 2015).

The use of tracker in physics learning is seen as an effective way in improving students' science process skills (Habibbuloh & Madlazim, 2014; Zulika, Wijaya, Masitoh, Utari, & Titin, 2018). The tracker can encourage students to feel like a scientist (Wee & Leong, 2015). But unfortunately, the tracker is not widely used by teachers at school. The researchers interviewed 20 physics teachers on August 8, 2017, regarding the use of tracker. The result of the interview revealed that the physics teachers did not know what tracker is and what benefits it could provide. Therefore in this research, tracker software was used in basic physics subject to encourage the students in using the tracker since they are expected to be a professional physics teacher after completing their study.

The objective of this study is to obtain a deeper insight of the students of physics education in utilizing the tracker software to improve science process skills, mastery of concepts, and as well as their perception and attitudes like their curiosity,

carefulness, environmental awareness, honesty, and cooperativity.

METHOD

The study was conducted in the basic physics course 1, the first semester of the 2016/2017 academic year. The population in this study were 2 classes of Physics Education Study Program. The sampling technique used was saturated sampling technique. The entire population which consisted of 77 students were used as research samples. The research instrument used was the science process skills assessment rubric, questionnaire, and mastery test concept. The science process skills assessment rubric covers nine aspects, namely: (1) asking questions, (2) making hypotheses, (3) planning experimental trials / procedures, (4) using tools and materials, (5) carrying out experiments: collecting and recapping data, (6) interpreting and analyzing data, (7) classifying, (8) concluding, and (9) communicating. The assessment rubric uses four levels of achievement, namely 1 (poor), 2 (fair), 3 (good), 4 (excellent). A questionnaire was used to obtain data on students' ability to use tracker software and to obtain data on students' perceptions and attitudes on the course. The attitude questionnaire of students was analyzed using the Guttman scale. Each student's answer to the statement is grouped on an agree (SS) category, and disagree (TS) category. The test was used to obtain data about the students' mastery progression of concepts on one-dimensional motion material.

The quantitative analysis of the students' science process skills was done by calculating the percentage of the number of students for each achievement with poor categories, fair, good, excellent based on the total number of scores for each aspect of the science process skills. To get the score, the score obtained is converted to a scale of 100 with the

following equation (Nuryantini, Setiadi, Kurniawan, & Farida, 2015).

$$Score = \frac{Obtained\ score}{Maximum\ total\ score} \quad (1)$$

The obtained science process skills score then grouped based on categories; poor, fair, good, and excellent. The categories are based on the maximum score (4 x 9 = 36) and minimum score (1 x 9 = 9). The criterion is presented in the following Table 1.

Table 1 Scientific report assessment criteria

Criteria	Total Score	Score
Maximum	9 x 4 = 36	100
Minimum	9 x 1 = 10	25
Excellent	29 - 36	81,25 to 100,0
Good	23 - 29	62,51 to 81,25
Fair	16 - 22	43, 76 to. 62,50
Poor	9 - 15	25 to 43,75

The criteria in Table 1 were determined by dividing each score range by a quarter of the overall score. A quarter of the low score in the score range of 9 to 15 has a maximum score of 43.75 (see table 1). Thus, the categorization of the science process skills is corresponding to the scale set for the achievement category in the range of 1 to 4.

Students' ability in using tracker software, perceptions and attitudes toward the course are presented in a percentage form. The percentage is calculated using the following equation.

$$T = (\sum J) / N \times 100\% \quad (2)$$

Information:

T = Percentage of each statement.

J = total answer of each group.

N = number of students

RESULTS AND DISCUSSION

Results

The Students' Ability to Use Tracker

Teaching and learning approach used in the course was the scientific approach. In scientific approach, learning strategies are suggested using disclosure / research-based learning (discovery / inquiry learning), based on problem solving (work based solving) and work-based (project-based learning) (Duch, Groh, & Allen, 2001; Khairiyah, 2017; Kuhlthau, Maniotes, & Capsari, 2007; Wieman & Gilbert, 2015).

Learning activities on one-dimensional motion material are carried out using discovery strategies. Discovery learning requires students to be able to design their knowledge acquisition independently. Courses are carried out through inexpensive material-based experiments using media balls dropped from a certain height and rolled on a flat table. The ball motion is then analyzed using tracker software. The learning steps taken are shown in Table 2.

The use of tracker software is intended to make students as candidates for skilled physics teachers to use media, technology, information and communication (ICT). The ability of pre-service teachers in using ICT will be transferred to students later in school. As in the syllabus of senior high school (SMA) or Madrasah Aliyah (MA) physics subjects which state that science learning is expected to deliver students to fulfill 21st-century abilities, including mastery of ICT (Trilling & Fadel, 2009; Wan Husin et al., 2016). Table 3 below illustrates the ability of students teacher to use tracker software in the basic physics 1 course.

Table 2. Learning steps using discovery strategy

Learning Steps	Students Learning Activities	Competences Being Developed
Stimulation	Students observed the demonstration of a ball being dropped from a certain height and rolled on a flat table.	Developing sincerity and thorough character, and the ability to observe and seek information.
Problem Identification	Students ask a question regarding the movement of the ball which fell and rolled on the flat table.	Growing curiosity, creativity, and ability in searching for information and developing the question.
Data collection	Students conducted an experiment on dropping a ball from a certain height and rolled it on a flat table and recorded the occurrence in a video.	Accuracy, honesty, social interaction between friends in groups, responsibility, communication.
Data processing and verification	Students analyzed the video of objects' motion using tracker software, so that obtained the position graph against time (s-t), velocity versus time graph (v-t), and the graph of acceleration with time (a-t). Students distinguished position graphs to time (s-t), velocity to time graphs (v-t), and graphs of acceleration to time (a-t) of the motion of the ball dropped and the motion of the rolling ball and confirmed it by one-dimensional motion theory.	Developing honesty, thoroughness, discipline, obeying the rules, working hard, having the ability to use effective reasons, implementing procedures and the ability to think inductively and deductively in concluding, being able to apply technology effectively.
Conclusion	Students described the difference in the motion of the dropped ball (the irregularly changing straight motion), and the ball rolled on a flat table (regular straight motion).	Developing honest, thorough, tolerant attitudes, the ability to think systematically, expressing opinions in brief and clear, and developing good and correct language skills.

Table 3. Students' ability in using software tracker.

No	Notes	Percentage (%)
1	Installing software tracker.	94,8
2	Importing video.	100
3	Cutting video.	94,8
4	Calibrating.	76,7
5	Deciding coordinate point.	92,2
7	Signing the motion of objects.	87,1
9	Importing graphic and table in other applications	84,5
Average		90,0

The data written in Table 3 show that generally, students have already been mastering the operation of tracker software even though 74% of students have never used it.

Science Process Skills

The skills of students in operating the tracker software are supported by the familiarity of computers for students and the ease of operating tracker software. Students' ability to operate tracker software can build students' science process skills in finding the concept of one-dimensional motion. Table 4 illustrates the percentage of the number of students based on the science process skills category.

Table 4. The Percentage of Science Process Skills.

Category of science process skills	Number of students	Percentage (%)
Excellent	4	5.19
Good	57	74.03
Fair	16	20.78
Poor	0	0

Students' science process skills are generally categorized as good as it is indicated by an average score of 70. Based on the science process skills category, 4% of students are classified under excellent categories, 74% are classified under good, and no students have poor categories. Students' science process skills which were built through motion analysis activities using tracker software consists of nine aspects

The following is a detailed explanation of each aspect of the students' science process skills.

Asking questions. Students ability in asking and conducting question is 60% of students are classified under excellent category, and 39% are in a good category, 1% are in the fair category, as shown in Figure 1a. The ability of students to ask questions represents that students have been able to show the relationship of two variables, the question relates with the results of the observations, and the questions asked are related to all observed phenomena. The following are examples of several questions asked by students: 1. Is there a difference between motion in the

direction of vertical and horizontal direction?; 2. What is the effect of mass (m) on speed (v) on the x-axis?; 3. What is the effect of mass (m) on speed (v) on the y-axis?; 4. What is the difference between mass graph (m) and speed (v) on the x-axis and y-axis?

Making the hypothesis. The hypothesis is an important part of science process skills. Figure 1b shows the ability of students in formulating hypotheses. 11% of students submitted hypotheses very well, 49% were good, and 40% were fine. There is no one student in the category of Poor. The hypothesis proposed by students has shown a complete idea, based on prior knowledge and or observation, and also specifically related to the problem or question. Although students do not follow it up with further reason about the thoughts behind the prediction or hypothesis and their considerations. The following are some hypotheses made by students: 1. The higher the initial position of the object being dropped the faster the speed of the object; 2. The volume of an object will not affect the motion of objects in the one-dimensional medium in the vertical position (on the y-axis); 3. The mass of an object greatly affects the speed of an object. If an object is dropped on a vertical medium, the heavier the mass of an object the faster the speed of an object will increase; 4. There is a significant difference between motion in the direction of the x and y-axes.

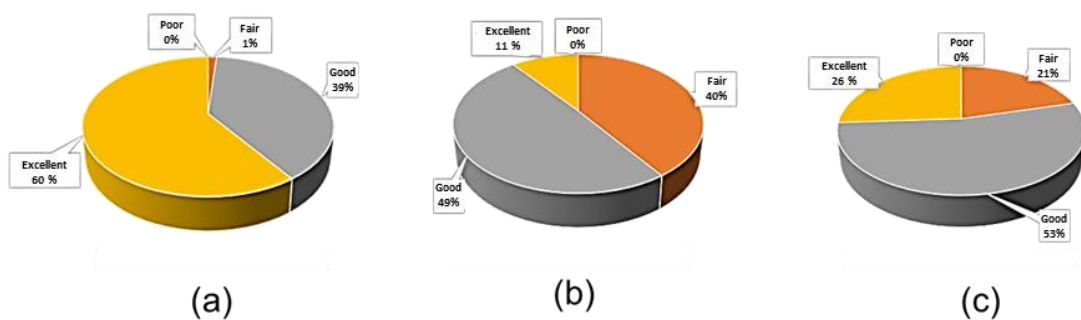


Figure 1. Students' science process skills (a) asking questions, (b) formulating hypotheses, (c) planning experiments

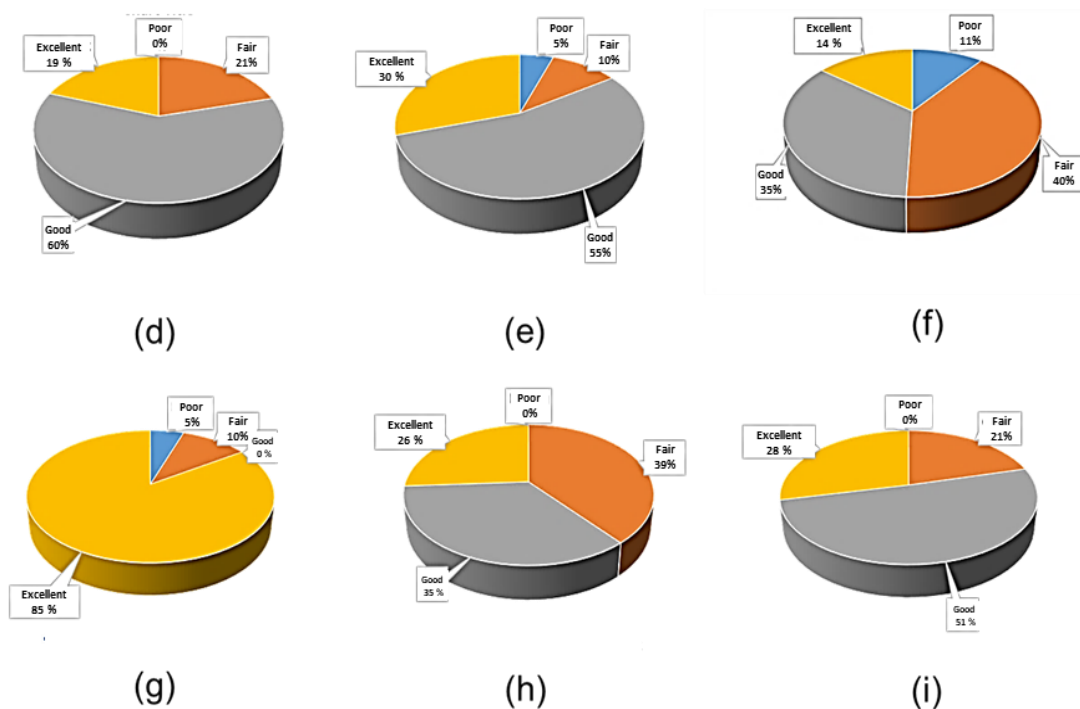


Figure 1. (d) using tools and materials, (e) collecting and recapping data, (f) analyzing data, (g) classifying, (h) making conclusions, and (i) communicating.

Planning experiments. In the experimental planning process, students describe the experimental procedures performed. The skills of students in planning experiments are shown in Figure 1c. 19% of students have the skills to plan experiments with excellent categories, 40% good category, and 21% with the fair category. In preparing the experimental procedure, students can sort the procedures to be carried out, the sequence of all procedures is arranged logically, and able to identify experimental variables and control variables.

Using tools and materials. After the trial procedure is made, the next task is the use of the correct tools and materials. Generally, students can use the tools and materials well as shown in Figure 1d. Students have been able to choose and use the tools/instruments needed.

Collecting and recapping data. Data collected by students is a video of motion of objects in the vertical and horizontal direction. Videos are recorded using the recording facilities on the phone. The

ability of students to record the motion of objects and recap the data can be seen in Figure 1e. 30% of students have the ability to collect and recap the data with excellent categories, 55% in good categories, 10% in fair categories and 5% in poor categories. The data collected by most students have been recapitulated in the right format in the form of charts and graphs, the measurements are determined precisely, the data collected has uniform units, the sequence is logical, and the information presented easy to read and interpret.

Analyzing Data. Data analysis is an activity that is carried out after the data had been collected. The students' skills in analyzing the data are 14% of students are categorized as excellent, 35% is good, 40% is fair, and 11% are poor as shown in Figure 1f. Data analysis is seen as a difficult activity by students. Students have difficulty in interpreting data with the concepts they will build. The biggest obstacle is because the understanding of student toward the concepts on straight motion material is very low. In data

analysis activities, students must check the data to see whether the recapitulated information is logical, the sentences that are expressed to explain complete data describe complete ideas, can verbally explain how data is organized, can accurately write experimental results based on data, can determine whether data has been collected/captured accurately, evaluating the relevance of data collected with the original question.

Grouping. The ability of students to classify is very good as shown by 85% of students in the excellent category shown in Figure 1g. In this grouping aspect students have been able to distinguish data and share it in groups so that data can be observed and clearly distinguished.

Concluding. In making conclusions, 26% of students are classified as very good, 35% is good and 39% are fair as illustrated in Figure 1h. The conclusions made by the students showed that the sentences and ideas used were complete, determining the results of the experiment. However, 39% of students had not been able to make conclusions that clearly describe the original questions, and interpret the intent of the data analyst

results by applying them correctly to a bigger scientific concept.

Communicating. In submitting research reports in oral or written form, students must be able to communicate it well. In the research conducted, the communication skills reviewed were written forms. Overall students have been good at writing communication in the form of reports, which is shown by 28% of students in excellent categories and 51% of good categories as shown in figure 1 (i). Communication skills are characterized by experimental reports made by students using active sentences, easy to understand, using standard language, and using enhanced spelling.

Mastery of Concepts

Students' science process skills in finding a concept are important things that need to be explored. Students high-level thinking skills and their concepts mastery can be developed through science process skills. Figure 2 is a graph of increasing the mastery of students' concepts on one-dimensional motion material obtained from the results of the pretest and posttest.

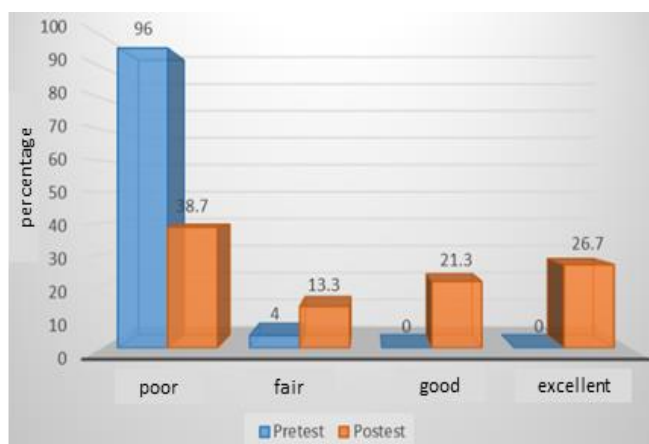


Figure 2. Graph of Students' Growth on Concepts Mastery in One-Dimensional Motion Material

Students' Perception and Attitudes

The results of observations of student activities in basic physics course indicate that all students actively play a role in

video data retrieval and data analysis. Students were enthusiastic and happy. To strengthen students' perception data in basic physics lectures, 10 items were

distributed to the questionnaire which described three aspects, namely feeling of pleasure, activity, and mastery of the concept. The data obtained from the questionnaire are illustrated in Table 5 below

Data obtained from questionnaires about student perceptions related the course taken to support the results of observations. Data from the questionnaire showed that 95.2% of students felt happy, 92.9% of students were active in the learning activity and 87.3% of students were helped in improving the mastery of one-dimensional motion concept. Students are usually afraid of facing basic

physics lectures, passive because they only listen and record, it is difficult to understand the concept of physics because concepts are studied abstractly. But with the motion analysis activity, students can immediately observe the GLB and GLBB phenomena and find their own characteristics of GLB and GLBB. Together with other friends, they enthusiastically take every step and activity of the course. The course gave also encourages curiosity, thorough, honesty and excellent cooperation. Moreover, students' awareness of motion phenomenon in their environment can be classified as good, as shown in the graph in Figure 3.

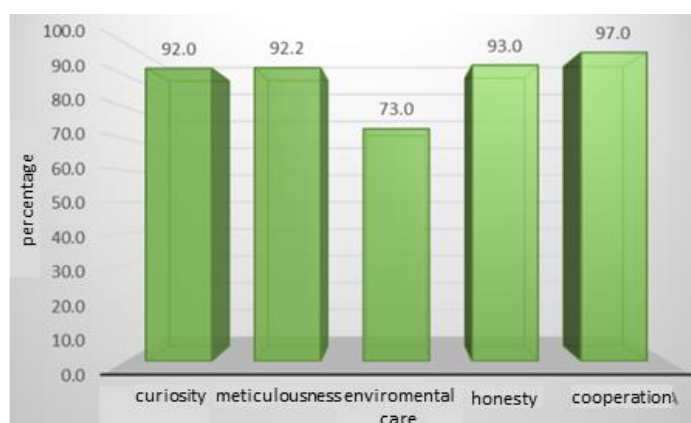


Figure 3. Percentage of curiosity, meticulousness, environmental care, honesty, and cooperation.

Course with an ICT-based discovery strategy has many positive effects on student learning outcomes both direct teaching and indirect teaching (Dwianto, Wilujeng, Prasetyo, & Suryadarma, 2017; Sabon & Sumadi, 2016). Mastery of concepts and skills is the result of direct learning, while attitudes

that grow from courses are indirect learning outcomes (Usmeldi, 2016). Courses should be interactive, inspiring, fun, challenging, motivating students to participate, as well as providing sufficient space for the initiative, creativity, and independence.

Table 5. Students' Perception of the Study

No	Aspect notes	Number of students (%)
1	Glad to follow the study by analyzing the motion of the ball using tracker software.	95,2
2	Actively follow the learning process by analyzing ball motion using tracker software.	92,9
3	Analyzing ball motion using tracker software to increases mastery of concepts.	87,3

Table 6. Students' abilities that can be developed from 21st-century skills

21th-century skills		Description
Learning and innovation skills	Critical thinking and problem-solving skills	Students are able to use effective reasons, use systems thinking, make judgments and decisions, and solve problems.
	Communication and collaborative skills	Students are able to communicate clearly and collaborate with others.
	Creative and innovation skills	Students are able to think creatively, work creatively with others, and apply innovation.
Digital literacy skill	Information literacy	Students are able to access and assess information, use and manage information.
	Media literacy	Students are able to analyze the media and create media products.
	ICT Literacy	Students are able to apply technology effectively.
Life and career skills	Flexibility and adaptability:	Students are able to adopt changes and are flexible in providing feedback and facing criticism.
	Initiative and self-regulating	Students are able to manage goals and time, work independently, become students who are able to self-regulate.
	Social and intercultural interaction	Students are able to interact socially with others, work effectively in different groups.
	Productivity and accountability. Leadership and responsibility.	Students are able to manage projects and produce products. Students are able to guide and lead others; are responsible for others.

(Trilling & Fadel, 2009)

Discussion

The learning outcomes present above have an agreement with 21st-century skills. 21st-century skills require students to develop their abilities, as described in Table 6. 21st-century skills can be used for decision making in dealing with problems in the era of information and digital technology.

In order to actualize the 21st-century skills in the world of education in Indonesia, the Ministry of Education and Culture of the Republic of Indonesia has adapted it along with the adaptation of scientific approach and authentic assessment in developing a new curriculum, the 2013 curriculum. All three concepts were adapted to develop education towards creative Indonesia in 2045 (Murti, 2014).

The learning process touches three domains, namely knowledge (know what), skills (know how) and attitude (know why). The end result of the learning process is to improve and balance soft skills and hard skills in the form of knowledge and skills. In the 21st century learning, the three domains above are known as KSAVE namely knowledge, skills, attitudes, values and ethics (Binkley, Erstad, & Herman, 2012; Salonen, Hartikainen-Ahia, Hense, Scheersoi, & Keinonen, 2017). Knowledge is the same as skills, and attitudes, values and ethics as well as attitudes. The results of the study conducted in this study include three domains, namely knowledge, skills in the form of science process skills with aspects of (1) asking questions, (2) making hypotheses, (3) planning trial / trial procedures, (4) using tools

and materials, (5) carrying out experiments: collecting and recapping data, (6) interpreting and analyzing data, (7) classifying, (8) concluding, (9) communicating, and skill in using tracker software as part of ICT literacy and curiosity, careful, caring for the environment, honest and cooperation.

CONCLUSION AND SUGGESTION

21st-century skills can be trained through basic physics lectures by using discovery strategies. Low budget materials around and ICT can be used to present physics phenomena to students. Phenomena are presented to build concepts, laws, or learned principles. Learning outcomes conducted in this study include three domains, namely knowledge, skills in the form of science process skills with aspects of (1) asking questions, (2) making hypotheses, (3) planning experimental trials / procedures, (4) using tools and materials, (5) carrying out experiments: collecting and recapping data, (6) interpreting and analyzing data, (7) classifying, (8) concluding, (9) communicating, and skill in using tracker software as part of ICT literacy and curiosity, careful, caring for the environment, honest and cooperation. Students' perceptions of the course indicate happiness, activeness, and encouragement in understanding the materials.

REFERENCES

- Arafiana, R. N., & Setyarsih, W. (2014). Penerapan pembelajaran gerak lurus dengan media pembelajaran macromedia flash dalam menyajikan grafik untuk meningkatkan hasil belajar fisika siswa di SMPN 3 Nganjuk. *Jurnal Inovasi Pendidikan Fisika*, 03(02), 70–73.
- Belloni, M., Christian, W., Brown, D., Belloni, M., Christian, W., & College, D. (2013). Teaching Astronomy Using Tracker. *The Physics Teacher*, 51, 1149–151. <https://doi.org/10.1119/1.4792008>
- Binkley, M., Erstad, O., & Herman, J. (2012). Defining Twenty-First Century Skills. In *Assessment and Teaching of 21st Century Skills* (1st ed., pp. 17–66). Netherlands: Springer Netherlands.
- Bonato, J., & Gratton, L. M. (2017). Using high-speed smartphone cameras and video analysis techniques to teach mechanical wave physics. *Physics Education*, 52(4), 1–5.
- Brown, D., & Cox, A. J. (2009). Innovative Uses of Video Analysis. *The Physics Teacher*, 47(2009), 145. <https://doi.org/10.1119/1.3081296>
- Duch, B. J., Groh, S. E., & Allen, D. E. (2001). *The Power of Problem Based Learning*. Virginia: Stylus Publishing.
- Dwianto, A., Wilujeng, I., Prasetyo, Z. K., & Suryadarma, I. G. P. (2017). The Development of Science Domain Based Learning Media Which is Integrated with Local Potential to Improve Science Process Skill and Scientific Attitude. *Jurnal Pendidikan IPA Indonesia*, 6(1), 23–31. <https://doi.org/10.15294/jpii.v6i1.7205>
- Habibuloh, M., & Madlazim. (2014). Penerapan Metode Analisis Video Software Tracker Dalam Pembelajaran Fisika Konsep Gerak Jatuh Bebas Untuk Meningkatkan Keterampilan Proses Siswa Kelas X Sman 1 Sooko Mojokerto. *Jurnal Pendidikan Fisika Dan Aplikasinya(JPFA)*, 4(1), 15–22.
- Jong, T. De, & Joolingen, W. Van. (1998). Scientific discovery learning with computer simulations of conceptual domains. *Review of Educational Research*, 68, 179–202.
- Khairiyah, U. (2017). Melatihkan life skills melalui pembelajaran IPA dengan pendekatan scientific untuk meningkatkan hasil belajar siswa. *At-Thulab*, 1(1), 33–41.
- Kuhlthau, C. C., Maniotes, L. K., &

- Capsari, A. K. (2007). *Guided Inquiry Learning in The 21 Century*. United States of America: Libraries Unlimited Inc.
- Mariati, P. S., Betty, M. T., & Sehat, S. (2017). The Problem Solving Learning Model by Using Video Recording on Experiments of Kinematics And Dynamics to Improve The Students Cognition and Metacognition. *Jurnal Pendidikan Fisika Indonesia* 13, 13(1), 25–32. <https://doi.org/10.15294/jpfi.v13i1.10154>
- Milner Bolotin, M., & Antimirova, T. (2009). A brief introduction to video analysis. *Physics in Canada*, 65(2), 74.
- Murti, K. E. (2014). Pendidikan Abad 21 dan Implementasinya pada Pembelajaran di Sekolah Menengah Kejuruan (SMK) untuk Paket Keahlian Desain Interior. Retrieved December 2, 2016, from http://p4tksb-jogja.com/arsip/index.php?option=com_content&view=article&id=478:pendidikan-abad-21-dan-implementasinya-pada-pembelajaran-di-smk-untuk-paket-keahlian-desain-interior&catid=68:pendidikan&Itemid=192
- Nuryantini, A. Y., Setiadi, T., Kurniawan, & Farida, I. (2015). The application of authentic assessment with feedback to improve the competence of mts students in constructing a scientific report of motion material in science learning. *Jurnal Pendidikan Fisika Indonesia*, 11(2), 108–116. <https://doi.org/10.15294/jpfi>
- Rosenblatt, R., & Heckler, A. F. (2011). A systematic study of student understanding of the relationships between the directions of force, velocity, and acceleration in one dimension. *Physical Review Special Topics-Physics Education Research*, 7(2), 1–20. <https://doi.org/10.1103/PhysRevSTPER.7.020112>
- Sabon, E. A. S., & Sumadi. (2016). Pengaruh model pembelajaran discovery learning terhadap prestasi belajar fisika pokok bahasan gelombang dan bunyi. *Jurnal Universitas Sarjanawiyata Tamansiswa*, 3(2), 74–83.
- Salonen, A., Hartikainen-Ahia, A., Hense, J., Scheersoi, A., & Keinonen, T. (2017). Secondary school students' perceptions of working life skills in science-related careers. *International Journal of Science Education*, 39(10), 1339–1352. <https://doi.org/10.1080/09500693.2017.1330575>
- Suyuti, H., Kusairi, S., & Sutopo. (2016). Pengembangan dan Penyetaraan Instrumen Tes Kinematika Gerak Lurus dengan Metode Linear. *Jurnal Pendidikan Sains*, 4(1), 17–24.
- Tirtasari, Y., Latief, F. D. E., Amahoru, A. H., & Azizah, N. (2015). Validasi Teknik Video Tracking Pada Praktikum Bandul Matematis Untuk Mengukur Percepatan Gravitasi Bumi. In *Prosiding Seminar Kontribusi Fisika* (pp. 399–406).
- Trilling, B., & Fadel, C. (2009). *21st Century Skills: Learning for Life in Our Times*. San Francisco: Jossey-Bass.
- Usmeldi. (2016). the Development of Research-Based Physics Learning Model With Scientific Approach To Develop Students' Scientific Processing Skill. *Jurnal Pendidikan IPA Indonesia*, 5(1), 134–139. <https://doi.org/10.15294/jpii.v5i1.5802>
- Wan Husin, W. N. F., Mohamad Arsad, N., Othman, O., Halim, L., Rasul, M. S., Osman, K., & Iksan, Z. (2016). Fostering students' 21st-century skills through project-oriented problem-based learning (POPBL) in an

- integrated STEM education program. *Asia-Pacific Forum on Science Learning & Teaching*, 17(1), 60–77. Retrieved from https://www.ied.edu.hk/apfslt/v17_issue1/%0Ahttp://content.ebscohost.com/ContentServer.asp?T=P&P=AN&K=118111100&S=R&D=ehh&EbscoContent=dGJyMNLr40SeqLc4zOX0OLCmr06ep65Sr664TLWWxWXS&ContentCustomer=dGJyMPGss0q1qK5IuePfgex44Dt6fIA
- Wee, L. K., Chew, C., Goh, G. H., Tan, S., & Lee, T. L. (2012). Using tracker as a pedagogical tool for understanding projectile motion. *Physics Education*, 47(4), 448–455. <https://doi.org/10.1088/0031-9120/47/4/448>
- Wee, L. K., & Leong, T. K. (2015). Video Analysis and Modeling Performance Task to promote becoming like scientists in classrooms. *American Journal of Educational Research*, 3(2), 197–207. <https://doi.org/10.12691/education-3-2-13>
- Wieman, C., & Gilbert, S. (2015). Taking a Scientific Approach to Science Education Part I—Research. *Microbe*, 10(4), 152–156.
- Wijayanto, & Susilawati. (2015). Rancangan Kinematika Gerak Menggunakan Alat Eksperimen Air Track Untuk Media Pembelajaran Fisika Berbasis Video. *Jurnal Informatika Upgris*, 1(2015), 120–125.
- Zulika, A. M., Wijaya, M. H., Masitoh, U., Utari, S., & Titin. (2018). Profil keterampilan proses sains (KPS) siswa dalam menggunakan ragam media pembelajaran gerak melingkar di SMA. *Jurnal Wahana Pendidikan Fisika*, 3(1), 80–84.

STUDENTS CRITICAL THINKING SKILL IN SOLVING SCIENTIFIC LITERACY USING A METACOGNITIVE TEST BASED ON SCIENTIFIC LITERACY

Zakaria Sandy Pamungkas^{*1}, Nonoh Siti Aminah², Fahru Nurosyid³

^{1,2} Physics Education of Post Graduate Program, Sebelas Maret University, Surakarta, Indonesia

³ Physics Department of Post Graduate Program, Sebelas Maret University, Surakarta, Indonesia

*corresponding address: pamungkaszakaria@student.uns.ac.id

Received: August 7th, 2018. Accepted: October 24th, 2018. Published: October 28th, 2018

Abstract: The purpose of this research is to measure students critical thinking skill in solving scientific literacy using a metacognitive test based on scientific literacy. This research is descriptive research. The subject of this research is 99 students of grade XI in SMA Batik 2 Surakarta. Data collection methods used are test methods which using a metacognitive test based on scientific literacy. Data analysis techniques use quantitative descriptive analysis. The results showed that the achievement of scientific literacy is still low at below 50% for all category. This is due to students critical thinking skill in solving all category of scientific literacy problem is still low. Low student critical thinking skill in solving science as a body of knowledge in the assessment stage with the percentage achievement is 21%. Low percentage achievement of critical thinking skill in solving science as a way of thinking is a clarification (34%), assessment (46%), inference (26%), and strategy (12%). Low percentage achievement of critical thinking skill in solving science as a way of investigating is assessment (39%), inference (5%), and strategy (6%). Low student critical thinking skill in solving science as an interaction between technology and society in the assessment stage with the percentage achievement is 31%.

© 2018 Physics Education, UIN Raden Intan, Lampung, Indonesia.

Keyword: Critical Thinking Skill, Metacognitive test, Scientific Literacy.

INTRODUCTION

The rapid advance of science and technology is one of the impacts of globalization which causing the mindset of a society increasingly critical to the need of their life (Rachmatullah, Diana, & Rustaman, 2016). This causes students not only required to have cognitive competence but also soft skills that can help students in overcoming the rapid advance of science and technology. One of the soft skill that related to science and technology development is scientific literacy (Adawiyah & Wisudawati, 2017). This is due to soft skill in the form of science literacy is able to make students to relate natural phenomenon to concepts that have been learned in school. The scientific literacy of students is expected to making progress in understanding the natural world (Good, Hafner, & Peebles, 2000).

Science Literacy is the ability to engage with science on related problems and with scientific ideas as a reflection of citizens (Asyhari, 2017). Scientific literacy is the goal of physics education as a basis for science education (Holbrook & Rannikmae, 2009). This is due to the main goals of science education are to provide an opportunity for students to make decisions about socio-scientific issues that affect their lives (OECD, 2004). This showed that scientific literacy is a necessary element of education in our modern science and technology. This cause teachers of science to engage a student in studied history, philosophy, and practice of science (Udeani, 2013).

Building students scientific literacy can be done through training student critical thinking skill. This is due to students' critical thinking skills can help students to solve problems related to scientific

literacy. Critical thinking is a self-regulatory judgment that results in interpretation, analysis, evaluation, and inference as well as an explanation of the evidential, conceptual, methodological, or contextual (White, Stains, Escriu-sune, Medaglia, & Rostamnjad, 2011). Critical thinking also can raise vital questions and problems to formulate them clearly, gather and asses relevant information to think open-mindedly (Duron, Limbach, & Waugh, 2006). So, it can be concluded that critical thinking skill will encourage students to understand the problem and make an alternative problem solving with the problem-solving stage is clarification, assessment, inference, and strategy (Jacob & Sam, 2008).

Student critical thinking skill in solving scientific literacy can be measure using metacognitive assessment instruments based on science literacy. This is due to critical thinking as the set of skill which enables to solve a problem logically and reflect autonomously by means metacognitive regulation (Gotoh, 2016). Metacognitive refers to ways of raising awareness of thinking and learning process (Yanti, Distrik, Khasyyatillah, & Khasyyatillah, 2017). It is shown that metacognitive knowledge plays an important role in the learning process because metacognitive is crucial in regulating and controlling the cognitive process of a person in learning and thinking (Warni, Sunyono, & Rosidin, 2018). The instrument of metacognitive assessment based on scientific literacy is an instrument of scientific literacy assessment which consisting of metacognitive knowledge question that is declarative knowledge, procedural knowledge, and conditional knowledge. Declarative knowledge is knowledge about oneself as a learner and about what factors influence one's performance, procedural knowledge is knowledge about doing things which are represented as heuristics and strategies, conditional

knowledge is knowledge about knowing when and why to use declarative and procedural knowledge (Schraw, 1998).

Based on the description, it can be concluded that the metacognitive test based on scientific literacy can measure student critical thinking skill in solving scientific literacy. Student critical thinking skill as an ability to solve problems is one of the goals of learning physics (Supeno, Subiki, & Rohma, 2018). Therefore it's important to analyze students' critical thinking skill in solving scientific literacy.

METHOD

This research is quantitative descriptive research. This research was conducted in the semester II of academic year 2017/2018 in SMA Batik 2 Surakarta. A sample in this research is 99 students of grade XI in SMA Batik 2 Surakarta. The method used in this research is survey method which surveys research procedure: 1) Research objective, 2) Concepts, 3) Questioner, 4) Population, 5) Sampling, 6) Data collection, 7) Data processing, 8) Interpretation (Biemer & Lyberg, 2003).

Data collection method used is a metacognitive test based on scientific literacy. The test is used to find out the profile of students critical thinking skill in solving scientific literacy. The questions on the test sheet consisted of 4 problems about a category of scientific literacy that is science as a way of thinking, science as a way of investigating, science as a body of knowledge, science and its interaction with technology and society (Chiappetta, Sethna, & Fillman, 1991; Udeani, 2013). Each of the scientific literacy problems contained three question about metacognitive knowledge that is declarative, procedural, and conditional knowledge (Rompayom, Tambunchong, Wongyounoi, & Dechsri, 2010). It can analyze student critical thinking skills in solving scientific literacy. The indicator of critical thinking skill in solving scientific literacy is adopted from Jacob and Sam

that is clarification, assessment, inference and strategy (Jacob & Sam, 2008). Data analysis technique used in this research is quantitative descriptive analysis. Quantitative descriptive analysis technique is used to process the data obtained from the test in the form of a descriptive percentage of critical thinking skill in solving scientific literacy.

RESULTS AND DISCUSSION

Student answer in a metacognitive test based on scientific literacy is analyzed to describe student critical thinking skill in solving scientific literacy. Critical thinking skill in solving scientific literacy is thinking skill to know the concept underlying a problem (clarification), visualize the problem schematically to see a relation of the variables or basic concept (assessment), giving strategy to solve a problem (inference) and evaluate strategy (Laurens, 2010). Percentage achievement of student scientific literacy for each category can be seen in Figure 1.

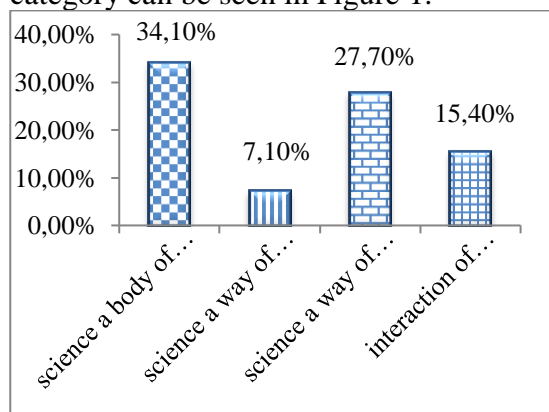


Figure 1. Percentage achievement of student science literacy in each category

In Figure 1 it can be seen that the achievement of science literacy of students in each category is still low. Percentage achievement for a category of science a body of knowledge is 34,1%. This shows that students still have difficulty in explaining situations /questions that require students to remember knowledge of information. Percentage achievement for a category of science as a way of

thinking is 7,1%. This suggests that students still have difficulty making about experiments or thinking activities. Percentage achievement for a category of science a way of investigating is 27,7%. This shows that students are still having difficulty in presents a scientific method and problem solving based on fact and evidence. Percentage achievement for a category of an interaction of science, technology, and society is still low with the percentage of achievement is 15.4%. This shows that students still do not understand the application of science and technology for society. Low percentage achievement of scientific literacy due to student still don't have more resources for continuing education. Some resources such as books and the internet can explore the latest advances in scientific research (Ogunkola, 2013). It can make student to increase critical thinking skill. Critical thinking enables the student to improve themselves ability to criticize, questioning, evaluating, and reflecting (Zhang & Kim, 2018). Furthermore, it's important to analyze student critical thinking skill in solving each category of scientific literacy: science as a body of knowledge, science as a way of thinking, science as a way of investigating, and interaction between science, technology, and society.

Percentage achievement of student critical thinking skill in solving a category of science as a body of knowledge can be seen in Figure 2.

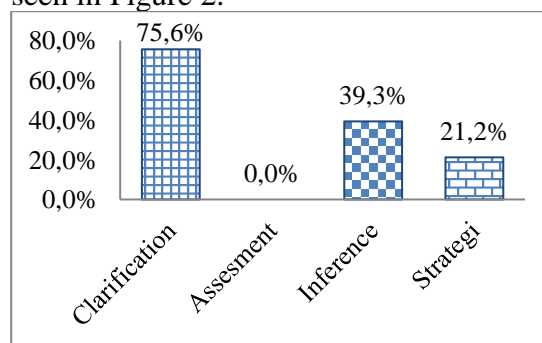


Figure 2. Percentage achievement of student critical thinking skill in solving a category of science as a body of knowledge

In figure 2 it can be seen that in the category of scientific literacy as a science of body of knowledge, it is found that the achievement of critical thinking skill is 75.6% for clarification stage, 0% for assessment, 39.3% for inference, and 21.2% for strategy. This shows that the low critical thinking skill of students in solving the scientific literacy for category science as a body of knowledge is in the assessment stage. This is due to students only understand the concepts and laws of physics without being able to understand the physical representation of the concepts and laws of physics. This is due to teaching materials used only to explain the concept of laws of physics without explaining further related to the meaning of the concept of laws of physics. Student answer in solving a category of science as a body of knowledge can be seen in figure 3.

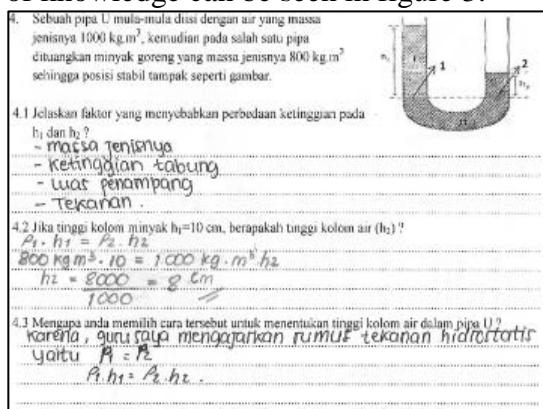


Figure 3. Student answer in solving a category of science as a body of knowledge

Figure 3 can be seen that scientific literacy problem in a category of science as a body of knowledge about U tube concept. Based on figure 3, it can be seen that students have been able to explain the concept of physics on the U tube problem. This is shown by the students' answers that the factors that cause differences in tube height are density, altitude, cross-sectional area and pressure. The answer shows that students are able to contact a problem with relevant concepts and theories. In this category of science as a body of knowledge, students are also able to

determine steps or strategies for solving a problem. This is shown by the students' answers that the pressure on a straight line is the same value so $\rho_1 \cdot h_1 = \rho_2 \cdot h_2$.

Percentage achievement of student critical thinking skill in solving a category of science as a way of thinking can be seen in Figure 4.

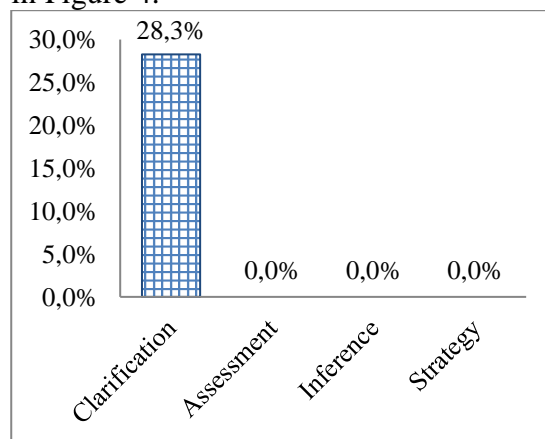


Figure 4. Percentage achievement of student critical thinking skill in solving a category of science as a way of thinking.

Figure 4 shows about percentage achievement for a category of scientific literacy as a science way of thinking. It is found that the achievement of critical thinking skill in the clarification stage is 28.3%, 0% for assessment, 0% for inference, and 0% for strategy. Results obtained in line with research (Rusilowati, Kurniawati, Nugroho, & Widiyatmoko, 2016) that students skills in critical thinking are lacking for a category of scientific literacy as a science a way of thinking. The data shows that students' critical thinking skills used in solving science literacy in the science a way of thinking category are only in the clarification stage. This indicates that the student is still having difficulty in explaining, conceptualizing, and determining the settlement step and evaluating the settlement step. The low ability of students in explaining and determining and evaluating the settlement step because students are less able to calculate the comparison formula. This is because the training questions given by the

teacher during the learning process only at the level of C3 (application) has not reached the level of C4 (analyze). So that student is poorly trained in solving problems that require the ability to think a level of analysis is a matter of comparison. Student answer in solving a category of science as a way of thinking can be seen in figure 5.

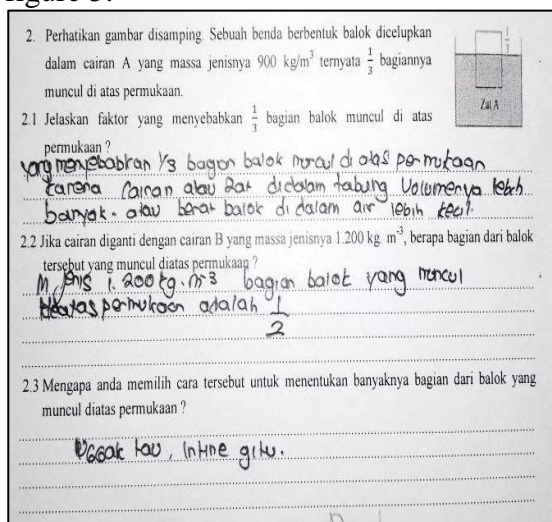


Figure 5. Student answer in solving a category of science as a way of thinking.

Figure 5 can be seen that scientific literacy problem in a category of science as a way of thinking about Archimedes Law. Figure 5 show that students in solving a category of science as a way of thinking with try and error. This is shown from the students' answers that the factors that cause the condition of floating objects are due to differences in the volume ratio between objects and fluids whereas what causes floating objects is the density of objects smaller than the density of fluid so that buoyancy is greater than gravity. It proves that a student can not think imaginatively and logically. Imaginatively and logically can be train based on reality through sketch strategy of knowledge (Amin, Abdullah, & Malago, 2018).

Percentage achievement of student critical thinking skill in solving a category of science as a way of thinking can be seen in Figure 6.

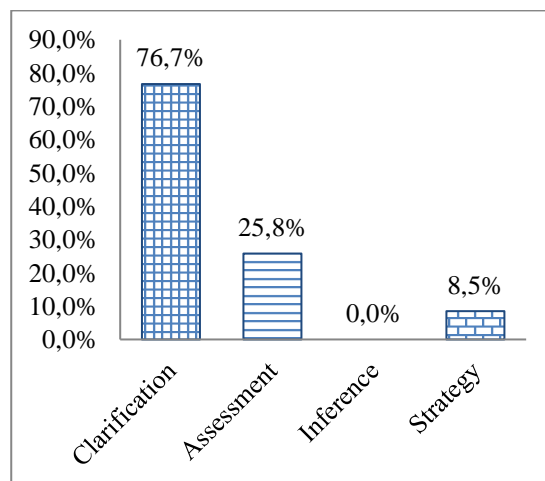


Figure 6. Percentage achievement of student critical thinking skill in solving a category of science as a way of investigating.

Figure 6 show about percentage achievement for a category scientific literacy as a science a way of investigating, it is found that the achievement of critical thinking ability at 76.7% clarification stage, 25,8% for assessment, 0% for inference, and strategy equal to 8,5%. The data shows that the students' least critical thinking skill in solving scientific literacy in the category of science as a way of thinking is in the stage of inference and strategy. This is because students are poorly trained in analyzing the tables of observations. One of the factors that cause it is the absence of practicum or experimental activities during the learning process so that students are poorly trained in making observation tables that cause students difficulties in analyzing information based on the observation table. This is supported by Rasmawan that the common mistake is that students judge a statement to be subjective and do not see and use the information provided in the table (Rahmat Rasmawan, 2017). Student answer in solving a category of science as a way of investigating can be seen in figure 7.

1. Informasi mengenai tekanan di beberapa posisi adalah sebagai berikut.

Posisi	Tekanan (atm)
5.000 m di atas permukaan laut	0,5
Tepat di permukaan laut	1
20 m di bawah permukaan laut	3

1.1 Berdasarkan informasi tersebut, jelaskan faktor yang menyebabkan perbedaan tekanan pada tabel diatas?
 * kedalaman tempat.
 → Karena semakin dalam tempat, maka semakin besar pula tekanannya.

1.2 Berapakah tekanan pada posisi 2500 m diatas permukaan laut dan 10 m dibawah permukaan laut?
 2.500 m → 0,25 atm
 10 m → 2 atm.

1.3 Mengapa anda memilih cara tersebut untuk menentukan tekanan pada posisi 2500 m diatas permukaan laut dan 10 m dibawah permukaan laut?
 - karena tekanan pd posisi 2500 m merupakan 1/2 dri tekanan 5000 m yaitu $0,5/2 = 0,25 \text{ atm}$.
 - karena tekanan pd posisi 10 m merupakan 1/2 dri tekanan 20 m yaitu $3/2 = 1,5 \text{ atm}$.

Figure 7. Student answer in solving a category of science as a way of investigating.

In Figure 7 it can be seen that students answer in a category of science as a way of investigating have been able to solve problems related to factors that cause pressure differences. Students argue that the factor that causes a pressure difference is the depth of the object. This shows that students are able to explain the concepts and theories of a problem. However, in this category, students still experience difficulties in solving mathematical problems about hydrostatic pressure which causes students to draw conclusions through reasoning by comparing the height and depth of an object. In fact, hydrostatic pressure is not only influenced by the position through external pressure with the mathematical equations used is $P = P_0 \pm \rho g h$. One of the efforts to improve students' critical thinking is through improvement metacognitive regulation. This agrees with (Gurcay & Ferah, 2018) that metacognitive self-regulation can increase student critical thinking skill.

Percentage of achievement of student critical thinking skill in solving a category of science as an interaction between technology and society can be seen in Figure 8.

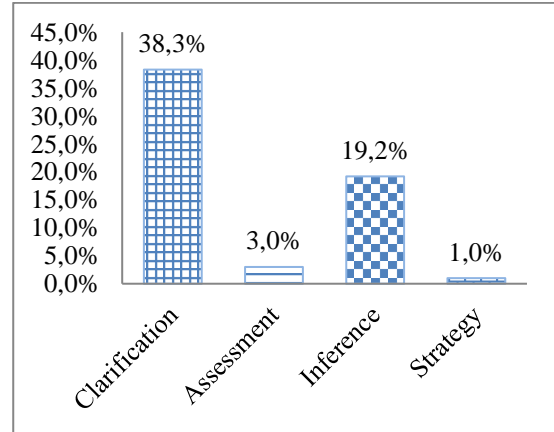


Figure 8. Percentage of achievement of student critical thinking skill in solving a category of science as an interaction between technology and society.

Figure 8 show about percentage achievement for a category of scientific literacy as the interaction of science, technology, and society. It is found that the achievement of critical thinking skill at the clarification stage is 38.3%, 3% for assessment, 19.2% for inference, and 1% for strategy. The data shows that students' critical thinking skills are in very low in solving science literacy category as an interaction of science, technology, and society is in the stage of assessment and strategy. The lack of students' critical thinking skills at the assessment stage indicates that students are still having difficulty explaining the concept of laws of physics applications that are in daily life. This is due to lack of explanation of the concept of physics in applications in daily life. The lack of students' critical thinking skills at the strategic stage shows that students are still having difficulties in evaluating the proposed settlement measures. This is because the teacher does not pay attention to the process so that physics will be a science that just memorizes the formula alone will foster students' negative stigma toward physics (Lisdianto, Masykuri, & Aminah, 2015). Student answer in solving a category of science as an interaction between technology and society can be seen in figure 9.

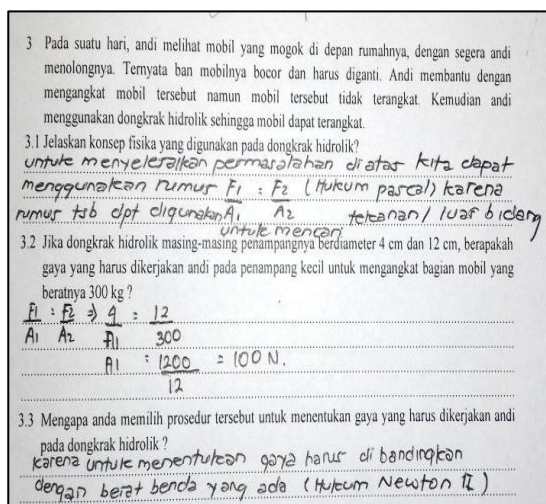


Figure 9. Student answer in solving a category of science as an interaction between technology and society.

Figure 9 shows that students can solve a problem of science as an interaction between technology and society that is hydraulic jack application. This is shown from students' answers that the physics concept used in hydraulic jack is pascal law because of the difference in a cross-sectional area used. The answer shows that students already have declarative knowledge that aims to understand the meaning of test and solving a problem with relevant concepts and theories. It's similar to the Wulandari and Nurhayati research that critical thinking can make students to understand the meaning of test question (Yuniasti & Wulandari, 2018). Students also have the procedural knowledge to determine steps or strategies for solving a problem. This is shown by the students' answers to procedural related problems that the pressure at each point is the same so that the pressure is directly proportional to the cross-sectional area. However, students do not have conditional knowledge that causes students to experience errors in evaluating the completion steps. This is shown based on errors in students' answers in entering data into the magnitude of the predetermined equation. The thing that causes this error is because students memorize more formulas

without understanding further about the quantities contained in the formula or equation.

CONCLUSION

In this research, the investigation had been conducted to determine student critical thinking skill in solving scientific literacy. The results of student scientific literacy are still low that is below 35%. This is due to students critical thinking skill in solving scientific literacy problem is still low. Low student critical thinking skill in solving science as a body of knowledge in the assessment stage (21%). Low percentage achievement of critical thinking skill in solving science as a way of thinking is a clarification (34%), assessment (46%), inference (26%), and strategy (12%). Low percentage achievement of critical thinking skill in solving science as a way of investigating is an assessment (39%), inference (5%), and strategy (6%). Low student critical thinking skill in solving science as an interaction between technology and society in the assessment stage with the percentage achievement is 31%. These results indicate that the teacher has not built students' critical thinking skills: clarification, assessment, inference, and strategy. This is due to the teacher has not conducted an assessment of students' critical thinking skills. Therefore, the teacher needs to do an assessment of students' critical thinking skill that is used as evaluation material to determine the learning model based on students' critical thinking skills weaknesses

REFERENCES

Adawiyah, R., & Wisudawati, A. W. (2017). Pengembangan Instrumen Tes Berbasis Literasi Sains : Menilai Pemahaman Fenomena Ilmiah Mengenai Energi. Indonesian Journal of Curriculum and Educational Technology Studies, 5(2), 112–121.

- <https://doi.org/http://dx.doi.org/10.15294/ijcets.v3i1.8675>
- Amin, B. D., Abdullah, H., & Malago, J. D. (2018). Sketch strategy of knowledge in physics learning and its influence on metacognitive. *Educational Research and Reviews*, 13(7), 230–235. <https://doi.org/10.5897/ERR2017.3293>
- Asyhari, A. (2017). Literasi Sains Berbasis Nilai-Nilai Islam dan Budaya Indonesia. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 6(1), 137. <https://doi.org/10.24042/jpifalbiruni.v6i1.1584>
- Biemer, P. P., & Lyberg, L. E. (2003). Introduction to Survey Quality. <https://doi.org/10.1002/0471458740>
- Chiappetta, E. L., Sethna, G. H., & Fillman, D. A. (1991). A quantitative analysis of high school chemistry textbooks for science literacy: Themes and expository learning aids. *Journal of Research in Science Teaching*, 28(10), 939–951. <https://doi.org/https://doi.org/10.1002/tea.3660281005>
- Duron, R., Limbach, B., & Waugh, W. (2006). Critical Thinking Framework For Any Discipline. *International Journal of Teaching and Learning in Higher Education*, 17(2), 160–166. <https://doi.org/10.1016/j.nepr.2006.09.004>
- Good, R., Hafner, M., & Peebles, P. (2000). Scientific understanding of sexual orientation: implications for science education. *The American Biology Teacher*, 62(5), 326–330. [https://doi.org/10.1662/0002-7685\(2000\)062\[0326:SUOSOI\]2.0.CO;2](https://doi.org/10.1662/0002-7685(2000)062[0326:SUOSOI]2.0.CO;2)
- Gotoh, Y. (2016). Development of critical thinking with metacognitive regulation. 13th International Conference on Cognition and Exploratory Learning Digital Age, (Celda), 353–356. Retrieved from <https://files.eric.ed.gov/fulltext/ED571408.pdf>
- Gurcay, D., & Ferah, H. O. (2018). High School Students' Critical Thinking Related to Their Metacognitive Self-Regulation and Physics Self-Efficacy Beliefs. *Journal of Education and Training Studies*, 6(4), 125–130. <https://doi.org/10.11114/jets.v6i4.2980>
- Holbrook, J., & Rannikmae, M. (2009). The meaning of scientific literacy. *International Journal of Environmental and Science Education*, 4(3), 275–288. <https://doi.org/10.1080/09500690601007549>
- Jacob, S. M., & Sam, H. K. (2008). Measuring critical thinking in problem solving through online discussion forums in first-year university mathematics. *Imecs 2008: International Multiconference of Engineers and Computer Scientists*, Vols I and II, I, 816–821.
- Laurens, T. (2010). Penjenjangan Metakognisi Siswa yang Valid dan Reliabilitas. *Jurnal Pendidikan Dan Pembelajaran*, 17(2), 201–213.
- Lisdianto, D., Masykuri, M., & Aminah, N. S. (2015). Pengembangan Integrated Contextual Module (ICM) Untuk Meningkatkan Kreativitas Dan Kemampuan Berpikir Kritis Siswa Smk Pada Pokok Bahasan Sifat Mekanik Bahan (Pembelajaran Fisika Di SMK Veteran 1 Sukoharjo Tahun Ajaran 2014/2015). *Jurnal Inkuiri*, 4(4), 2252–7893. Retrieved from <http://jurnal.fkip.uns.ac.id/index.php/sains>
- OECD. (2004). The PISA 2003 Assessment Framework. *Oecd*, 194. <https://doi.org/10.1787/9789264101739-en>
- Ogunkola, B. J. (2013). Scientific Literacy: Conceptual Overview, Importance, and Strategies for Improvement. *Journal of Educational*

- and Social Research, 3(1), 265–274.
<https://doi.org/10.5901/jesr.2013.v3n1p265>
- Rachmatullah, A., Diana, S., & Rustaman, N. Y. (2016). Profile of middle school students on scientific literacy achievements by using scientific literacy assessments (SLA). AIP Conference Proceedings, 1708(2016).
<https://doi.org/10.1063/1.4941194>
- Rahmat Rasmawan. (2017). Profil Keterampilan Kerja Ilmiah dan Berpikir Kritis Siswa SMA di Kalimantan Barat. Edusains, 9(1), 60–70.
<https://doi.org/http://dx.doi.org/10.15408/es.v9i1.4417>
- Rompayom, P., Tambunchong, C., Wongyounoi, S., & Dechsri, P. (2010). The Development of Metacognitive Inventory to Measure Students' Metacognitive Knowledge Related to Chemical Bonding Conceptions. International Association for Educational Assessment (IAEA 2010), (Iaea), 1–7. Retrieved from <http://selectscore.com/fullpaper/221.pdf>
- Rusilowati, A., Kurniawati, L., Nugroho, S. E., & Widiyatmoko, A. (2016). Developing an instrument of scientific literacy assessment on the cycle theme. International Journal of Environmental and Science Education, 11(12), 5718–5727.
- Schraw, G. (1998). Promoting general metacognitive awareness. Instructional Science, 26(1), 113–125.
<https://doi.org/10.1023/A:1003044231033>
- Supeno, S., Subiki, S., & Rohma, L. W. (2018). Students' Ability In Solving Physics Problems on Newtons' Law of Motion. Jurnal Ilmiah Pendidikan Fisika Al-Biruni, 7(1), 59–70.
<https://doi.org/10.24042/jipfalbiruni.v7i1.2247>
- Udeani, U. (2013). Quantitative Analysis of Secondary School Biology Textbooks for Scientific Literacy Themes. Research Journal in Organizational Psychology & Educational Studies, 2(1), 39–43.
- Warni, Sunyono, & Rosidin. (2018). Measuring metacognitive ability based on science literacy in dynamic electricity topic Measuring metacognitive ability based on science literacy in dynamic electricity topic. Journal of Physics: Conference Series, 948.
<https://doi.org/10.1088/1742-6596/948/1/012041>
- White, B. B., Stains, M., Escriu-sune, M., Medaglia, E., & Rostamjad, L. (2011). A Novel Instrument for Assessing. Journal of College Science Teaching, 40, 102–107.
- Yanti, H., Distrik, I. W., Khasyyatillah, I., & Khasyyatillah, I. (2017). Profile of Senior High School Metacognitive Ability in Solving Problems of Abstraction on Physics Material. Jurnal Ilmiah Pendidikan Fisika Al-Biruni, 6(2), 241.
<https://doi.org/10.24042/jipfalbiruni.v6i2.2061>
- Yuniasti, A., & Wulandari, R. (2018). The Relationship Between Verbal Ability and Critical Thinking Skill: The Implementation of Susan Loucks Horsley Model. Jurnal Ilmiah Pendidikan Fisika Al-Biruni, 07(April), 89–97.
- Zhang, L., & Kim, S. (2018). Critical Thinking Cultivation in Chinese College English Classes. English Language Teaching, 11(8), 1.
<https://doi.org/10.5539/elt.v11n8p1>

SYNTHESIS AND CHARACTERIZATION OF THE MICROSTRUCTURE AND FUNCTIONAL GROUP BOND OF Fe₃O₄ NANOPARTICLES FROM NATURAL IRON SAND IN TOBELO NORTH HALMAHERA

Ferni Malega¹, I Putu Tedy Indrayana*², Edi Suharyadi³

¹ Physics Study Program, Universitas Halmahera, North Maluku, Indonesia

^{2, 3} Physics Department, Faculty of Mathematics and Science, Universitas Gadjah Mada, Yogyakarta, Indonesia

*Correspondence address: tedyindrayana@gmail.com

Received: June 26th, 2018. Accepted: October 24th, 2018. Published: October 28th, 2018

Abstract: The Fe₃O₄ nanoparticles have been successfully synthesized from natural iron sand by using coprecipitation method at a temperature of 56°C. The elemental identification, structural characterization, and bonding analysis were carried out using XRF, XRD, and FTIR, respectively. The sample nanoparticles contain elements of Al, P, Ca, Ti, V, Cr, Mn, Ni, Cu, Zn, Rb, Re, Bi, and Fe. The composition of Fe element is 87.37%. The sample of the nanoparticle exhibited as the Fe₃O₄ which was shown by the diffraction pattern that belongs to a cubic spinel structure of Fe₃O₄. The crystallite size of the nanoparticle is 42.25 ± 0.42 nm. The lattice parameter was found at 8.384 ± 0.049 Å. The crystallite density is 5.232×10^3 kg/m³ while the lattice strain is 1.413×10^{-3} /line. The FTIR spectra confirm that the existence of Fe-O stretching vibration in the range frequency of 658 cm⁻¹-506 cm⁻¹.

© 2018 Physics Education, UIN Raden Intan, Lampung, Indonesia.

Keywords: Characterization, coprecipitation, microstructure, iron sand, synthesis.

INTRODUCTION

Ferrite (MFe₂O₄) is one group of oxide materials that for three decades has received a lot of attention from researchers to study. This is because ferrite nanoparticles have unique physical properties, including unique mechanical, optical, electrical, acoustic, and magnetic properties compared to other material groups. Ferrite chemical properties such as the stability of chemical reactions and photocatalysis are also unique (Jaswal, Singh, & Jaswal, 2014).

Ferrite materials are in various forms, such as nanoparticles, nanoribbons,

nanosheets, and nanowires. Nanoparticles are a form of ferrite material in the form of particles with various morphologies, for example like solid balls.

One example of ferrite nanoparticles is magnetite (Fe₃O₄). The Fe₃O₄ nanoparticles consist of divalent cation Fe²⁺ and trivalent Fe³⁺ cations. This nanoparticle has an inverse spinel crystal structure with the formula of cation distribution that is (Fe³⁺)_{tet} [Fe²⁺ Fe³⁺]_{octa} O₂⁻⁴ (Rani & Varma, 2015). The geometry of the crystal structure of Fe₃O₄ nanoparticles can be illustrated in Figure 1.

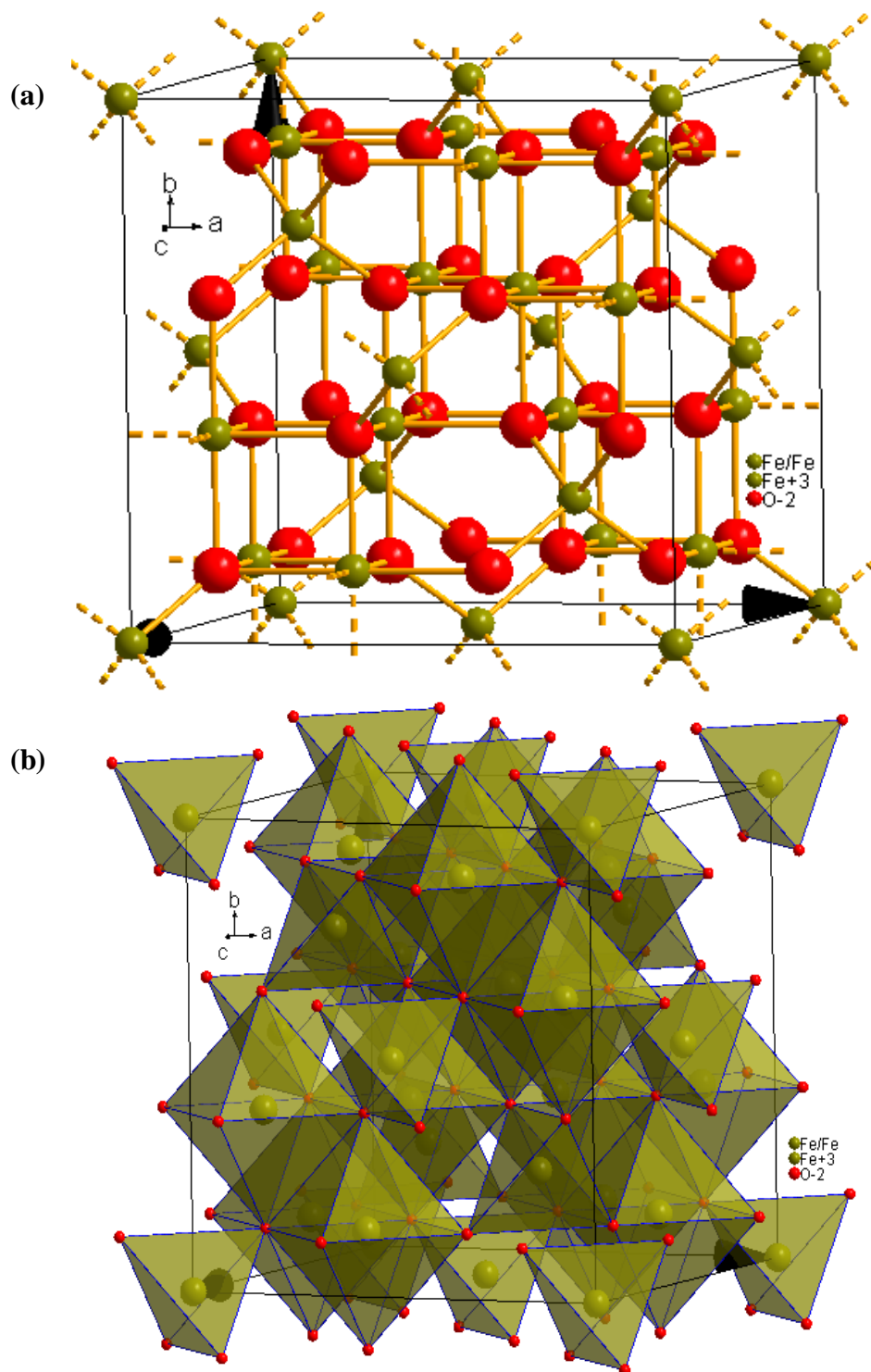


Figure 1. Crystal structure inverse spinel Fe_3O_4 : (a) crystal structure of Fe_3O_4 , (b) octahedral and tetrahedral sub lattice structures (Montoro, 1938)

Based on its physical and psychochemical properties, the Fe_3O_4 nanoparticles have various potential applications. In the medical field, the Fe_3O_4 can be used as a contrast agent for MRI images, drug delivery agents, and

cancer thermotherapy agents. In the environmental field, the Fe_3O_4 can be used as catalysis to reduce organic and inorganic compounds found in contaminated liquid substances. In this field, the Fe_3O_4 can also be used as a

magnetic adsorbent for dissolved heavy metal ions in a liquid (Li et al., 2010; Tang & Lo, 2013; Xu et al., 2012). In the field of electronics and instrumentation, the Fe_3O_4 can be applied as the main material in the manufacture of inductor coils, electromagnetic wave coating materials, and microwave absorber (Valenzuela, 2012).

The superior physical and chemical properties of Fe_3O_4 nanoparticles are influenced by various factors, such as microstructure, grain morphology structure and particle size (Jianling, Decai, Shaolan, Hongchao, & Cui, 2011). Microstructure factors include crystal structure, length of crystal lattice parameters, lattice defects, and crystal density, including the various phases of the nanoparticles. The microstructure factor is influenced by several factors, namely the type of starting material, synthesis method, precursor mole composition, synthesis temperature, and additional heat treatment such as annealing, sintering, or calcination (Mascolo, Pei, & Ring, 2013).

Various methods have been used to synthesize Fe_3O_4 nanoparticles, such as coprecipitation (Frey, Peng, Cheng, & Sun, 2009; Jianling et al., 2011; Mascolo et al., 2013; Wang, Wei, & Qu, 2013) thermal decomposition and metal reduction reactions (Taufiq, Triwikantoro, Pratapa, & Darminto, 2008). The coprecipitation method is the easiest chemical method to do compared to other methods because the co-precipitation method does not involve a high synthesis temperature ($> 150^\circ\text{C}$), a long synthesis time, and the process is not complicated (Nuzully, Kato, Iwata, & Suharyadi, 2013).

The use of coprecipitation method in the synthesis of Fe_3O_4 nanoparticles involves precursors in the form of anhydrous metal salt compounds (metal salt), such as $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ as providers of Fe^{3+} and $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ cations as providers

of Fe^{2+} , or $\text{Fe}_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$ cations as Fe^{2+} providers (Dewi, Puji, & Suharyadi, 2014; Triwikantoro, Yahya, & Darminto, 2011). The synthetic anhydrous compounds can be replaced with natural materials such as iron sand containing Fe^{2+} and Fe^{3+} metals. Several studies have succeeded in synthesizing Fe_3O_4 nanoparticles using natural materials of iron sand, such as (A. Taufik et al., 2017; Bilalodin, Sunardy, & Effendy, 2013; Setiadi et al., 2016; Taufiq et al., 2008; Triwikantoro et al., 2011).

In this research, Fe_3O_4 nanoparticles will be synthesized from natural materials of iron sand found in Wari Ino Beach, Tobelo Subdistrict, North Halmahera as precursors in providing Fe^{2+} and Fe^{3+} ions. The availability of iron sand in Wari Ino Beach is very abundant, and until now there has been no research that covers the metal mineral content of iron Fe^{2+} and Fe^{3+} , especially using them as a base for the synthesis of Fe_3O_4 nanoparticles. Information about the mineral content of iron sand from Wari Ino Beach is very interesting to study, and the process of synthesizing Fe_3O_4 nanoparticles using those sand needs to be done in the framework of its application for various fields, especially the environment. Microstructure studies of Fe_3O_4 nanoparticles from iron sand are important to be carried out in order to provide empirical justification of their physical and chemical properties.

This study focuses on the synthesis and microstructure studies of Fe_3O_4 nanoparticles including crystal structure, lattice parameters (lattice parameters), crystal spacing, X-ray density, lattice strain, and texture coefficient.

METHOD

Apparatus and Materials

The apparatus used to synthesize Fe_3O_4 nanoparticles are 250 ml beaker, 100 ml beaker, spatula rod, drop pipette, pour bottle, petri dish, magnetic hot plate, oven, thermometer, pH meter, and digital scales.

The characterization tools used for the identification of elemental composition, the crystal structure and functional group bonds of nanoparticle are X-Ray Fluorescence (XRF), X-Ray Diffractometer (XRD) and Fourier Transform Infrared (FTIR) Spectrophotometer, consecutively. The material used for the synthesis of Fe_3O_4 nanoparticles is iron sand from Wari Ino Beach.

Sample Preparation Procedure

The synthesis process of Fe_3O_4 nanoparticles can be illustrated such as Figure 2. The process was started by dissolving iron sand (total mass of 10 grams) into 20 ml HCl (6M) and stirred while heating at 70°C for 30 minutes on a hot plate stirrer with the aim of forming a solution of FeCl_3 and FeCl_2 . A total of 3.0 grams of NaOH were dissolved in 20 ml of

distilled water. The NaOH solution was heated for 10 minutes after being sterilized for 15 minutes. The iron sand solution is dropped into a NaOH solution using a dropping pipette while being sterilized and heated with a synthesis temperature of 56°C .

After an hour, black deposits will form. The temperature of this precipitate is naturally derived until it reaches thermal equilibrium with room temperature. The precipitate was rinsed with distilled water and deposited again on a permanent magnet for 30 minutes. The rinsing process is carried out five times. The precipitate is then in the oven at a temperature of 100°C for 3 hours. This slurry heating process will produce solid pieces which are a collection of Fe_3O_4 nanoparticles. The chips are crushed to produce nanoparticle powder which is further characterized.

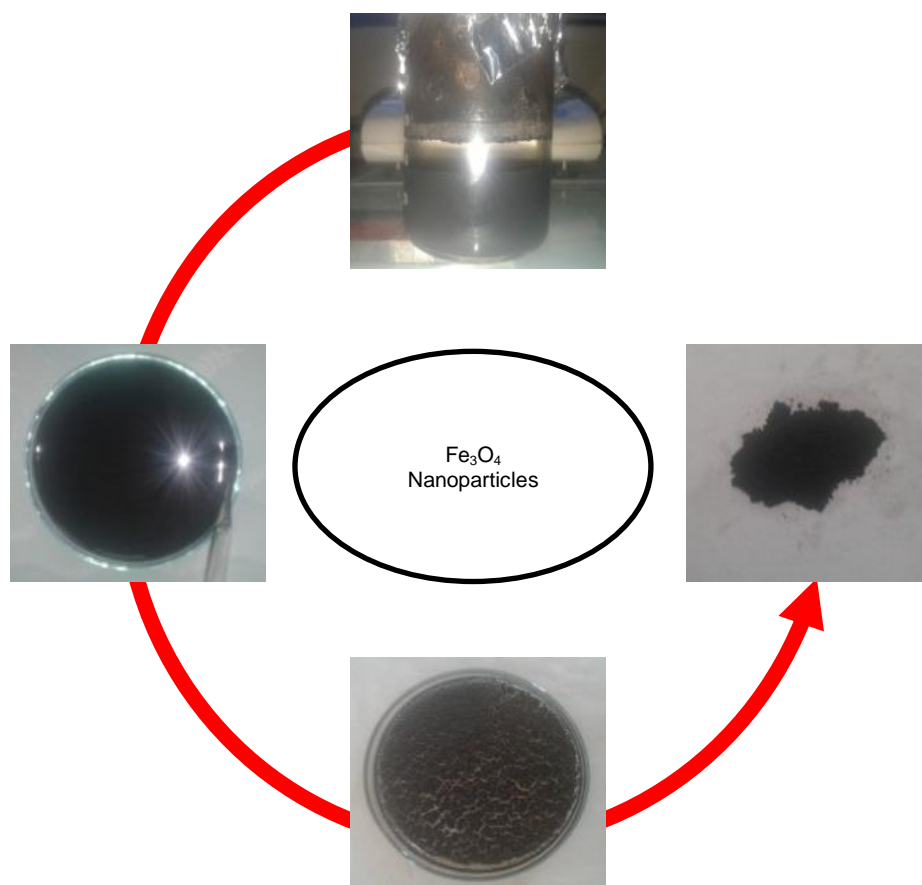


Figure 2. The process of synthesis of Fe_3O_4 samples.

Characterization of Nanoparticles

The elemental composition of the samples was identified using the XRF instrument. Characterization of a microstructure of nanoparticles including crystal structure, lattice parameters, crystal spacing distance, X-ray density, lattice strain, and texture coefficient was carried out using XRD. Nanoparticle functional groups were characterized using FTIR.

RESULTS AND DISCUSSION

Qualitative Description of Fe₃O₄ Nanoparticles

The sample obtained from the synthesis of Fe₃O₄ nanoparticles in the form of fine black powder. The black color is one of the characteristics of Fe₃O₄ nanoparticles. In addition, other characteristics have also been observed, namely the response of powder nanoparticles when tested with an external magnet. Powder nanoparticles

experience a magnetic attraction to external magnets.

The Elemental Composition of Fe₃O₄

The XRF characterization results of Fe₃O₄ nanoparticle samples provide information regarding the type and composition of the elements contained in the sample. The types of these elements are determined based on characteristic X-ray energy radiated by the atoms contained in the material. Meanwhile, the element composition is indicated by the peak height of the spectra as shown in Figure 3.

The XRF spectra confirmed the presence of fourteen types of elements contained in Fe₃O₄ nanoparticle samples, namely aluminum (Al), phosphorus (P), calcium (Ca), titanium (Ti), vanadium (V), chromium (Cr), manganese (Mn), Iron (Fe), Nickel (Ni), copper (Cu), Zinc (Zn), Rubidium (Rb), rhenium (Re) and bismuth (Bi) are presented in Table 1.

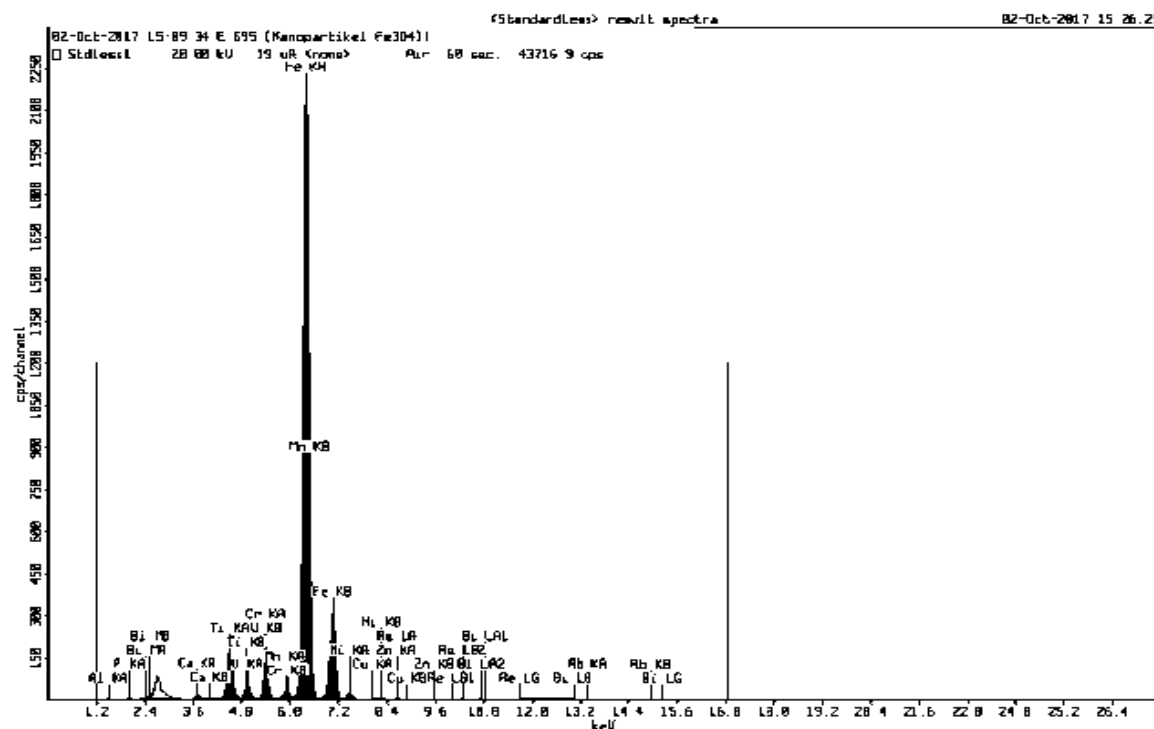


Figure 3. The XRF Spectra of Fe₃O₄ nanoparticles

According to the results, the most elemental content is iron (Fe) with an

elemental composition of 87.35%, while the least elemental content is zinc (Zn)

with an elemental composition of 0.08%. The composition of Fe metal in the sample results of this study is greater than the results obtained by (Bilalodin et al., 2013; Linda & Pratapa, 2014; Triwikantoro et al., 2011). (Triwikantoro et al., 2011) used the coprecipitation synthesis method at 80°C for an hour and produced Fe₃O₄ samples with Fe content of 76.92%. Bilalodin et al. (2013) obtained a Fe content of 21.00%. Meanwhile, Kartika and Pratama (2014) using the dissolved metal method of hydrochloric acid produced Fe₃O₄ samples with Fe composition of 87.00%. The difference in results can be caused by differences in synthesis methods and synthesis parameters used in producing Fe₃O₄ nanoparticles. Therefore, the selection of the right synthesis method and the value of the synthesis parameter is very influential mainly on the composition and physical properties of Fe₃O₄ produced.

Table 1. Elemental composition of sample

No	Element	Composition (%)
1	Al	1.00
2	P	0.26
3	Ca	0.61
4	Ti	4.73
5	V	0.63
6	Cr	1.75
7	Mn	0.56
8	Fe	87.35
9	Ni	1.34
10	Cu	0.14
11	Zn	0.08
12	Rb	0.46
13	Re	0.20
14	Bi	0.68

Based on the results in Table 1, the Fe₃O₄ nanoparticles still contained impurities such as Al, P, Ca, Ti, V, Cr, Mn, Ni, Cu, Zn, Rb, Re, and Bi. This states that the process of separating magnetic iron material with nonmagnetic elements has not yet occurred optimally. The existence of these elements does not significantly

affect the physical and psycho-chemical properties of Fe₃O₄ nanoparticles.

The Microstructural properties of Fe₃O₄

X-ray diffraction test was carried out to identify the microstructure and crystal structure of Fe₃O₄ nanoparticles which included crystallite size, lattice parameters, crystal density, lattice strain, and texture coefficient. X-ray diffraction data of Fe₃O₄ samples were adjusted to the standard data of Joint Committee Powder Diffraction Standard (JCPDS) no. 11-0614.

The X-ray diffraction test results of Fe₃O₄ nanoparticles give data in the form of 2θ diffraction angle and intensity. The diffraction pattern was plotted by using Origin 9.0 for Windows software as shown in Figure 4. The diffraction pattern shows the existence of seven diffraction peaks. The seven diffraction peaks state the electron diffraction process that occurs in the diffraction (hkl) plane of Fe₃O₄ nanoparticles, namely fields (220), (311), (400), (422), (511), (440), and (533) which are characteristics of Fe₃O₄ nanoparticle diffraction pattern according to JCPDS standard data 11-0614. In this diffraction pattern, no diffraction peaks were found in phases other than Fe₃O₄, so it can be concluded that the pure synthesized samples consisted of Fe₃O₄ nanoparticles.

The calculation results of the crystal lattice of Fe₃O₄ nanoparticle approach the standard value according to JCPDS number 11-0614, which is 8.34 ± 0.049 Å. This value is equivalent to the results of research by Darminto et al (2011), Setiadi et al (2016) and the standard value of the JCPDS data is 8.396 Å. The volume of the Fe₃O₄ crystal lattice is 0.589×10^{-27} m³. The average size of Fe₃O₄ nanoparticles is 24.25 ± 0.042 nm. The crystal lattice density (ρ_x) Fe₃O₄ is 5.232×10^3 kg/m³ and the strain value that occurs in the lattice (ϵ) is 1.413×10^{-3} /line.

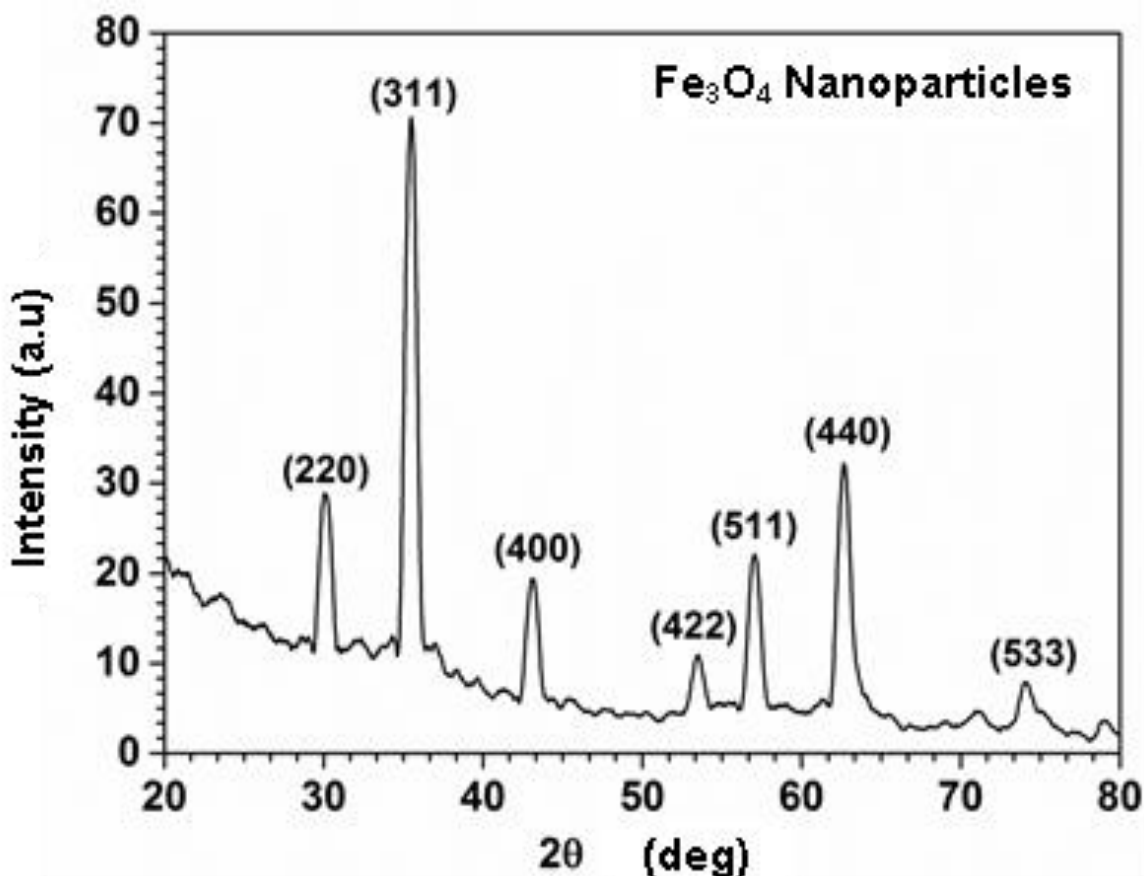


Figure 4. The XRD pattern of Fe_3O_4 nanoparticles

The degree of crystallinity of Fe_3O_4 samples can be identified based on data of texture coefficient (TC) of relating diffraction peak (hkl). Figure 5 shows the TC value (hkl) for each orientation direction of Fe_3O_4 nanoparticles crystal grains. The results of calculation of TC values (hkl) diffraction peaks in fields (220), (311), (400), (422), (511), (440) and (533) respectively (0.9), (2, 3), (0.7), (0.4),

(0.8), (1.2) and (0.6). From the calculation of the TC (hkl) value there are five diffraction peaks which have a TC value (hkl) smaller than 1 of them namely the diffraction peaks of the fields (220), (440), (422), (511) and (533) indicates that the growth of Fe_3O_4 nanoparticles at the diffraction peak tends to be very low and the direction of the crystal grain orientation is not regular.

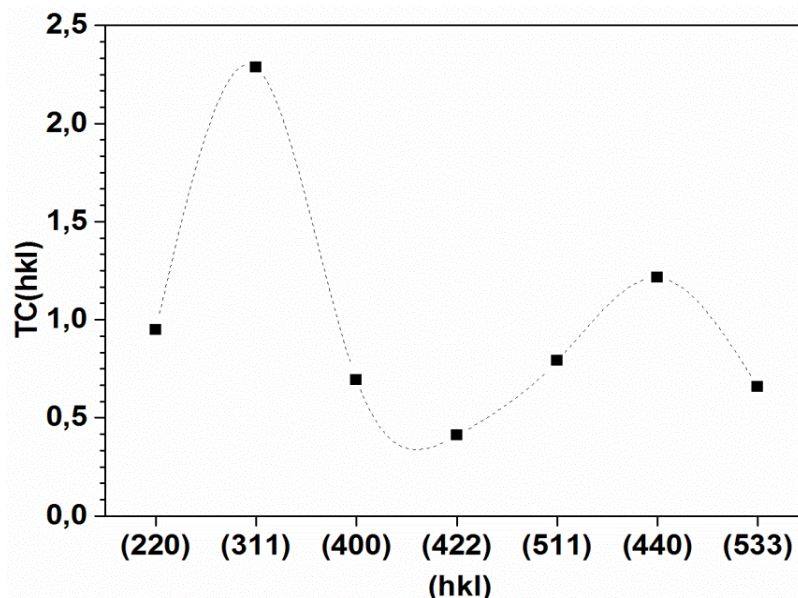


Figure 5. Texture coefficient of the XRD peaks of the Fe₃O₄ nanoparticle

4. Functional Groups Bonds of Fe₃O₄

The Fourier Transform Infrared Spectroscopy (FTIR) test results provide information about the infrared spectra absorption profile on Fe₃O₄ nanoparticle samples. Characterization of Fe₃O₄ nanoparticles FTIR was carried out for the 500 cm⁻¹- 4000 cm⁻¹ wavenumber interval. The data plot transmits the wave number of infrared light in the form of sharp absorption peaks in certain wavenumbers resulting from the vibration of certain functional groups, as shown in Figure 6 and Table 2.

The stretching vibration of Fe-O functional groups occurs for absorption of infrared wavenumbers in the range 506 cm⁻¹- 658 cm⁻¹. These results are consistent with the findings of (Setiadi et al., 2016). In the wave number interval 1672 cm⁻¹ - 1367 cm⁻¹ it is identified the occurrence of bending vibration of the H-O-H group, while the O-H group vibrates stretching at a wave number interval of 3028 cm⁻¹- 3400 cm⁻¹. At wave number interval 2920 cm⁻¹ - 2855 cm⁻¹, stretching vibration of C-H group is identified.

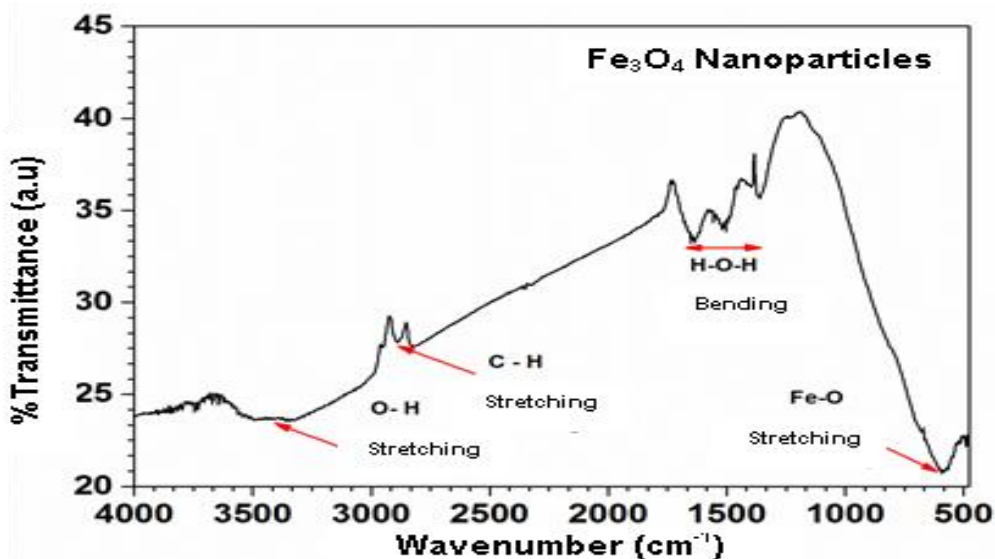


Figure 6. The FTIR Spectra of Fe₃O₄ nanoparticle

Table 2. Functional group bonds of Fe₃O₄ nanoparticles

No	Wavenumber (cm ⁻¹)	Functional group
1	658 – 506	Fe – O stretching
2	1672 – 1367	H – O – H bending
3	3028 – 3400	O – H stretching
4	2920 – 2855	C – H stretching

CONCLUSION

The Fe₃O₄ nanoparticles have been successfully synthesized using the coprecipitation method at 56°C. The Fe₃O₄ samples synthesized from the iron sand of Wari Ino Beach contain elements of Fe at 87.35%. The Fe₃O₄ nanoparticles have a spinel cubic crystal structure. The average crystallite size (*t*) of Fe₃O₄ nanoparticles was 24.25 ± 0.42 nm, and the crystal lattice (*a_{ex}*) parameter value was 8.34 ± 0.049 Å. The appearance of stretching vibration of the Fe-O functional group at a wave number of 658 cm⁻¹ - 506 cm⁻¹ also shows the success of the formation of Fe₃O₄ nanoparticles.

ACKNOWLEDGMENTS

The author would like to thank the staff of Laboratorium IPA Terpadu Universitas Halmahera for providing opportunities using the research facilities, staff of the Mineral Laboratory and Advanced Materials of the Mathematics and Natural Sciences Faculty of Malang State University which helped provide facilities for characterizing Fe₃O₄ nanoparticles, as well as the Magnetic Nanomaterial Research Group UGM for providing the materials.

REFERENCES

A. Taufik, R.E. Saputro, Sunaryono, N. Hidayat, A. Hidayat, N. Mufti, & H. Nur. (2017). Fabrication of Magnetite Nanoparticles Dispersed in Olive Oil and Their Structural and

Magnetic Investigations. In IOP Conf. Series: Materials Science and Engineering (p. 9). Malang: IOP Publishing Ltd.
<https://doi.org/10.1088/1757-899X/202/1/012008>.

Bilalodin, Sunardy, & Effendy, M. (2013). Analisis Kandungan Senyawa Kimia dan Uji Sifat Magnetik Pasir Besi Pantai Ambal. *Jurnal Fisika Indonesia*, 17, 29–31.

Dewi, S., Puji, F., & Suharyadi, E. (2014). Studi Penurunan Kadar Logam Fe dan Co pada Limbah Cair dengan Sistem Purifikasi Berbasis Adsorben Nanopartikel Magnetik Fe₃O₄. *Jurnal Fisika Indonesia*, 18, 16–19.

Frey, N. A., Peng, S., Cheng, K., & Sun, S. (2009). Magnetic Nanoparticles: Synthesis, Functionalization, and Applications in Bioimaging and Magnetic Energy Storage. *Chemical Society Review*, 2532–2542.
<https://doi.org/10.1039/b815548h>.

Jaswal, L., Singh, B., & Jaswal, L. (2014). Ferrite materials: A Chronological Review. *Journal of Integrated Science & Technology*, 2(2), 69–71.

Jianling, L. I., Decai, L. I., Shaolan, Z., Hongchao, C. U. I., & Cui, W. (2011). Analysis of the Factors Affecting the Magnetic Characteristics of Nano-Fe₃O₄ Particles. *Chinese Science Bulletin*, 56(8), 803–810.
<https://doi.org/10.1007/s11434-010-4126-z>.

Li, J., Fan, M., Brown, R. C., Van, J. H., Wang, J., Wang, W., & Song, Y. (2010). Synthesis, Properties, and Environmental Applications of Nanoscale Iron-Based Materials: A Review. *Critical Reviews in Environmental Science and Technology*, 36, 37–41.

Linda, D., & Pratapa, S. (2014). Sintesis Fe₂O₃ dari Pasir Besi dengan Metode Logam Terlarut Asam Klorida. *Jurnal Sains Dan Seni Pomits*, 3(2), 33–35.

- Mascolo, M. C., Pei, Y., & Ring, T. A. (2013). Nanoparticles in a Large pH Window with Different Bases. *Materials*, 6, 5549–5567. <https://doi.org/10.3390/ma6125549>.
- Montoro. (1938). Miscibilita Fra Gli Ossidi Salini di Ferroe di Manganese. *Gazzetta Chimica Italiana*, 68, 728–733.
- Nuzully, S., Kato, T., Iwata, S., & Suharyadi, E. (2013). Pengaruh Konsentrasi Polyethylene Glycol (PEG) pada Sifat Kemagnetan Nanopartikel Magnetik PEG-Coated Fe₃O₄. *Jurnal Fisika Indonesia*, 17, 35–40.
- Rani, S., & Varma, G. D. (2015). Superparamagnetism and Metamagnetic transition in Fe₃O₄ Nanoparticles Synthesized via Coprecipitation Method at Different pH. *Physica B: Physics of Condensed Matter*. <https://doi.org/10.1016/j.physb.2015.05.016>.
- Setiadi, E. A., Sebayang, P., Ginting, M., Sari, A. Y., Kurniawan, C., Saragih, S. ., & Simamora, P. (2016). The synthesization of Fe₃O₄ Magnetic Nanoparticles Based on Natural Iron Sand by Coprecipitation Method for the Used of the Adsorption of Cu and Pb Ions. *Journal of Physics: Conference Series*. <https://doi.org/10.1088/1742-6596/776/1/012020>.
- Tang, S. C. N., & Lo, I. M. C. (2013). Magnetic nanoparticles : Essential Factors for Sustainable Environmental Applications. *Water Research*, 47(8), 2613–2632. <https://doi.org/10.1016/j.watres.2013.02.039>.
- Taufiq, A., Triwikantoro, T., Pratapa, S., & Darminto. (2008). Sintesis Partikel Nano Fe_{3-x}Mn_xO₄ Berbasis Pasir Besi dan Karakterisasi Struktur serta Kemagnetannya Sintesis Partikel Nano Fe_{3-x}Mn_xO₄ Berbasis Pasir Besi. *Jurnal Nanosains & Nanoteknologi*, 1(2).
- Triwikantoro, Yahya, & Darminto. (2011). Synthesis of Fe₃O₄ Nanoparticles from Iron Sands and Effects of Ni and Zn Substitution on Structures and Magnetic Properties. *Journal of Materials Science and Engineering A*, 1(2), 182–189.
- Valenzuela. (2012). Novel Applications of Ferrites. *Physics Research International*, 2012, 9. <https://doi.org/10.1155/2012/591839>.
- Wang, B., Wei, Q., & Qu, S. (2013). Synthesis and Characterization of Uniform and Crystalline Magnetite Nanoparticles via Oxidation-precipitation and Modified coprecipitation Methods. *International Journal of Electrochemical Science*, 8, 3786–3793.
- Xu, P., Ming, G., Lian, D., Ling, C., Hu, S., & Hua, M. (2012). The Use of Iron Oxide Nanomaterials in Wastewater Treatment : A Review. *Science of the Total Environment*, 424, 1–10. <https://doi.org/10.1016/j.scitotenv.2012.02.023>.

DEVELOPMENT OF PHOTONOVELA WITH CHARACTER EDUCATION: AS AN ALTERNATIVE OF PHYSICS LEARNING MEDIA

Farida Ariyani*¹, Taras Nayana², Antomi Saregar³, Yuberti⁴, Agitha Pricilia⁵

^{1,5} Faculty of Education and Teacher Training, University of Lampung, Lampung, Indonesia

^{2,3,4} Physics Education Department, Universitas Islam Negeri Raden Intan, Lampung, Indonesia

*Correspondence address: dulifarida@gmail.com

Received: June 14th, 2018. Accepted: October 07th, 2018. Published: October 28th, 2018

Abstract: The internalization of character education in science learning through a variety of learning media has been researched recently, one of which is through the photonovela media which is the medium of insertion of character values in learning material. The focus of this research is; 1) developing photonovela learning media with character education on work material and energy, 2) knowing photonovela media feasibility as a supplement to physics learning with character education on work material and energy 3) knowing the response of students to photonovela media with character education in an energy material. This research is a Research and Development study adopted the development of Borg and Gall with the subject of junior high school students. The research instruments used were questionnaires by material experts, media experts, and junior high school physics teachers and questionnaires for students' responses in the three schools. The results of the assessment by material experts obtained a percentage of 85%, the assessment of media experts was 90%, and the assessment of junior high school teachers was 84.16%, while the response of students in three junior high schools was 87.6%, 94%, and 93.6%. In conclusion, this study produced a product in the form of appropriate photonovela media as a supplement to physics learning with character education on business material and energy.

© 2018 Physics Education, UIN Raden Intan, Lampung, Indonesia.

Keywords: character education, media photonovela, work, and energy.

INTRODUCTION

The values of character education can be developed, integrated and internalized with students through the learning process, including in physics learning (Anwar, 2017; Diani, 2015; Khoiron & Sutadji, 2012; Maiyena, 2013; Nurhuda, Waluyo, & Suyitno, 2017). Physics is known as science that is very closely related to human behavior and life (Saregar, 2016; Venisari, Gunawan, & Sutrio, 2015). This shows that the competencies students must possess are not only limited to cognitive abilities but also the character of students (Sole & Anggraeni, 2016; Widyaningsih & Yusuf, 2015). While all this time learning physics still focuses on cognitive aspects only (Mujizatullah, 2018).

The problem of most students is that physics is difficult to understand (Chhetri, 2017; Hofer, Schumacher, Rubin, & Stern, 2018; Irmawati, Djalaluddin, & Wahyuni, 2017; Irwandani, Latifah, Asyhari, Muzannur, & Widayanti, 2017; Rosdianto, Murdani, & Hendra, 2017; Sugiana, Harjono, & Sahidu, 2016), one of the causes is the lack of proper use of learning media used by teachers (Agustin, Bektiarso, & Bachtiar, 2018), so students can hardly observe the mechanism that occurs during learning activities (Weng, Lin, & She, 2017), preferably the previous learning conditions should be improved (Saregar, Latifah, & Sari, 2016), so students play an active role in the learning process (Haruehansawasin & Kiattikomol, 2018).

Education is currently facing the challenges of the fourth industrial revolution or Industry 4.0 (Ciffolilli & Muscio, 2018). The teacher as a facilitator must be skilled in mastering various models and learning media that are in accordance with the characteristics of the material to be delivered (Barus & Sani, 2017; Suranti, Gunawan, & Sahidu, 2016; Suryani, Sakti, & Purwanto, 2018), using or making interesting learning media, so learning materials are easy to understand (Ardiyanti, Usman, & Bandu, 2018; Saregar, Diani, & Kholid, 2017; N. Sari, Suryanti, Manurung, & Sintia, 2017; Suyanto, 2018), and encourage students actively in the learning process (Abdurrahman, Saregar, & Umam, 2018).

The types of learning media that are relevant include; information technology-based learning media (I. A. D. Astuti, Nurullaeli, & Nugraha, 2018), and rack and pinion type media (Rubiyanto & Susanto, 2018), as well as other learning media that can be used to facilitate the learning process, in this case selected learning media to shape the character of students as learners, the selected media is photonovela learning media.

Photonovela is a media that resembles comics or picture stories, using photographs as a substitute for illustrated images (Anggia & Dra. An Fauzia Rozani Sy., 2014; Herdiani, Maskur, & Noordiana, 2017). The general characteristics of this media are some of them that; easy to make yourself in a simple manner, in accordance with the students' emotions and the theme in this media is based on the students' real conditions with the intention that students are easier to understand (Widyaningrum & Prihastari, 2018), then aim to determine the direction of learning activities, in order to be able to practice character values to students (Oktaviani, Yulkifli, & Murtiani, 2017; R. T. Sari & Jusar, 2017), one of the advantages of this media is that space and time limitations can be overcome (Yusro

& Sasono, 2016). So that the students will feel helping in the learning (E.P, Bektiarso, & Gani, 2017). So, the learning media occupies an important position as one of the supporting components in the learning system (Muslina, Abdul, & Ibnu, 2017; Ramadhanti, Edwita, & Sumantri, 2018; Setiawan, Arifin, & Ardianto, 2018; Widada & Rosyidi, 2017).

Photonovela media is not only used in the field of education but in the field of health media is often used as an alternative media, this is in accordance with previous research that produced local wisdom-based photonovela learning media on the subject of effective and practical Newton law (Rahayu, Sutikno, & Masturi, 2015), in the field of health explains photonovela is able to increase knowledge of depression and reduce stigma among Hispanic adults (Unger, Cabassa, Molina, Contreras, & Baron, 2013), then photonovela is able to increase knowledge, attitudes, and intentions of human papillomavirus vaccine in the community Hispanic income is low (Chan, Brown, Sepulveda, & Teran-Clayton, 2015). Furthermore, it can influence Dutch adults with varying levels of literacy to find out about diabetes by reading photonovela (Koops van 't Jagt et al., 2018).

Different from this research and development from previous research, researchers will develop photonovela media with character education, in the form of inserting character values on each material, then choosing different materials namely business and energy, as well as the conditions of different schools and places.

METHOD

Research Design

This research is a research and development that uses Borg & Gall procedural models. Procedural models are descriptive models that describe procedural steps that must be followed to produce products (Wicaksono, Roekhan, & Hasanah, 2018).

In the stages of development research consist of 10 development steps (Nugraha, 2017). The tenth steps are not all to be done, the researcher just adopt seven steps because they have answered the research

objectives that test the attractiveness and feasibility of learning media as a supplement to physics learning with character education. The seven-step procedure carried out by researchers is;

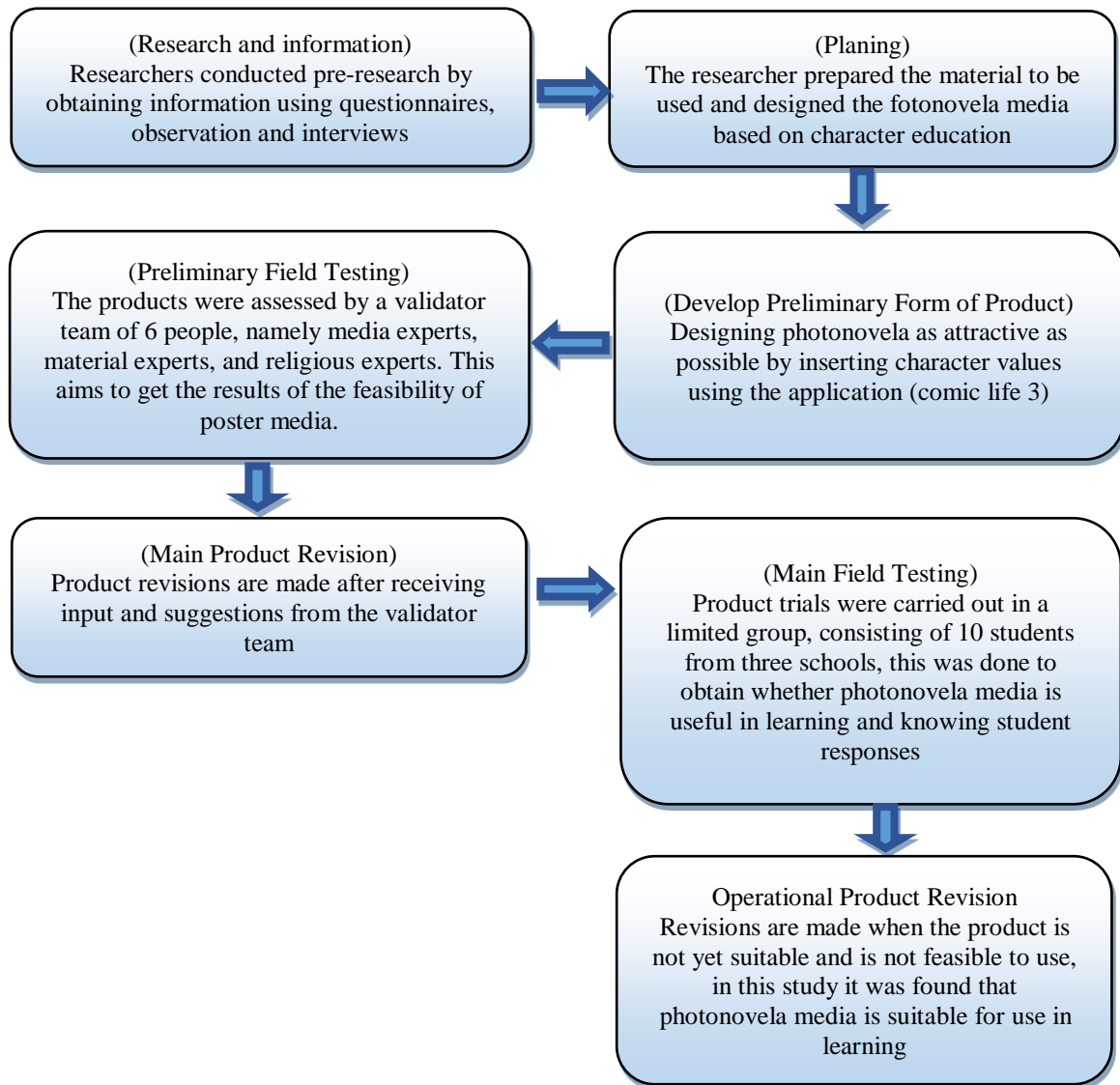


Figure 1. The research procedures of Borg and Gall

The results of the product are feasible or not, and student responses are measured using research instruments in the form of questionnaires by material experts, media experts, junior high school physics teachers and questionnaires for students' responses in the three schools.

Data Analysis

The data of research was collected using expert validation sheets, educator response sheets. The student response sheets and then the validation data were analyzed using a Likert scale (Adawiyah, Lesmono, & Prastowo, 2018).

Calculate the percentage of eligibility of each aspect with the Likert scale formula (Asyhari & Silvia, 2016):

$$N = \frac{\sum x}{\sum xi} x 100 \%$$

Information:

P = Persentase

$\sum x$ = Number of respondents' answers in 1 item

$\sum xi$ = Number of the ideal score in item

Rating Score

Changes in the results of the assessment of media experts, material experts, educators and responses of students from letters to scores are the provisions in the following figure 2;



Figure 2. Scoring rules

To determine the feasibility of photonovela media as a supplement to physics learning, it contains character education in business and energy material, namely by giving respondents respite.

The result of percentage score obtained from the study is interpreted on the scale of interpretation of criteria in the following Table 1;

Table 1. Scale of Intrepretation Criteria (Damayanti, Komikesari, Syafei, & Rahayu, 2018).

Persentase	Criteria
80% < P ≤ 100%	Very decent
60% < P ≤ 80%	Decently
40% < P ≤ 60%	Enough decent
20% < P ≤ 40%	Less decent
0 % ≤ P ≤ 20%	Very less decent

In Table 1 the scale of interpretation criteria the researchers can see the percentage of the results of the feasibility assessment or not the product to serve as a learning medium.

RESULTS AND DISCUSSION

Result of Research

The researcher presents the results of the products developed, namely the photonovela media as a supplement to physics learning with character education. The cover of photonovela media developed can be seen in the following figure 3;

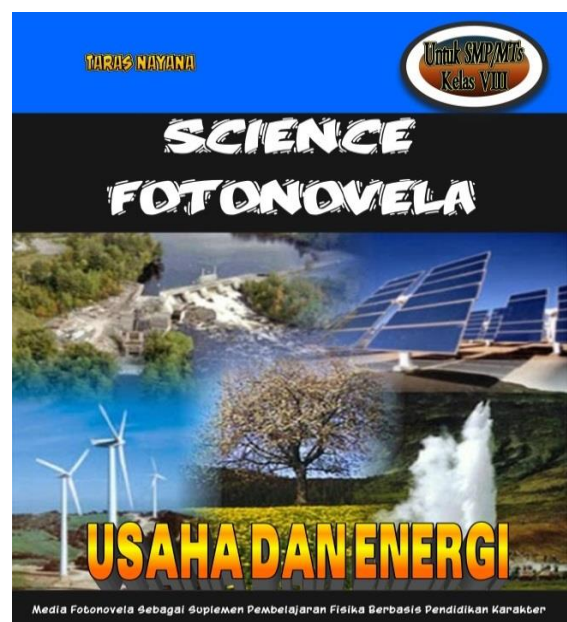


Figure 3. Cover media photonovela

Figure 3 is a photonovela cover developed. Photonovela media with the insertion of character values on energy material, using photographs obtained from the results of the shoot.

After the product was successfully developed and tested its feasibility by-product validation. The following are the results of the feasibility test;

Validation of Material Expert

The results of the validation of the material expert assessment on the product can be seen in the following figure 4;

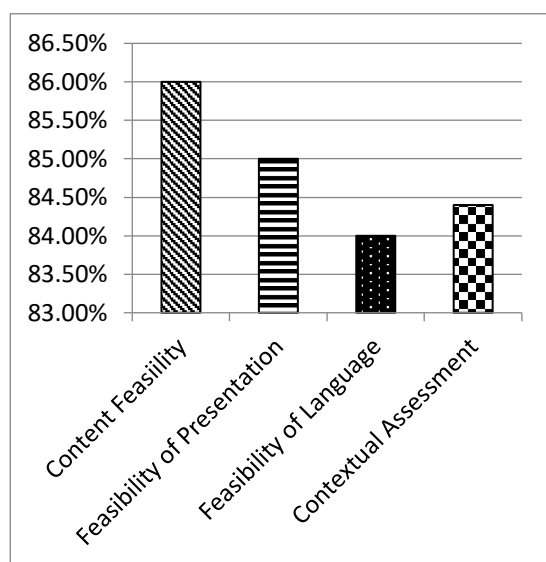


Figure 4. Percentage of material assessment

Based on Figure 4, the percentage of material expert validator evaluations on the aspect of content eligibility with business and energy material obtained a percentage of 86%, 85% percentage of the feasibility of presentation evaluation, 84.40% for language feasibility assessment, and 84 for the contextual assessment. 40%, all proceeds of the percentage are stated as very feasible.

Validation of Media Expert

The results of the validation of media expert judgment on the product can be seen in the following figure 5;

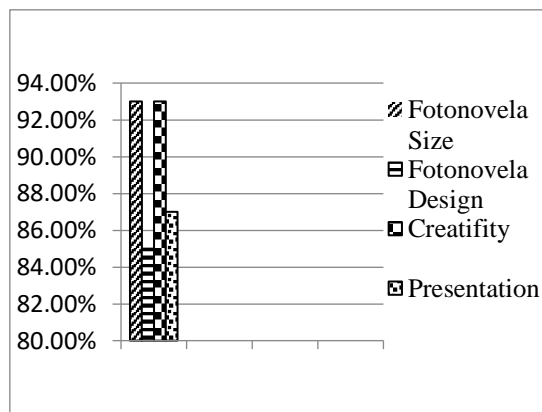


Figure 5. Results of evaluation by media experts

Based on Figure 5, the percentage of media expert validator evaluations on the photonovela size aspect obtained a percentage of 93%, the photonovela design assessment obtained a percentage of 85%, the creativity assessment got a percentage of 93%, and the percentage assessment was 87%, the very decent category expressed all percentage results.

Validation of SMP/MTs Educators in Three Schools

The results of validation by SMP Al-Huda Jati Agung, MTs Muhammadiyah Sukarame Bandar Lampung, and SMP N 1 Gisting, can be seen in the following figure 6;

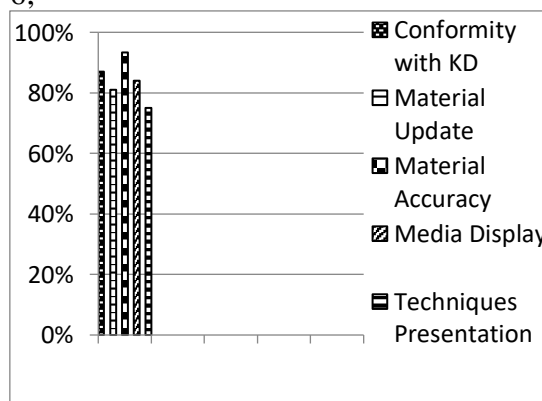


Figure 6. Results of validation by educators in Schools

Based on Figure 6, the percentage of the results of the three School educators' assessment of the material suitability aspects with basic competencies (KD) obtained a percentage of 87%,

the material assessment obtained a percentage of 81%, the assessment of the accuracy of the material obtained a percentage of 93.30%, evaluation of media appearance obtained percentage by 84%, the percentage results are expressed as very feasible, then the evaluation of the presentation technique is 75% with a decent category.

The response of Students in Three Schools

The results of trials on students can be seen in Figure 7 below;

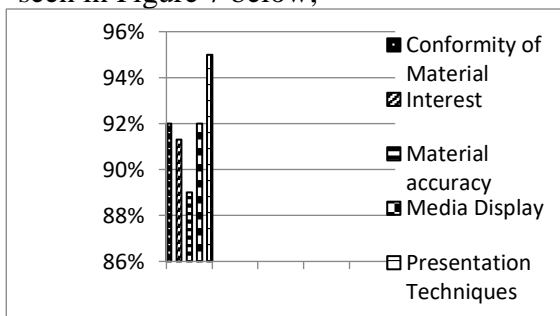


Figure 7. Results of the Response of Students in Schools

Based on Figure 7, the percentage of the results of field trials on students in the three schools in the material suitability aspects with basic competencies obtained a percentage of 92%, an interest assessment obtained a percentage of 91.30%, an assessment of the accuracy of the material obtained by 89%, an assessment of media appearance obtained percentage at 92%, then the assessment on the presentation technique obtained a percentage of 95% of the results of all percentages included in the very feasible category.

DISCUSSION

The results of a product that have been developed, namely photonovela learning media received a positive assessment by students as product users. Some product results can be seen in Figure 8 below,

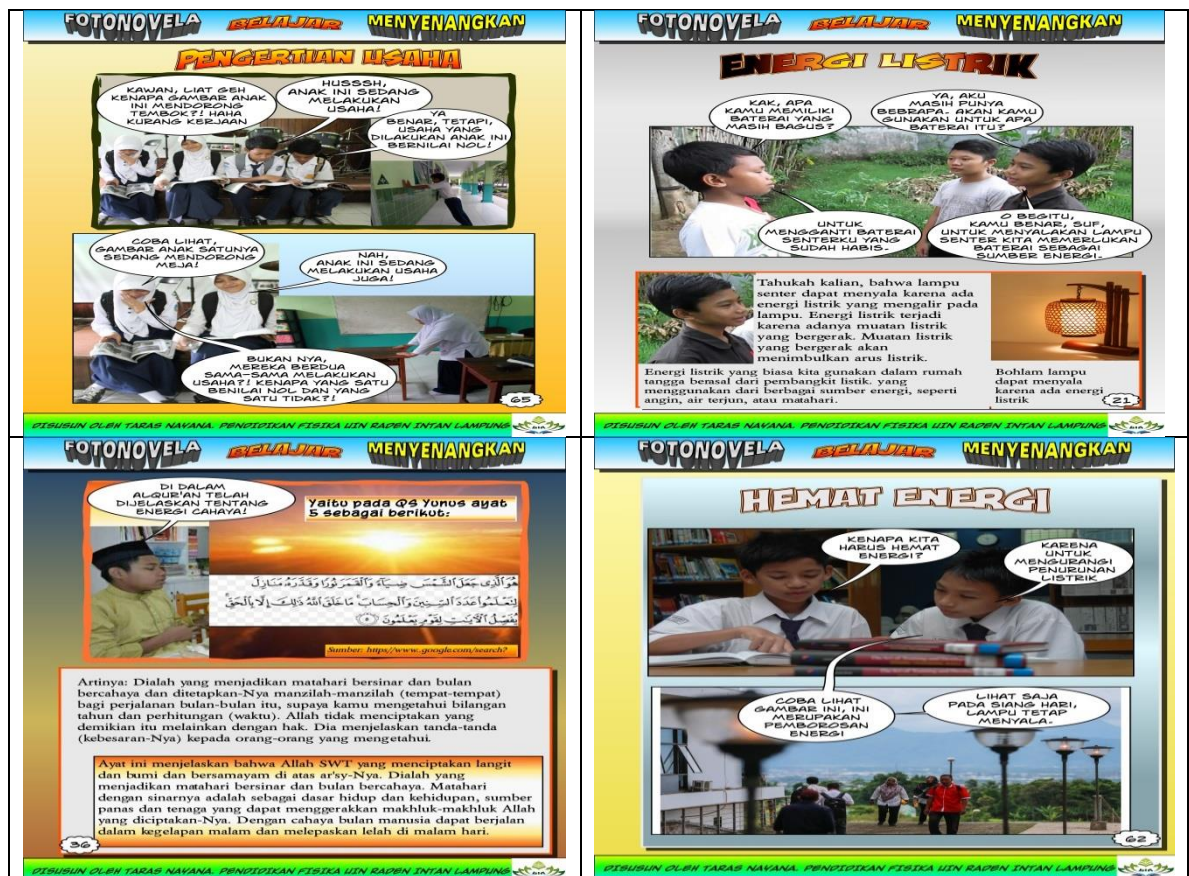


Figure 8. Footage of content on the results of photonovela media development

Figure 8, it shows that the product developed contains character values in business and energy material, using photographs obtained from the results of shooting and equipped with the material, examples of questions and evaluations that can be used in student learning to be more interesting. In accordance with its characteristics, the theme of the media is based on the real conditions of students with the aim that students more easily understand the material presented.

The products developed have been validated by six experts including three material experts and three media experts with the results of material validation, media expert validation, validation by junior high school / Madrasah educators in the three schools, and responses from students in all three schools. Then in each aspect of the assessment to obtain a percentage ranging from 75% to 95%, the products included in the category of decent to very feasible. Photonovela learning media helps students to be able to study physics material either independently, in groups or learning with teachers in class. Through this media students are not only required to obtain good cognitive values, but the insertion of character values in the media is able to influence student character education, where students not only understand the material presented but students naturally learn character values that able to educate students' behavior so that positive habits are embedded in each learning activity. In line with previous research was that succeeded in increasing students' motivation and creative thinking abilities using photonovela media (P. Astuti, 2017).

The advantages of photonovela learning media found after research include: 1) Photonovela can motivate students during the teaching and learning process; 2) Photonovela consists of images which are media that can improve the quality of learning; 3) Photonovela is

permanent and able to integrate character values through learning; 4) Photonovela can generate interest in reading and direct students to read discipline especially those who do not like to read; 5) Photonovela is part of popular culture.

The disadvantages of photonovela learning media found after research include: 1) Photonovela limits even allowing the killing of imagination; 2) Submission of subject matter through photonovela media is too simple and may be developed again; 3) The use of photonovela media is only effective in visual-style students.

CONCLUSION AND SUGGESTION

Conclusion

This research concluded that photonovela learning media with character education can provide a more interesting learning atmosphere by inserting character education each learning using photonovela media. Then photonovela learning media as a supplement to physics learning with character education is worthy of being used in learning. The results of the trials carried out were small group trials from three schools that obtained an average percentage of eligibility of 88.3% with a very feasible category. In the field trials conducted in three schools, the average percentage of feasibility was 92% with a very feasible category to be implemented in learning in class and outside the classroom.

Suggestion

The use of photonovela learning media can affect student character education. From the results of this research can be carried out further research on learning with photonovela learning media for different concepts or topics. In making photonovela learning media with character education on work material and energy there are several obstacles or difficulties that might be an improvement for future researchers.

REFERENCES

- Abdurrahman, A., Saregar, A., & Umam, R. (2018). The Effect of Feedback as Soft Scaffolding on Ongoing Assessment Toward The Quantum Physics Concept Mastery of The Prospective Physics Teachers. *Jurnal Pendidikan IPA Indonesia*, 7(1), 41–47. <https://doi.org/10.15294/jpii.v6i2.7239>
- Adawiyah, R. Al, Lesmono, A. D., & Prastowo, S. H. B. (2018). Pengembangan Bahan Ajar Fisika Berupa Buku Berbasis REACT (Relating, Experiencing, Applying, Cooperating, and Transferring) pada Pembelajaran Fisika di SMA. *Jurnal Pembelajaran Fisika*, 7(2), 202–209.
- Agustin, H. A., Bektiarso, S., & Bachtiar, R. W. (2018). Pengembangan Modul Komik Fisika pada Pokok Bahasan Hukum Kepler di SMA Kelas XI. *Jurnal Pembelajaran Fisika*, 7(2), 168–174.
- Anggia, P. V., & Dra. An Fauzia Rozani Sy., M. A. (2014). Designing Photonovela As a Media in Teaching Listening to Junior High School Students. *JELT*, 3(1), 295–301.
- Anwar, M. K. (2017). Pembelajaran Mendalam untuk Membentuk Karakter Siswa sebagai Pembelajar. *Tadris: Jurnal Keguruan Dan Ilmu Tarbiyah*, 2(2), 97–104. <https://doi.org/10.24042/tadris.v2i2.1559>
- Ardiyanti, A., Usman, M., & Bandu, I. (2018). Pembelajaran Kosakata Bahasa Prancis dengan Media Flashcard (Studi Kasus pada Mahasiswa Sastra Prancis). *Jurnal Ilmu Budaya*, 6(1), 176–186.
- Astuti, I. A. D., Nurullaeli, & Nugraha, A. M. (2018). Pengembangan Pembelajaran E-Learning dengan Web Log Sebagai Alternatif Bahan Ajar Guru. *Jurnal Terapan Abdimas*, 3(2), 165–169.
- Astuti, P. (2017). Peningkatan Motivasi dan Kemampuan Berpikir Kreatif Siswa pada Materi Pencemaran Lingkungan melalui Media Fotonovela. *Jurnal Refleksi Edukatika*, 8(1), 35–42.
- Asyhari, A., & Silvia, H. (2016). Pengembangan Media Pembelajaran Berupa Buletin dalam Bentuk Buku Saku untuk Pembelajaran IPA Terpadu. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 5(1), 1–13. <https://doi.org/10.24042/jpifalbiruni.v5i1.100>
- Barus, E. L., & Sani, R. A. (2017). Pengaruh Model Pembelajaran Latihan Inkuiri terhadap Hasil Belajar Siswa pada Materi Pokok Usaha dan Energi di Kelas X Semester II. *Jurnal Inovasi Pembelajaran Fisika*, 1(1), 16–22.
- Chan, A., Brown, B., Sepulveda, E., & Teran-Clayton, L. (2015). Evaluation of fotonovela to increase human papillomavirus vaccine knowledge, attitudes, and intentions in a low-income Hispanic community. *BMC Research Notes*, 8(1), 1–10. <https://doi.org/10.1186/s13104-015-1609-7>
- Chhetri, V. (2017). Challenges in Undergraduate Physics Education: A Interpretive Structural Modeling Approach. *International Journal of Engineering and Management Research Page*, 7(3), 372–378.
- Ciffolilli, A., & Muscio, A. (2018). Industry 4.0: national and regional comparative advantages in key enabling technologies. *European Planning Studies*, 0(0), 1–21. <https://doi.org/10.1080/09654313.2018.1529145>
- Damayanti, A. E., Komikesari, H., Syafei, I., & Rahayu, R. (2018). Kelayakan Media Pembelajaran Fisika Berupa Buku Saku Berbasis Android Pada Materi Fluida Statis. *Indonesia Journal of Science and Mathematics Education*, 01(1), 63–70.
- Diani, R. (2015). Pengembangan Perangkat Pembelajaran Fisika Berbasis Pendidikan Karakter dengan Model Problem Based Instruction. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 4(2), 241–253.

- <https://doi.org/10.24042/jpifalbiruni.v4i2.96>
- E.P, R. H., Bektiarso, S., & Gani, A. A. (2017). Model Pembelajaran Generatif (Generative Learning) dilengkapi Media Kartu Masalah pada Pembelajaran Fisika di SMA (Studi pada Materi Elastisitas di SMA N 1 Pakusari). *Jurnal Pembelajaran Fisika*, 5(4), 399–403.
- Haruehansawasin, S., & Kiattikomol, P. (2018). Scaffolding in Problem-Based Learning for Low-Achieving Learners. *Journal of Educational Research*, 111(3), 363–370. <https://doi.org/10.1080/00220671.2017.1287045>
- Herdiani, H., Maskur, & Noordiana, M. A. (2017). Efektivitas Media Fotonovela terhadap Mata Pelajaran Bahasa Indonesia pada Siswa Tunagrahita SLB B-C YGP Selaawi Tahun Pelajaran 2016/2017. *Jurnal Teknologi Pendidikan Dan Pembelajaran*, 2(1), 151–161.
- Hofer, S. I., Schumacher, R., Rubin, H., & Stern, E. (2018). Enhancing Physics Learning With Cognitively Activating Instruction: A Quasi-Experimental Classroom Intervention Study. *Journal of Educational Psychology*, 1–17. <https://doi.org/10.1037/edu0000266>
- Irmawati, Djalaluddin, M., & Wahyuni, A. (2017). Pengaruh Model Pembelajaran Kooperatif Physics Mysterious Berbasis Fun Learning terhadap Minat dan Hasil Belajar. *Jurnal Pendidikan Fisika*, 5(1), 6–9.
- Irwandani, Latifah, S., Asyhari, A., Muzannur, & Widayanti. (2017). Modul Digital Interaktif Berbasis Articulate Studio'13 : Pengembangan pada Materi Gerak Melingkar Kelas X. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 06(2), 221–231. <https://doi.org/10.24042/jipfalbiruni.v6i2.1862>
- Khoiron, A. M., & Sutadji, E. (2012). Kontribusi Implementasi Pendidikan Karakter dan Lingkungan Sekolah terhadap Berpikir Kreatif serta Dampaknya pada Kompetensi Kejuruan. *Jurnal Pendidikan Dan Pembelajaran*, 22(2), 103–116.
- Koops van 't Jagt, R., Hoeks, J. C. J., Duizer, E., Baron, M., Molina, G. B., Unger, J. B., & Jansen, C. J. M. (2018). Sweet Temptations: How Does Reading a Fotonovela About Diabetes Affect Dutch Adults with Different Levels of Literacy? *Health Communication*, 33(3), 284–290. <https://doi.org/10.1080/10410236.2016.1258617>
- Maiyena, S. (2013). Pengembangan Media Poster Berbasis Pendidikan Karakter untuk Materi Global Warming. *Jurnal Materi Dan Pembelajaran Fisika (JMPF)*, 3(1), 18–26.
- Mujizatullah. (2018). Pengintegrasian Pendidikan Karakter Keagamaan pada Pembelajaran Hakikat Ilmu Fisika dan Keselamatan Kerja di Laboratorium Madrasah Aliyah Puteri Aisyiah di Palu. *Jurnal Pendidikan Fisika Universitas Muhammadiyah Makassar*, 6(2), 115–128.
- Muslina, Abdul, H., & Ibnu, K. (2017). Kelayakan Media Animasi Hukum Newton II tentang Gerak pada Bidang Miring dan Katrol di SMA Kabupaten Aceh Besar. *Jurnal IPA Dan Pembelajaran IPA*, 1(1), 64–72.
- Nugraha, A. (2017). Pengembangan Media Komik Motivasi Berprestasi sebagai Layanan Bimbingan Pribadi bagi Siswa SMP Muhammadiyah 1 Godean. *Jurnal Riset Mahasiswa Bimbingan Dan Konseling*, 3(6), 465–473.
- Nurhuda, T. A., Waluyo, H. J., & Suyitno. (2017). Novel Simple Miracles Karya Ayu Utami Serta Relevansinya pada Pembelajaran Sastra di SMA. *Jurnal Ilmiah Didaktika*, 18(1), 103–117.
- Oktaviani, R., Yulkifli, & Murtiani. (2017). Pengaruh Penerapan Bahan Ajar Bermuatan Nilai-Nilai Karakter dalam Model Pembelajaran SAVI terhadap Kompetensi Fisika Peserta Didik pada Materi Momentum, Impuls dan Getaran Harmonis Kelas X MIPA

- SMAN 2 Bukittinggi. *Jurnal Berkala Ilmiah Pendidikan Fisika*, 10, 113–120.
- Rahayu, A., Sutikno, S., & Masturi, M. (2015). Pengembangan Media Pembelajaran Hukum Newton menggunakan Fotonovela Berbasis Kearifan Lokal. *Prosiding Seminar Nasional Fisika*, IV, 33–37.
- Ramadhanti, M., Edwita, & Sumantri, M. S. (2018). Media Pembelajaran BCCT (Beyond Center and Circle Time) Berbasis Multiple Intelligences. *Jurnal Ilmiah PGSD*, 2(1), 55–66.
- Rosdianto, H., Murdani, E., & Hendra. (2017). Implementasi Model Pembelajaran POE (Predict Observe Explain) untuk Meningkatkan Pemahaman Konsep Siswa pada Materi Hukum Newton. *Jurnal Pendidikan Fisika*, 6(1), 55–59.
- Rubiyanto, E., & Susanto, A. (2018). Pengembangan Media Pembelajaran Sistem Kemudi Tipe Rack and Pinion untuk Meningkatkan Hasil Belajar Siswa pada Mata Pembelajaran Chassis Kelas XI SMK Patriot Pituruh. *Jurnal Pendidikan Teknik Otomotif Universitas Muhammadiyah Purworejo*, 12(01), 56–61.
- Saregar, A. (2016). Pembelajaran Pengantar Fisika Kuantum dengan Memanfaatkan Media PhET Simulation dan LKM Melalui Pendekatan Saintifik: Dampak pada Minat dan Penguasaan Konsep Mahasiswa. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 5(1), 53–60. <https://doi.org/10.24042/jpifalbiruni.v5i1.105>
- Saregar, A., Diani, R., & Kholid, R. (2017). Efektivitas Penerapan Model Pembelajaran ATI (Aptitude Treatment Interaction) Dan Model Pembelajaran TAI (Team Assisted Individualy) : Dampak Terhadap Hasil Belajar Fisika Siswa. *Jurnal Pendidikan Fisika Dan Keilmuan*, 3(1), 28–35.
- Saregar, A., Latifah, S., & Sari, M. (2016). Efektivitas Model Pembelajaran CUPs: Dampak terhadap Kemampuan Berpikir Tingkat Tinggi Peserta Didik Madrasah Aliyah Mathla'ul Anwar Gisting Lampung. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, 05(2), 233–243. <https://doi.org/10.24042/jpifalbiruni.v5i2.123>
- Sari, N., Suryanti, K., Manurung, S. M., & Sintia. (2017). Analisis Penggunaan Media Pembelajaran untuk Meningkatkan Motivasi Peserta Didik terhadap Pembelajaran Fisika Kelas XI MIPA 1 SMA Titian Teras Muaro Jambi. *Pendidikan Fisika Dan Keilmuan (JPFK)*, 3(2), 110–112.
- Sari, R. T., & Jusar, I. R. (2017). Analisis Kebutuhan Modul Pembelajaran IPA Berorientasi Pendidikan Karakter melalui Pendekatan Quantum Learning di Sekolah Dasar. *Jurnal Pendidikan Biologi Universitas Muhammadiyah Metro*, 8(1), 26–32.
- Setiawan, D., Arifin, I., & Ardianto, R. (2018). Implementasi Pengembangan Sistem Media Pembelajaran Pengenalan Komputer: Program Studi Sistem Informasi Universitas PGRI Madiun. *Intensif*, 2(2), 127–135. <https://doi.org/10.29407/intensif.v2i2.12099>
- Sole, F. B., & Anggraeni, D. M. (2016). Pengembangan Instrumen Penilaian Sikap Ilmiah Sains Siswa Sekolah Dasar (SD) Berbasis Pendidikan Karakter. *Jurnal Penelitian Pendidikan IPA*, 3(2), 99–105.
- Sugiana, I. N., Harjono, A., & Sahidu, H. (2016). Pengaruh Model Pembelajaran Generatif Berbantuan Media Laboratorium Virtual Terhadap Penguasaan Konsep Fisika Siswa pada Materi Momentum dan Impuls. *Jurnal Pendidikan Fisika Dan Keilmuan*, 2(2), 61–65.
- Suranti, N. M. Y., Gunawan, G., & Sahidu, H. (2016). Pengaruh Model Project Based Learning Berbantuan Media Virtual Terhadap Penguasaan Konsep Peserta didik pada Materi Alat-alat Optik. *Jurnal Pendidikan Fisika Dan*

- Teknologi*, 2(2), 73–79.
- Suryani, N. A., Sakti, I., & Purwanto, A. (2018). Perbedaan Hasil Belajar Antara Model Pembelajaran Clis (Children'S Learning in Science) dengan menggunakan Media Kit IPA di SMP Negeri 21 Kota Bengkulu. *PENDIPA Journal of Science Education*, 2(1), 113–116.
- Suyanto, S. (2018). Magnetic Swings and Magic Circle: Belajar Cerdas Induksi Magnetik dengan Barang Bekas melalui Pendekatan Pembelajaran Fisika Berbasis Inkuiri (Level of Inkuiri Based Learning). *Jurnal Penelitian Pembelajaran Fisika*, 9(1), 53.
<https://doi.org/10.26877/jp2f.v9i1.2345>
- Unger, J. B., Cabassa, L. J., Molina, G. B., Contreras, S., & Baron, M. (2013). Evaluation of a Fotonovela to Increase Depression Knowledge and Reduce Stigma Among Hispanic Adults. *J Immigr Minor Health*, 15(2), 398–406.
<https://doi.org/10.1021/n300902w>. Release
- Venisari, R., Gunawan, & Sutrio. (2015). Penerapan Metode Mind Mapping pada Model Direct Instruction untuk Meningkatkan Kemampuan Pemecahan Masalah Fisika Siswa SMPN 16 Mataram. *Jurnal Pendidikan Fisika Dan Teknologi*, 1(3), 193–198.
- Weng, W. Y., Lin, Y. R., & She, H. C. (2017). Scaffolding for argumentation in hypothetical and theoretical biology concepts. *International Journal of Science Education*, 39(7), 877–897.
<https://doi.org/10.1080/09500693.2017.1310409>
- Wicaksono, H., Roekhan, & Hasanah, M. (2018). Pengembangan Media Permainan Imajinasi dalam Pembelajaran Menulis Puisi bagi Siswa Kelas X. *Jurnal Pendidikan*, 3(2), 223–228.
- Widada, & Rosyidi, A. (2017). Perancangan Media Pembelajaran Fisika SMP Berbasis Multimedia Interaktif. *Jurnal IT CIDA*, 3(2), 53–68.
- Widyaningrum, R., & Prihastari, E. B. (2018). Implementasi model pembelajaran talking chips disertai media fotonovela untuk meningkatkan sikap peduli lingkungan dan kemampuan menyampaikan pendapat mahasiswa. *Jurnal Pendidikan Dasar Dan Pembelajaran*, 8(1), 22.
<https://doi.org/10.25273/pe.v8i1.2033>
- Widyaningsih, S. W., & Yusuf, I. (2015). Penerapan Pembelajaran Listrik Dinamis Model Kooperatif Tipe STAD menggunakan Pendekatan CTL dengan Integrasi Nilai-Nilai Karakter terhadap Aktivitas dan Hasil Belajar Peserta Didik. *Jurnal Universitas Jember*, 4(2), 223–234.
- Yusro, A. C., & Sasono, M. (2016). Penggunaan Modul Ilustratif Berbasis Inkuiri Terbimbing Pokok Bahasan Kinematika Gerak Lurus untuk Meningkatkan Hasil Belajar dan Kemandirian Siswa Kelas VII SMPN 14 Madiun. *Jurnal Pendidikan Fisika Dan Keilmuan (JPFK)*, 2(1), 29.
<https://doi.org/10.25273/jpfk.v2i1.22>