Vol 9 No 2 2023 DOI : 10.24036/jppf.v9i2.123690 Page : 202-209
JURNAL PENELITIAN PEMBELAJARAN FISIKA (JPPF)
Journal of Physics Learning Research
ISSN 2252-3014 (Print) | ISSN 2746-8445 (Electronic)

Development of STEM-Based Physics E-LKS to Improve Students' Scientific Literacy Abilities

Nurul Hasanah Daniyah Putri[1*], Ramli[2]

[1] Masters Study Program of Physics Education, Universitas Negeri Padang, West Sumatera, Indonesia
[2] Department of Physics, Universitas Negeri Padang, West Sumatera, Indonesia

ARTICLE INFORMATION

Received : 2023-06-13
Revised : 2023-08-44
Accepted : 2023-09-28

Correspondence
Email: nanahdputri@gmail.com
Phone: 081360175007

KEYWORDS :

E-Student worksheet, Physics, STEM, Science literacy

ABSTRACT

Science literacy is one of the skills learners possess in the 21st century. The main objective of science literacy is to make learners aware that science is a mandatory curriculum component up to the secondary level. The focus should be on developing awareness among learners about the relationship between science, technology, and society, sensitizing learners, especially to environmental and health issues, and enabling them to acquire knowledge and skills. Therefore, a physics E-worksheet is needed that can help students improve their science literacy skills. The research method used is R&D with the Plomp development model. In the preliminary analysis, science literacy analysis, STEM approach, and analysis of the use of electronic teaching materials were analyzed. Furthermore, it continued with the validity test with the result that the STEM-based physics E-worksheet to improve students' science literacy skills is valid for use.

INTRODUCTION

Scientific literacy is a person's ability to apply his knowledge to identify questions, construct new knowledge, provide scientific explanations, draw conclusions based on scientific evidence, and the ability to develop a reflective mindset so that he can participate in overcoming issues and ideas related to science (OECD, 2019). The main goal of scientific literacy is to make students aware that science is a mandatory curriculum component up to the secondary level. The focus should be on developing awareness among students about the relationship between science, technology, and society, sensitizing students, especially to environmental and health issues, and enabling them to acquire knowledge and skills.

Based on the results of preliminary data observations carried out in several schools, several things are analyzed, the first of which is students' scientific literacy. The results showed that the average percentage of students' scientific literacy was 68.3%, which was sufficient (Kemendikbud, 2015). It can be seen that there are still students who do not understand the concepts of physics, and this causes students to be less able to understand the meaning and principles of the laws of physics itself and students not to be able to use scientific knowledge to identify questions, acquire new knowledge, explain scientific phenomena and conclude based on scientific evidence. According to Poedjiadi (Toharudin et al., 2011),

someone who has scientific and technological literacy is characterized by having the ability to solve problems using scientific concepts obtained in education according to their level, knowing the technical products around them and their impacts, can use technology products and maintain them, be creative in making simplified technological results so that students can make decisions based on community values and culture. The second is an analysis of the use of electronic teaching materials. This analysis obtains an average percentage of 69% in the sufficient category. It can be seen that it is necessary to develop electronic teaching materials to increase interest, motivation, learning styles, and learning outcomes to answer challenges in the 21st century. One of the electronic teaching materials that can be developed is electronic student worksheets, or what is called E-LKS.

Based on PISA (Program for International Student Assessment) data, students' scientific literacy skills are still far below the average compared to the average score from OECD countries. 2012, Indonesia was ranked 64th out of 65 participants (OECD, 2013). In PISA 2015, students' scientific literacy scores experienced a slight increase from 382 in 2012 to 403 in 2015 while placing Indonesia at number 62 out of 72 participating countries (OECD, 2016). However, in PISA in 2018, students' scientific literacy scores again decreased to 396, ranking 70th out of 78 participating countries (OECD, 2019). From the PISA results for the last three years, it can be seen that the ability of Indonesian students to compete at the international level still needs to be improved. Even in the previous few periods, Indonesia has been below other countries. This shows that the scientific literacy abilities of students in Indonesia are still meager when compared to other countries. In contrast, scientific literacy is one of the skills that students must have in the 21st century.

The progress and demands of the times mark the development of the world in the 21st century. The era of the 21st century has made world developments faster and more complex. The 21st century is called the century of knowledge, the century of a knowledge-based economy, information technology, globalization, industrial revolution 4.0, and so on. These changes aim to improve modern society's quality of life (Pratiwi et al., 2019). Learning in the 21st century certainly requires educators to be even more creative in the learning process to match the demands of the 21st century. Researchers can take advantage of this by developing electronic LKS (E-LKS). According to Purnama & Suparman (2020), E-LKS is a student work guide to make it easier for students to understand learning material in electronic form, whose application uses desktop computers, notebooks, smartphones, and mobile phones.

An approach must be used to produce quality human resources in the learning process. One approach that can be used is the STEM approach (Science, Technology, Engineering, and Mathematics). STEM education is an approach that emphasizes learning more than one field of science within it (Roberts, 2012). The learning objectives using a STEM approach are suitable for vocational high school learning, where learning requires complex knowledge (Hannover, 2017). STEM learning can develop if the learning process is associated with the natural world experienced by students to attract students' interest in understanding the process. STEM-based learning can be applied to physics subjects, where physics is part of science. Physics is a science field that studies natural phenomena so that they can be used in everyday life. This is in line with STEM theory, namely that it can help students grow curiosity about scientific investigations and help develop the ability to solve problems.

Based on the problems that have been described, one solution that can be done is to develop STEM-based physics e-LKS to improve students' scientific literacy skills. It is expected to increase students' interest in physics lessons, and the Development of STEM-based physics E-LKS to enhance students' literacy skills can be used as a guide for educators in implementing physics learning. The research aims to produce good e-LKS to be used in the learning process.

METHODS

This study's research type is R & D (Research and Development), where the development model uses the Plomp development model. This plomp development model consists of three steps, namely: 1) preliminary research, 2) the prototyping phase, and 3) the assessment phase (Nieveen & Folmer, 2013). This development model was chosen because it has shorter steps (Ardiansyah, 2018) and considers that this model has clear, practical, systematic, directed, and uninterrupted links between one step and another (Suwigno, 2020).

At the preliminary research stage, information about existing problems in the education sector is needed. The purpose of this stage is, among other things, to obtain various details regarding existing issues that may require improvement and innovation, as well as to get the characteristics/characteristics of the product to be developed. Needs analysis includes analysis, use of electronic teaching materials, STEM approach, and students' scientific literacy skills. The results of the preliminary analysis were obtained based on the distribution of the questionnaire that had been carried out. In the distributed questionnaire, the scores obtained will be converted into grades.

The prototype is developed, evaluated, and revised repeatedly (cycles) in the prototyping phase. The design results at this stage produce a prototype. Then, a formative evaluation of the prototype is carried out. Formative evaluation is an evaluation aimed at improvement, present in all phases and repeated cycles of design research. Formative evaluation has several stages depicted in Figure 1.

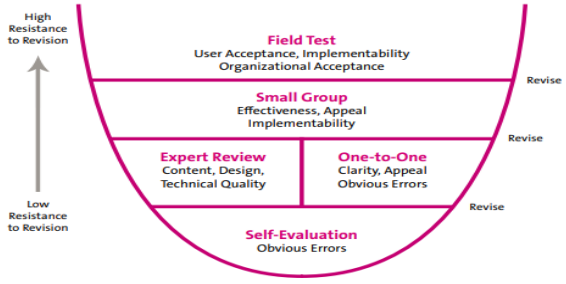

Figure 1. Formative Evaluation of the Plomp Development Model

Based on the picture above, it can be seen that there are several formative evaluations in it, namely: 1) Self-Evaluation (self-evaluation), namely by making improvements to the STEM-based physics E-LKS that has been designed. 2) Expert Review (expert review) is the result of the design of prototype I, which has been evaluated and then given to the expert (expert) for validation. This validation was carried out to assess the feasibility of the STEM-based physics E-LKS design. In this validity test, calculations are carried out using Aiken's formula after obtaining the validity value in the validity category. If the value obtained is in the $0.0 \leq v \leq 0.66$ categories, it means that the product being developed is not valid, but if the value obtained is in the range $0.67 \leq v \leq 1.00$, then the product being developed is in a valid category (Fauzi, 2019). 3) One-to-One Evaluation (one-to-one evaluation) aims to see the level of practicality of the STEM-based physics E-LKS that has been designed. Products that have been developed are tested on students. The selected students represent the level of ability of students in the class. 4) Small Group (small group evaluation) The revised results of the one-on-one evaluation were tested on a limited basis for this STEM-based physics E-LKS on a group of students with different ability levels. This research activity Field Test (field test) was carried out to assess STEM-based physics E-LKS on a larger scale.

During the assessment phase, a trial was also carried out to develop the STEM-based physics E-LKS to see how effective the STEM-based physics E-LKS was being developed. Product effectiveness means a measure that states whether or not there is an effect or influence

of the product being produced on users, namely on students. Data collection techniques at the preliminary analysis stage using a questionnaire and the validation stage using the validation sheet instrument.

RESULTS AND DISCUSSION

Results

This results from research on teaching materials using STEM-based physics E-LKS to improve students' scientific literacy skills. E-LKS development uses the Plomp model with the following steps.

Preliminary Research Results

A preliminary analysis is carried out in the first stage, namely primary research. Preliminary analysis is the initial stage in the Development of STEM-based Physics E-LKS. This preliminary analysis was carried out to obtain information about problems and needs in learning. This preliminary analysis is in the form of an analysis of scientific literacy, an analysis of the use of electronic teaching materials, an analysis of students, and an analysis of the STEM approach. The preliminary analysis graph can be seen in Figure 1.

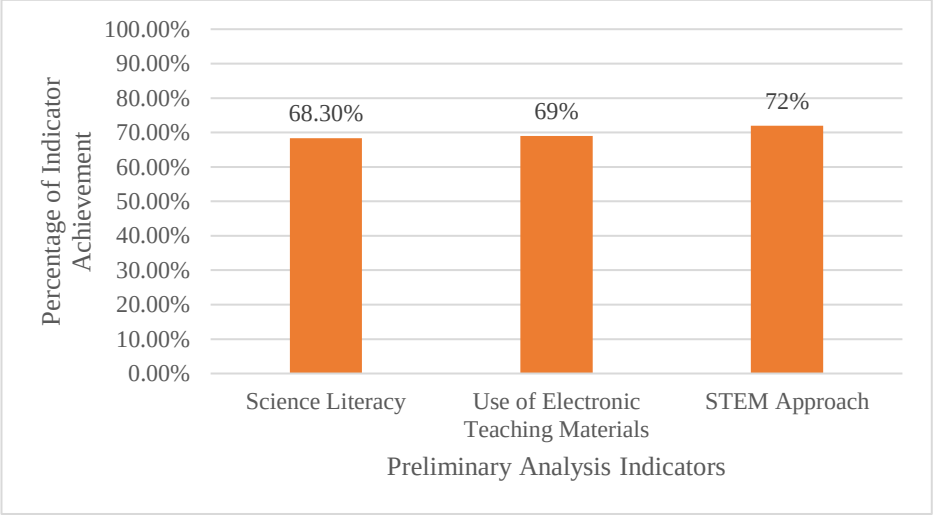

Figure 1. Preliminary Analysis Results

Based on Figure 1, it can be explained that an average percentage of 68.3% is obtained in the sufficient category in the analysis of scientific literacy. It can be seen that there are still students who cannot understand the concepts of physics, which causes students to be less able to understand the meaning and principles of the laws of physics themselves. So, it can be seen that students cannot use scientific knowledge to identify questions, obtain new knowledge, explain scientific phenomena, and draw conclusions based on scientific evidence.

In the analysis of electronic teaching materials, an average percentage of 69% is obtained in the sufficient category. It can be seen that it is necessary to develop electronic teaching materials to increase students' interest, motivation, learning styles, and learning outcomes to answer the challenges of the 21st century. The 21st century is the technological century, and students tend to use cell phones or gadgets more often. This can be utilized by developing electronic teaching materials that can be created, namely electronic student worksheets or E-LKS.

In the results of the analysis of the STEM approach, an average percentage of 72% is obtained in the good category. Based on the questionnaire, many students still cannot apply what they have learned in everyday life. Second is the number of students who have been

unable to solve problems or questions given by educators. In general, students can solve the questions given in the form of groups or discussions.

The second stage is the development or prototyping phase. After conducting a needs analysis, the next step is the design stage. The design stage is the product design stage in the form of STEM-based physics E-LKS. At this stage, it is necessary to determine the design of the STEM-based physics E-LKS, and then the design that has been created is developed into a product. The structure of the STEM-based physics E-LKS to improve students' scientific literacy skills is guided by the Ministry of National Education (2008) regarding guidelines for developing teaching materials. The structure of the LKPD is 1) there is a title, 2) there are study instructions or instructions for using the LKPD, and 3) it contains essential competencies or subject matter. 4) there is supporting information, 5) tasks or work steps, 6) an assessment or evaluation.

Results of the Development or Prototyping Phase

After conducting a needs analysis, the next step is the design stage. The design stage is the product design stage in the form of STEM-based physics E-LKS. At this stage, it is necessary to determine the design or design of the STEM-based physics E-LKS, and then the design that has been made is developed into a product. The researchers carried out this self-evaluation stage to examine the developed effects before being validated by a team of experts. At this stage, the researcher fixes the part not to the existing guidelines. After being developed and evaluated by the researchers, the validity was tested by experts using a validation sheet for the product being developed. Three experts filled in the validation sheet. The STEM-based physics E-LKS validation includes five aspects, namely content feasibility, presentation feasibility, language feasibility, graphics, and media. The graph of the results of the validity of this E-LKS can be seen in Figure 2.

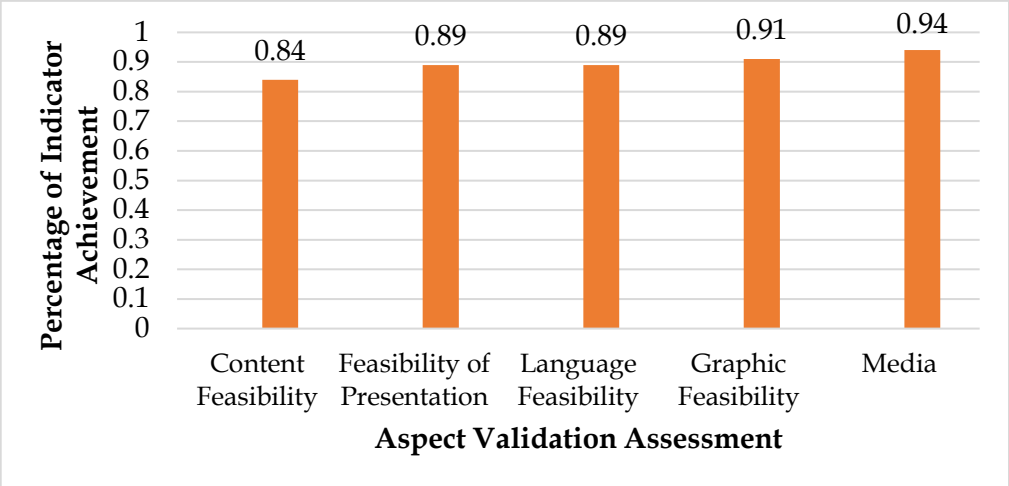

Figure 2. Validity Assessment Results

Based on Figure 2, several aspects are assessed by experts, the first of which is the content suitability aspect. In the feasibility aspect, the content has indicators that include material in the STEM-based physics E-LKS, whether by the 2013 curriculum. The topics presented are by KD and the indicators formulated, examples of cases presented are by everyday life, and questions -The questions in the evaluation can measure student competency. Based on these indicators, an average percentage of 0.84 was obtained, which is in the valid category.

The second aspect is the feasibility of the presentation. The feasibility aspect of this presentation includes whether the designed E-LKS is arranged by the order in the standard LKPD, then on the introductory page consisting of a cover and preface, the pages in the

manuscript presented are difficult systematically starting from the title, study instructions, KD, and objectives learning. Then, the learning objectives and presentation in the developed E-LKS are easy for students to understand, and the images presented can explain the material clearly. Based on these indicators, an average percentage of 0.89 was obtained, which is in the valid category.

The third aspect is language feasibility. This aspect includes the language used in the product being developed, whether using Indonesian with enhanced spelling, communicative, simple, straightforward, and easy to understand. Based on several indicators of language suitability that were assessed, an average percentage of 0.89 was obtained.

The fourth aspect is graphics. In this aspect, several things are assessed, namely the size and type of letters used, whether they can be read, whether the color of the E-LKS being developed is attractive and whether the cover on the STEM-based physics E-LKS is attractive. Based on several indicators assessed, an average percentage of 0.91 was obtained, which is in the valid category.

The last aspect is the media. In this aspect, several things are assessed: whether the developed STEM-based physics E-LKS can be used anywhere and anytime, whether it is difficult according to the development of science and technology, and whether the developed STEM-based physics E-LKS is easy to operate and access in learning. Based on the indicators above, an average percentage of 0.94 is obtained, which is in the valid category.

Discussion

During the preliminary research phase, several analyses were carried out: an analysis of scientific literacy, an analysis of the use of electronic teaching materials, an analysis of students, and an analysis of the STEM approach. Afifulloh & Cahyanto (2021) said that this needs analysis is necessary as initial information in developing a teaching material product and what treatment is appropriate in the learning process to improve the ability to understand learning material. The analysis results of students' scientific literacy are in the sufficient category. In line with research conducted by Sutrisna (2021), students' scientific literacy abilities are still low. The low knowledge of students' scientific literacy is caused by the inability of students to work on questions that require understanding and analysis of questions. Fuadi et al. (2020) said that there are several factors causing students' low scientific literacy skills, namely low reading ability, misconceptions, non-contextual learning, learning environment and climate, and selection of teaching materials. According to the OECD (2015), students need knowledge of concepts, theories, and procedures related to scientific investigations to enable science to move forward.

The analysis results of using electronic teaching materials in Physics learning are in the sufficient category. In line with the research conducted by Aqil (2018), knowledge that only relies on textbooks does not necessarily fully touch the souls of students. As a result, the learning process becomes tedious, and students do not understand the subject matter in everyday life. So, it is necessary to develop teaching materials that can increase students' interest, motivation, and learning styles to answer the demands of 21st-century learning; teaching materials that can be created are electronic student worksheets known as E-LKS. Based on the opinion of Ikhsan (2019), today, the development of the era where everyone has used technology learning resources is also developing by following existing technology. Learning resources that were previously in print are now available in electronic form.

The results of the analysis of the STEM approach in physics learning are in the sufficient category. This can be seen in the questionnaire, the number of students who stated that they could still not apply what they had learned daily. STEM learning shows students how concepts

and principles of science, technology, engineering, and mathematics are integrated to develop products, processes, and systems that benefit human life (Hanouver, 2017).

The prototyping phase or design phase is carried out to describe the results of the STEM-based physics E-LKS design that suits your needs. At this stage, the designed STEM-based physics E-LKS also pays attention to cover design, suitability of images, and illustrations for selecting font sizes and font types used. In developing STEM-based physics E-LKS, the font sizes used are pretty varied. This is reinforced by Farwati et al. (2018), which state that the appropriateness of the images, illustrations, and the type and size of the font used must be made as attractive as possible. The design of the STEM-based physics E-LKS is made in such a way that the design needs guidance so that the procedure becomes more focused. In this study, STEM-based physics E-LKS was created based on guidelines for developing ICT-based teaching materials according to the Ministry of National Education (2010) and components of teaching materials according to the Ministry of National Education (2008).

Self-evaluation (self-assessment) aims to check possible errors that still exist in the STEM-based physics E-LKS, developed before being validated by experts. This assessment is to re-check the mistakes seen in the STEM-based physics E-LKS being developed, such as clarity of writing, errors in typing, errors in the use of punctuation marks, and suitability of layout. Octaria (2013) states that this self-evaluation aims to re-analyze and evaluate the teaching materials that have been designed. This is in line with Sari's opinion (2019), which says that self-evaluation seeks to improve and perfect the product to be developed.

In the development stage, instrument and product validity tests were carried out by experts who are lecturers at the Padang State University Physics Department. Sugiyono (2011) states that several experienced experts or experts can carry out product validation to assess the weaknesses or strengths of the products produced. The purpose of validation is to get a decent product. The instrument used to test the validity of the STEM-based physics E-LKS is in a good category. This indicates that the instrument is valid and can be used. This can also be seen from Rizkika's research (2022), which says that the E-LKS developed using the STEM approach is valid.

Furthermore, the instrument is used to test STEM-based physics E-LKS. Test the validity of STEM-based physics E-LKS, namely content feasibility, presentation feasibility, language feasibility, graphics, and media. On the other hand, not all components on the validation instrument sheet have reached perfection. Based on the validator's suggestion during the validation process, it is known that it is necessary to revise the resulting product after making improvements according to the validator's directions by paying attention, starting from adding indicators and learning objectives, lacking learning materials, errors in typing on STEM-based physics E-LKS. Thus, the STEM-based physics E-LKS can be used in physics learning.

CONCLUSION

Based on the research that has been carried out, it can be concluded that first, at the preliminary analysis stage, the scores obtained will be converted into grades and in the validity test using Aiken's formula. In the analysis of scientific literacy, the average percentage was obtained at 68.3% in the sufficient category. Secondly, in analyzing the approach to using electronic teaching materials, the average rate was obtained at 69%, which was sufficient. Thirdly, in the analysis of the STEM approach, the average percentage was 72% in the good category. Second, regarding validity, it can be concluded that five aspects are assessed in the validity test. The first is the content feasibility aspect, with a value of 0.84. Both aspects of the feasibility of the presentation have a value of 0.89. The three aspects of language feasibility have a value of 0.89. The four graphics have a value of 0.91. The last is the media aspect, with

a value of 0.94. Based on these five aspects, it can be seen that the five aspects assessed are in the valid category.

REFERENCES

Afifulloh, M., & Cahyanto, B. (2021). Analisis Kebutuhan Pengembangan Bahan Ajar Elektronik Di Era Pandemi Covid-19. *JPDI (Jurnal Pendidikan Dasar Indonesia)*, *6*(2), 31.

Aiken, L. (1985). Three Coefficients For Analyzing The Reliability And Validity of Rating. Malibu: Pepperdine University.

Depdiknas. (2008). *Panduan Pengembangan Bahan Ajar.* Jakarta: Direktorat Pembinaan Sekolah Menengah Atas.

Fauzi, A. (2019). Validity of Flood-Themed Science Textbook for Junior High School with Sequenced Model Using Problem-Based Learning. The 2018 International Conference on Research and Learning of Physics (pp. 1-8). Padang: IOP Conf. Series: Journal of Physics: Conf. Series 1185 (2019) 012129.

Farwati, R., Permanasari, A., Firman, H., & Suhery, T. (2018). Integrasi Problem Based Learning dalam STEM Education Berorientasi pada Aktualisasi Literasi Lingkungan dan Kreativitas. *Seminar Nasional Pendidikan IPA Tahun 2021*, *1*(1), 198–206.

Fuadi, et al. (2020). Analisis Faktor Penyebab Rendahnya Kemampuan Literasi Sains Peserta Didik. Jurnal Ilmiah Profesi Pendidikan, 5 (2): 108 – 116, DOI:

Kemendikbud. (2015). *Panduan Penilaian Untuk Sekolah Menengah Pertama (SMP).* Jakarta: Dit. Pembinaan SMP – Ditjen Pendidikan Dasar dan Menengah.

Hannover. (2017). Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics. *National Academies Press*.

Nieveen, N., & Folmer, E. (2013). Educational Design Research Educational Design Research. *Netherlands Institute for Curriculum Development: SLO*, 1–206.

OECD. (2013). *PISA 2012 Assessment and Analytical Framework Mathematics, Reading, Science, Problem Solving and Financial Literacy*. OECD Publishing.

OECD. (2015). PISA 2015 Framework. *Oecd*, *March 2015*, 52.

OECD. (2016). *Programme for International Students Assessment (PISA) Result: Excellent Equity in Education*. OECD Publishing.

OECD. (2019). *PISA 2018 Assessment and Analytical Framework*. OECD Publisher.

Permatasari, Intan. (2019). Pengembangan Bahan Ajar IPA Berbasis Inkuiri Terintegrasi SETS (Science, Enviroment, Technologi and Society) Pada Materi Sistem Reproduksi Manusia. Jurnal Pijar MIPA, 13(3), 74-78.

Pratiwi, S. N., Cari, C., & Aminah, N. S. (2019). Pembelajaran IPA Abad 21 dengan Literasi Sains Siswa. *Jurnal Materi Dan Pembelajaran Fisika*, *9*, 34–42.

Rizkika, et al. (2022). Pengembangan E-LKS berbasis STEM pada Materi Tekanan Zat untuk Meningkatkan Kemampuan Berpikir Kritis Siswa SMP

Roberts, A. (2012). A Justification for STEM Education. *Technology and Engineering Teacher*,

Sari, Y.S, et al. (2019). Role of Students Worksheet in STEM Approach to Achieve Competence of Physics Learning. Journal of Physics: Conference Series.

Sugiyono. (2011). *Metode Penelitian Kuantitatif Kualitatif dan R&D* . Bandung : Alfabeta.

Sutrisna, N. (2021). Analisis Kemampuan Literasi Sains Peserta Didik Sma Di Kota Sungai Penuh. *Jurnal Inovasi Penelitian*, *1*(12), 2683–2694.

Toharudin, et.al. (2011). Membangun literasi sains peserta didik. Bandung: Humaniora.