JISE 11 (2) 2022 : 241–249

Journal of Innovative Science Education

http://journal.unnes.ac.id/sju/index.php/jise

Development of E-module Based on Science, Technology, Engineering, and Mathematics (STEM) To Improve Science Literacy of Junior High School Students

Bagus Addin Hutomo[1]✉, Sigit Saptono[2], Bambang Subali[2]

[1]SMP Kesatrian 1 Semarang, Indonesia
[2]Pascasarjana, Universitas Negeri Semarang, Indonesia

Article Info

Article History :
Received
February 2022
Accepted
June 2022
Published
August 2022

Keywords:
E-modul, STEM, Science Literacy

Abstract

In the 21st century, the development of science and technology is increasing rapidly, especially in the field of education. To prepare for these developments, students must be equipped with skills that support the use of technology and scientific literacy skills. The importance of scientific literacy skills in science learning is motivated by the results of the 2015 PISA test. The purpose of this study was to test the feasibility of STEM-based e-modules, analyze the effectiveness and profile of scientific literacy skills after using STEM-based e-modules. This research includes Research and Development (R&D) which has been modified without widespread dissemination. The data analysis technique used in this study includes descriptive data analysis related to the feasibility and profile of students' scientific literacy abilities, while the N-gain test is used to determine the effectiveness of the product. The results showed (1) the STEM-based (Science, Technology, Engineering, and Mathematics) e-module that was developed had very feasible criteria regarding aspects of content, presentation, and language (2) the results of the student's scientific literacy assessment showed an increase in the N-gain value with high criteria. (3) the profile of students' scientific literacy abilities which includes the process of science, the context of science, and the content of science have good criteria. Based on this, the use of the developed Science, Technology, Engineering and Mathematical (STEM)-based e-module is feasible to be used as an alternative learning resource for substance pressure material in science learning.

✉ correspondence:
Soekarno Hatta No.64, Palebon, Pedurungan, Semarang, Jawa Tengah, Indonesia 50246
E-mail: gusaddin@gmail.com

p-ISSN 2252-6412
e-ISSN 2502-4523

INTRODUCTION

Scientific literacy is considered one of the most important learning outcomes in the education of 15-year-old students, regardless of whether the student is interested in continuing science education (Gucluer & Kesercioglu, 2012). Scientific literacy is directly related to building a new generation of strong scientific thinking and attitudes that can effectively convey knowledge and research results to the general public. A person with scientific literacy is one who can apply scientific learning related to scientific concepts and scientific process skills to evaluate and make everyday decisions. Science learning is inseparable from the nature of science as part of scientific literacy. Chiappetta & Koballa (2010) states that science is a predictive and socially applicable area of science.

The scientific literacy evaluation conducted by PISA 2009 (OECD, 2010), showed that Indonesian students were ranked 57th with a score of 383 (OECD average score of 501), while PISA 2012 showed Indonesian students were ranked 64th with a score of 382. (OECD average score 501) (OECD, 2014). A total of 65 countries participated in PISA 2009 and 2012. In PISA 2015 Indonesia was ranked 64th out of 72 of the participating countries. The score obtained by Indonesia at PISA 2015 was 403 (OECD average score of 493) (OECD, 2016). From these three results, it is stated that the educational practices implemented in the school do not demonstrate the function of the school as a learning organization that seeks to equip all citizens with literacy in order to support them as lifelong learners. You can conclude. The low literacy level of students' science is one of the reasons the government is switching the curriculum from KTSP to the 2013 curriculum (Odja & Payu, 2014).

A preliminary study conducted at SMP Kesatrian 1 Semarang showed that, based on the results of a documentary study, student learning outcomes indicate a student's low scientific literacy. The results of the assessments performed during the daily assessment of 27 to 15 students in Class VIII did not meet the minimum learning criteria. The results of the observational studies conducted show that the learning practices were carried out appropriately and accurately according to the learning tools according to the curriculum. However, some students have not yet paid attention to the learning process.

In the process of learning, the students saw no connection between what they learned and their daily lives. Teachers use materials from publishers, but many students still do not fully understand the materials. The materials used in the learning process are in the form of textbooks or student activity sheets (Widyaningrum et al., 2013). In addition, teachers have shown limitations in STEM-based learning (Erdogan, 2017). Research has shown that teachers tend to develop their learning by providing as much material as possible in the hope that they will be able to understand and apply the knowledge they have acquired (as much as possible) (Saptono, 2016).

It is important to improve student literacy during the learning process. By providing materials such as modules, we can stimulate students' interest and joy in learning. Module is presented interestingly and systematically to make it easier for students to understand a particular material, that is, to get an overview of a particular material and reach the expected level (Putra & Winarti, 2014). It is a kind of teaching material that is useful for evaluating things of ability. More practical modules that can be inserted in the video can be presented in the electronic module (e-module).

Electronic modules make it easier to carry and improve students' scientific literacy. Moreover, in the age of globalization, efforts to improve scientific literacy, such as through the integration of science, technology, engineering, and math (STEM) based learning, need to keep up. Some of the benefits of the STEM approach make students better problem solvers, innovators, inventors, independent logical thinkers, and technical intellectuals (Morrison in Stohlmann et al., 2012). This study aims to improve science literacy using e-modules based on science, technology, engineering, and mathematics (STEM), the feasibility of e-modules developed based on science, technology, engineering, and mathematics (STEM). The purpose is to test the effectiveness of. After using e-modules based on science, technology, engineering, and mathematics (STEM), analyze the ability profile of junior high school students' scientific literacy.

METHODS

This study uses a Research and Development (R&D) approach. This research was carried out by the workflow of the R & D method by Borg & Gall as quoted in Sugiyono (2012) which has been modified. The modification from 10 steps to 9 steps without widespread dissemination and modifications in this study is divided into two stages of the process, namely: the stage of the STEM-based e-module development process and the effectiveness test stage as shown in Figure 1. The subjects in this study were class VIII and IX SMP Kesatrian 1 Semarang. The research subjects for the readability test consisted of ten students of class IX, while the effectiveness test consisted of two classes of VIII with a total of 52 students. The instrument used is an e-module eligibility sheet, with 20 multiple choice questions consisting of 6 questions about science context indicators, 7 questions about science process indicators, and 7 questions about science content indicators. Furthermore, the scores of each student's answer are categorized according to the criteria. The STEM-based e-modules in this study were validated and revised before being used in learning. Students can access directly via smartphones or laptops. The material presented in the e-module provides convenience for students in learning to improve scientific literacy skills. The technique used in collecting data on the feasibility of e-modules uses product assessment, then for the effectiveness of e-modules on scientific literacy and profiles of scientific literacy abilities using test techniques. The test technique carried out was in the form of pre-test and post-test which were analyzed using N-gain.

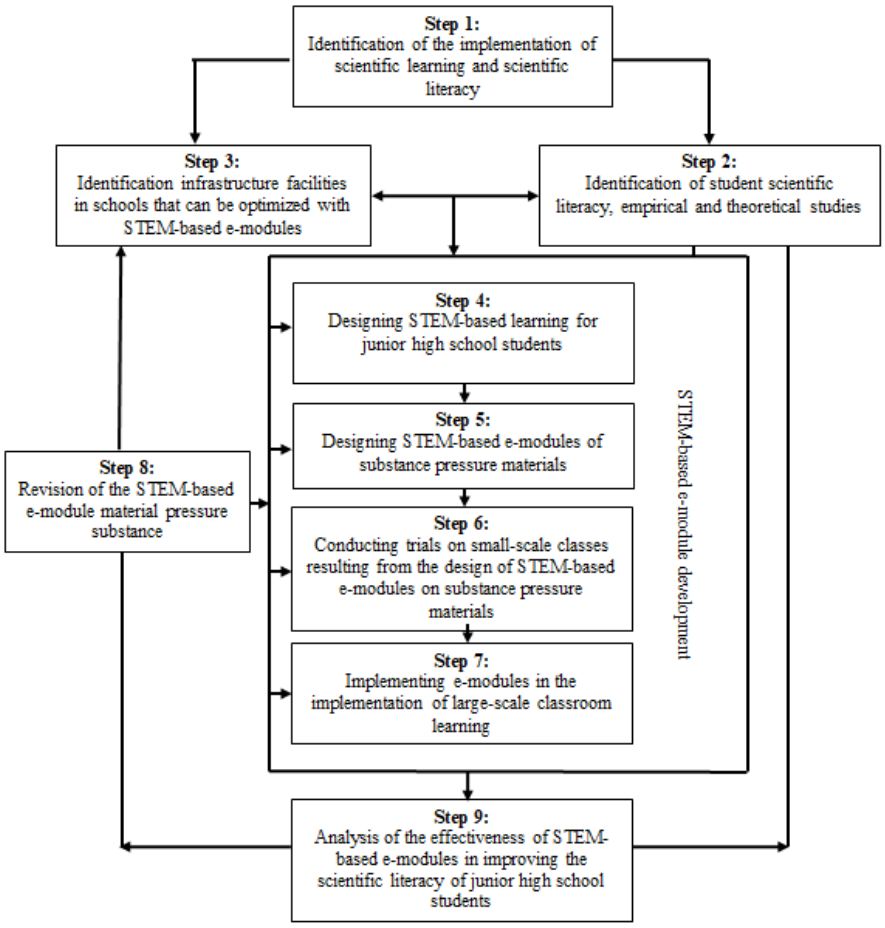

Figure 1. Research Steps

RESULTS AND DISCUSSION

STEM e-module eligibility

Developing a STEM-based e-module begins with collecting material, creating a storyboard, and editing an overall script based on previously collected literature. Creating a STEM-based e-module using the program Adobe Flash Professional CS6. Sukariasih et al., (2019), Adobe Flash CS6 is highly interactive, can be integrated with much other software, and can be extended with many plugins. In addition, after some updates, the language and database are more powerful than previous versions. All this means that this player can deliver unique and interactive software. You can use this application to add material, including animations, text-enhanced simulations, and audio, as shown in Figure 2, to promote understanding and arouse student interest.

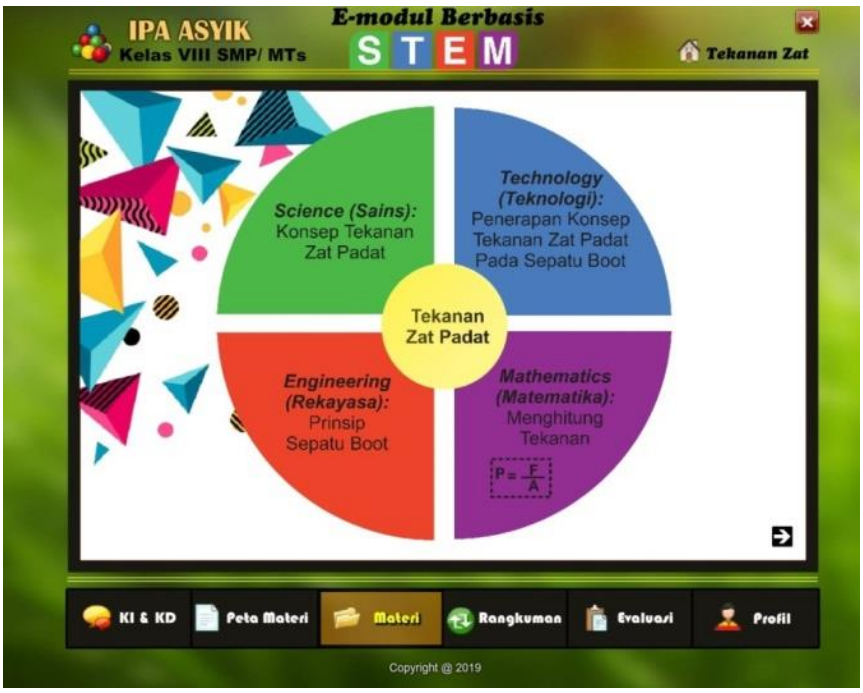

Figure 2. STEM-based e-module display

The feasibility of the developed e-module product was analyzed by descriptive percentage analysis for expert validation results. To determine the percentage of e-module eligibility, a validation calculation formula is used by experts. The feasibility of STEM-based e-modules by media experts is presented in Table 1.

Table 1. Expert Eligibility Assessment Results

Expert	Score (%)	Criteria
Content	94.44	Very Worthy
Presentation	93.33	Very Worthy
Language	98.08	Very Worthy

The data from the expert assessment is used as the basis for revising the STEM-based e-module which was developed as an effort to improve the STEM-based e-module component before being tested on students at school. The validated STEM-based e-module design was then revised according to input from the three experts. The revisions from the three experts can be seen in Table 2.

Table 2. STEM Based E-module Design Revision

Content Eligibility Components	
Suggestion	Revision
Use more relevant media	Choose media that are more relevant to the subject
Fixed KI-KD navigation not working	Fixed a malfunction in KI and KD navigasi navigation
Use additional interactive video media	Adding video interactive media according to the subject
Components of Eligibility of Presentation	
Suggestion	Revision
Some video content that is not directly related to the material is removed/reduced	Choose media that are more relevant to the subject
Add the option "Are you sure you want to exit?" on exit button	Added sure exit option on E-module exit button
Components of Language Eligibility	
Suggestion	Revision
Pay attention to the writing of English words	Correcting some sentences that contain incorrect English words

The design of the STEM-based e-module from the three experts stated that the product was in the very feasible category so that the product could be used in learning activities. STEM-based e-modules are suitable for use in learning based on indicators on aspects of content, presentation, and language. The e-module presented also refers to an assessment based on students' scientific literacy. The scientific literacy presented in the e-module material is adapted to STEM to improve students' understanding. Through STEM students are more motivated and actively involved in the learning process, increasing science content, and participation in class discussions (Karahan, et al., 2015).

Existence of STEM students can be motivated and actively involved in the learning process, the goal is that in the implementation of learning that takes place feedback occurs with what students have obtained in the lesson. According to Astuti et al. (2021), STEM learning can make students have higher motivation and a systematic way of thinking. Motivation is needed initially to get students involved in learning and it is needed during the knowledge construction process (Moeed, 2016). The existence of practice questions that are presented as feedback already contains indicators of scientific literacy understudy, contains scientific content, scientific context, and scientific processes in the form of multiple-choice questions and descriptions. It is intended that students learn pressure material through a STEM approach which is intended to familiarize students with solving problems to improve students' scientific literacy. Presentation of practice questions and quizzes is given at the end of the explanation of the material being taught.

The practice questions are packaged in an attractive way, such as in the form of interactive quizzes, making students more enthusiastic about working on the exercises presented. The interactive quiz developed was designed to provide feedback on student answers. Students immediately know the answers given are correct or still wrong and students can repeat answering questions until all answers are correct. The feedback carried out aims to strengthen students' understanding of concepts and concepts connectedness so that they can correct their misunderstandings (Saptono et al., 2017). Learning will be better if in the process students play a role in their learning activities. There is a relationship between learning activities and student learning outcomes that high learning outcomes will only be obtained if serious learning activities are carried out (Harahap, 2014; Hutomo et al., 2016).

The e-module concept link presented already contains a STEM field. The elastic module presented contains a STEM linkage diagram for each material. Since the teaching materials are

developed by applying STEM in a single unit, these teaching materials represent not only the concept of science but also the application of science to technology, engineering, and mathematics (Syahroni et al., 2021). This allows students to easily examine the material pressure of a material with the STEM approach. Asking students practice questions will help them solve them. In addition, this e-module can be accessed from the student's smartphone or the student's laptop. Electronic modules increase student interest in the learning process because they are accessible anytime, anywhere, supported by the right tools, and not difficult for students (Iriani et al., 2020). Students can easily get the electronic module outside of study hours. With the latest learning materials via your smartphone, you can motivate yourself and improve your students' learning outcomes (Dini, 2018). The e-modules presented include core competencies, basic competencies, and learning goals. In addition, there is a practice question at the end of the material that trains basic science education. The E-module can be used as a learning medium that includes the availability of materials, methods, and learning assessments that are designed to stimulate students' interest in learning (Istuningsih et al., 2018). The E-module has navigation buttons that are easy for students to operate. In addition, there are some impressions in the form of animation used as a perception in the early delivery of the material.

Apperception is the start of a preparatory activity or lesson aimed at stimulating a student's interest in learning. It begins with STEM integration into the material to help students understand the material being studied. The illustrations presented are tailored to the student's environmental conditions and are more contextual. To motivate students to learn, it is necessary not only to support their learning but also to build a supportive environment with STEM learning (Vennix et al., 2018). The photos and videos presented come from everyday life. The video also helps to provide an overview of abstract concepts that are difficult for students to understand. In print, students know that car washing using the concept of hydraulics has already taken place, but with the help of video animations, students have never seen the contents of hydraulics, so students get a better understanding. can do. In addition, Apperception aims to provide an overview of the materials taught to students so that there is no misunderstanding when learning begins. Hutomo et al., (2020), the occurrence of misunderstandings may be due to the lack of concentration of the learning student or the lack of emphasis by the teacher in conveying the apperception as the first image of the learning student.

Effectiveness of STEM e-module (Improvement of Student Science Literacy)

The effectiveness of using STEM-based e-modules on students' scientific literacy was measured by a test. The effectiveness of the product can be seen by using the N-gain formula. The use of N-gain aims to determine the increase in students' scientific literacy skills before the treatment (pretest) and after the treatment (pretest). N-gain is used to measure the difference in pretest-posttest scores. The results of the N-gain from each class are included in the high category. The pretest-posttest and N-gain result scores are presented in Table 3.

Table 3. N-gain Result

	Class VIII B	Class VIII E
Mean pre-test scores	30.00	29.23
Mean post-test scores	80.38	80.00
N-Gain	0.72	0.71
Category	High	High

Based on Table 3. The N-gain values obtained by class VIII B and VIII E indicate the high category. Literacy assessment conducted after learning using STEM-based e-modules has increased scientific literacy learning outcomes. STEM has shown that it can improve student learning outcomes (Safitri et al., 2018; Amatullah et al., 2019).

Science literacy ability profile

There are three indicators of the students' scientific literacy ability that is measured. The indicators of students' scientific literacy are context, process, and content of science. The profile of scientific literacy ability before and after learning using STEM-based e-modules for the average scores from the pre-test and post-test results for each scientific literacy indicator can be seen in Figure 3.

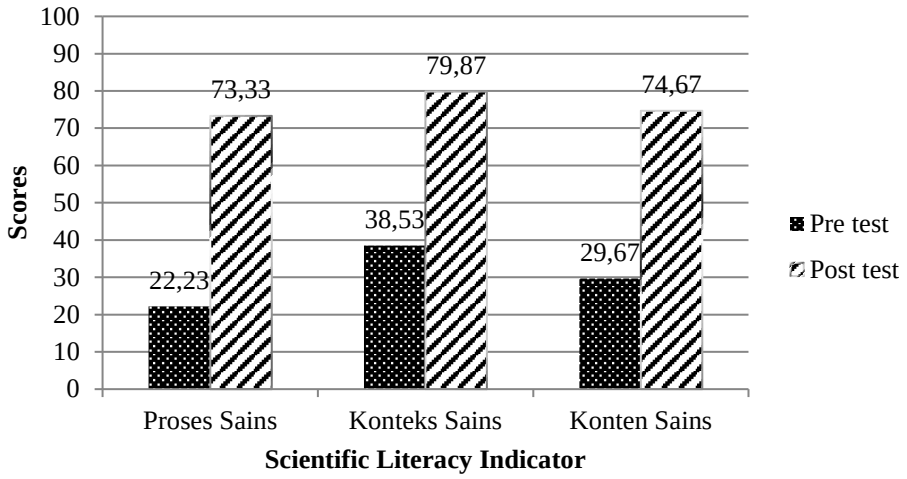

Figure 3. Scientific literacy results

The scientific literacy ability profile based on the three indicators studied showed different results for the indicators with the lowest mean scores on the pre-test and post-test, namely the science process of 22,23 and 73,33. In the indicators of the science process, some students still find it difficult to solve existing problems. Indicators of the science process students are asked to search for, interpret problems, and apply evidence. In addition, the indicators with the highest mean scores in the pre-test and post-test, namely the science context, were 38,53 and 79,87. In the context of science indicators students are asked to emphasize everyday life rather than the classroom or laboratory. Students can solve problems in questions well with the help of e-modules packaged in STEM students can relate the substance pressure material that has been presented in the e-modules with problems that exist in life. daily. According to Dasgupta et al., (2019), STEM can involve students more actively in learning and gain a better understanding of material concepts and their benefits in everyday life. The material packaged in STEM-based e-modules gives students the convenience of observing technology and the application of hydraulics and natural phenomena that exist in everyday life.

The availability of game applications as attractive, easy-to-use learning media will improve student learning outcomes (Adnan et al., 2017). Then the average value that experienced the highest to lowest increase from the pre-test and post-test, namely the process of science, science content, and the context of science was 51, 45, and 41. The results of research by Alfan et al., (2021) stated that the use of e-mobile android applications can improve students' scientific literacy marked by an increase in the N-gain value in the high category. Then the research of Prasetyo et al., (2021) stated that STEM-based e-modules were effective in improving students' scientific literacy, indicating an increase before and after using STEM-based e-modules in the moderate category. Based on previous research, the use of STEM-based e-modules in the research that has been done there is a difference in the value of N-gain in improving students' scientific literacy, which was previously in the high category. This happens because the difference in the material being taught is also different in many different things, even though the media model is the same shape the level of difficulty between the materials may cause differences in improvement. The use of the developed Science, Technology, Engineering and Mathematical (STEM)-based e-module is feasible to be used as an alternative learning resource for substance pressure material in science learning.

CONCLUSION

The feasibility of e-modules based on Science, Technology, Engineering, and Mathematics (STEM) from content feasibility experts, presentation feasibility experts, and linguistic feasibility experts respectively obtained very feasible criteria so that the product can be used as an

alternative source of learning substance pressure in learning IPA in middle school. The effectiveness test on students' scientific literacy skills showed the N-gain value in the high category. These results indicate that the product developed is effectively used to improve scientific literacy skills in learning the material of substance pressure. The profile of students' scientific literacy skills in the use of e-modules based on Science, Technology, Engineering, and Mathematics (STEM), the average scores that experienced the highest to lowest increases from the pre-test and post-test, namely the process of science, science content, and the context of science. Based on this, the use of the developed Science, Technology, Engineering and Mathematical (STEM)-based e-module is feasible to be used as an alternative learning resource for substance pressure material in science learning.

REFERENCES

Adnan, F., Prasetyo B., & Nuriman N. (2017). Usability Testing Analysis on The Bana Game as Education Game Design References on Junior High School. *Jurnal Pendidikan IPA Indonesia*, *6*(1): 88–94.

Amatullah, S. F., Distrik, I. W., & Wahyudi, I. (2019). Pengaruh Model Pembelajaran Inkuiri Terbimbing Berbantukan Buku Siswa Berbasis Pendekatan Terpadu STEM terhadap Hasil Belajar. *Jurnal Pendidikan Fisika*, *7*(1), 15-27.

Astuti, N. H., Rusilowati, A., & Subali, B. (2021). STEM-Based Learning Analysis To Improve Students' Problem Solving Abilities In Science Subject: A literature Review. *Journal of Innovative Science Education*, *10*(1): 79-86.

Alfan, D. C., Saptono, S., & Lisdiana, L. (2021). Effectiveness of E-Supplement Mobile Android Application toward Science Literacy Skills on Minimum Competency Assessment Oriented in Respiratory System of Junior High School Students. *Journal of Innovative Science Education*.

Chiappetta, E. L. & Koballa. T. R. (2010). *Science Instruction in The Middle and Secondary Schools: Developing Fundamental Knowledge and Skills*. United State of America: Pearson Education Inc.

Dasgupta, C., Magana, A. J., & Vieira, C. (2019). Investigating The Affordances of a CAD Enabled Learning Environment for Promoting Integrated STEM Learning. *Computers & Education*, *129*: 122-142.

Dini, N. P. A. (2018). Pengaruh Penggunaan Smartphone dan Motivasi Belajar terhadap Hasil Belajar Mata Pelajaran Ekonomi pada Kelas XI IIS di SMA Negeri 1 Mojosari. *Jurnal Pendidikan Ekonomi*, 6(3), 349-354.

Erdogan, I., & Ciftci, A. (2017). Investigating the Views of Pre-Service Science Teachers on STEM Education Practices. *International Journal of Environmental and Science Education*, *12*(5): 1055-1065.

Gucluer, E & Kesercioglu, T. (2012). The Effect of Using Activities Improving Scientific Literacy on Students' Achievement in Science and Technology Lesson. *International Online Journal of Primary Education*, 1(1): 3-10.

Harahap, N. (2014). Hubungan Antara Motivasi dan Aktivitas Belajar Siswa Terhadap Hasil Belajar Kognitif Siswa dengan Penerapan Model Pembelajaran Kooperatif Tipe Student Teams Achievement Division pada Konsep Ekosistem. *Visipena*, 5(1): 35-46.

Hutomo, B. A., Parmin, P., & Khusniati, M. (2016). Pengaruh Model Active Learning Berbantuan Media Flash Terhadap Pemahaman Konsep Dan Aktivitas Belajar Siswa SMP Kelas VII Pada Tema Kalor Dan Perpindahannya. *Unnes Science Education Journal*, *5*(3): 1321-1330.

Hutomo, B. A., Suryaningsih, Y., Subali, B., & Marwoto, P. (2020). Profil Pemahaman Konsep Peserta Didik SMP Pada Materi Kalor dan Perpindahannya. *JPPS (Jurnal Penelitian Pendidikan Sains)*, *9*(2), 1777-1782.

Karahan, E., Canbazoglu Bilici, S., & Unal, A. (2015). Fen, Teknoloji, Mühendislik ve Matematik (FeTeMM) Eğitimine Medya Tasarım Süreçlerinin Entegrasyonu. *Egitim Arastirmalari-Eurasian Journal of Educational Research*, (60): 221-24.

Iriani, T., Elvarita, A., & Handoyo, S. S. (2020). Peningkatan Materi Pelajaran Mekanika Tanah. *Jurnal Pendidikan Teknik Sipil*, *9* (1), 1-7.

Istuningsih, W., Baedhowi, & Sangka, K. B. (2018). The Use Of Electrinic Modules For Learning Effectiveness. *International Journal of Educational Research Review*, *3*(3): 75-85.

Moeed, A. (2016). Novelty, Variety, Relevance, Challenge and Assessment: How Science Investigations Influence The Motivation of Year 11 Students In New Zealand. *School Science Review*, 97(361): 75-81.

Odja, A. H., & Payu, C. S. (2014). Analisis Kemampuan Awal Literasi Sains pada Konsep IPA. Prosiding Seminar Nasional Kimia. Jurusan Kimia FMIPA Universitas Negeri Surabaya. ISBN: 978-602-0951-00-3. hlm 40-47.

OECD. (2010). *PISA 2009 Results: What Students Know and Can Do – Student Performance in Reading, Mathematics and Science (Volume I).* OECD Publishing.

OECD. (2014). *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science (Volume I, Revised edition, February 2014), PISA*. OECD Publishing.

OECD. (2016). *PISA 2015 Results (Volume I): Excellence and Equity in Education, PISA.* Paris: OECD Publishing.

Prasetyo, D., Marianti, A., & Alimah, S. (2021). Improvement of Students' Science Literacy Skills Using STEM-Based E-Modules. *Journal of Innovative Science Education*, *10*(1), 216-221.

Putra, G. S. & Winarti, P. (2014). Pengembangan Modul Pembelajaran Pada Mata Kuliah Sistem Telekomunikasi di Jurusan Teknik Elektro Universitas Negeri Surabaya. *Jurnal Pendidikan Teknik Elektro*, 3(3): 493-498.

Safitri, E., Handayani, S., & Mujdalipah, S. (2018). Pembelajaran Praktikum dengan Modul Berbasis Science, Technology, Engineering and Mathematics (STEM) untuk Meningkatkan Hasil Belajar Siswa Pada Kompetensi Dasar Melakukan Dasar Pengawetan. *Edufortech*, *3*(2): 93-100.

Saptono, S., Rustaman, N. Y., Saefudin, & Widodo, A. (2016). Memfasilitasi Higher Order Thinking Skills Dalam Perkuliahan Biologi Sel Melalui Model Integrasi Atribut Asesmen Formatif. *Jurnal Pendidikan IPA Indonesia*, *5*(3): 1408-1417.

Saptono, S., Idrus, Irdam., & Irawati, Sri. (2017). Formative Learning Progression (FLP) Program to Improve Students' Reasoning Skill in Cell Biology. *Proceeding of ICMSE*, 4(1): 39-44.

Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research (J-PEER)*, 2(2): 1-28.

Sugiyono. (2012). *Metode Penelitian Kuantitatif Kualitatif dan R & D.* Bandung: Alfabeta.

Sukariasih, L., Erniwati, E., & Salim, A. (2019). Development of interactive multimedia on science learning based adobe flash CS6. *International Journal for Educational and Vocational Studies*, *1*(4): 322-329.

Syahroni, M. W., Rusilowati, A., & Ridlo, S. (2021). Developing of STEM-Oriented Teaching Materials on Object Motion for Class VIII Junior High Schools. *Journal of Innovative Science Education*, *10*(1): 259-268.

Widyaningrum, R., Sarwanto, & Karyanto. (2013). Pengembangan Modul Berorientasi POE (Predict, Observe, Explain) Berwawasan LingkunganPada Materi Pencemaran Untuk Meningkatkan hasil Belajar Siswa. *Jurnal Bioedukasi*. 6(1): 100-117.

Vennix, J., Brok, P. D., & Taconis, R. (2018). Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM? *International Journal of Science Education*, *40*(11): 1263–1283.