JPPIPA 7(Special Issue) (2021)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of Electronic Modules (E-Modules) Based on Guided Inquiry on Temperature and Heat Materials to Improve Students' Science Literacy.

Sri Andriani[1*], Sukarmin[1,2], Mohammad Masykuri[1]

[1] Science Education Study Program, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia
[2] Physics Education Study Program, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Surakarta, Indonesia

DOI :10.29303/jppipa.v7iSpecialIssue.1234

Article Info
Received: November 10th, 2021
Revised: December 12th, 2021
Accepted: December 15th, 2021

Abstract: Scientific literacy skills are one of the needs of students in the 21st century which is experiencing very fast changes. This study aims to determine the characteristics, feasibility, and effectiveness of the guided inquiry-based E-temperature and heat module in improving students' scientific literacy. The learning steps in the E-module are structured with guided inquiry syntax which is integrated with scientific literacy indicators. The type of research used is research and development using the Borg and Gall model which is modified into 9 stages, namely: 1) preliminary research and information gathering, 2) planning, 3) initial product development, 4) initial product testing, 5) initial product revision. 6) limited trial phase, 7) second product revision, 8) operational trial, 9) final product revision. The data analysis technique used is descriptive analysis to describe the characteristics of the E-module, the feasibility analysis of the E-module based on the criteria score, and the analysis of the effectiveness of the E-module to improve students' scientific literacy based on the N-gain score. The results showed that the temperature and heat E-module has been successfully developed according to the guided inquiry model to improve students' scientific literacy, the guided inquiry-based temperature, and heat E-module is very suitable for use in learning, and the guided inquiry-based temperature and heat e-module is effective in improving the scientific literacy of students with a high category N-gain score.

Keywords: Science Literacy; Electronic Module; Guided Inquiry.

Citation: Andriani, S., Sukarmin., & Masykuri, M. &. (2021). Development of Electronic Modules (E-Modules) Based on Guided Inquiry on Temperature and Heat Materials to Improve Students' Science Literacy. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 281–287. https://doi.org/10.29303/jppipa.v7iSpecialIssue.1234

Introduction

The development of the 21st century is marked by the rapid development of science and technology. One of the goals of education in the 21st century is to encourage students to have the skills to be responsive to rapid changes in line with the times (Sutrisna, 2021). However, the reality is that the scientific literacy ability of students in Indonesia is still far from expectations, which is ranked 72 out of 79 test-taking countries. The results of the average score of students are 371 for reading skills, 379 for math skills, and 396 for science skills. This achievement score is still below the average of 79 test-taking countries, namely 487 for reading ability, 489 for math and science ability (OECD, 2019). Based on this information, it shows that most of the students in Indonesia have not been able to analyze and apply science concepts to solve a problem. Students' interest in reading and writing is very less. Most of the students are good at memorizing but are still less skilled in using their knowledge, so that knowledge of other literacy is reduced (PISA, 2018).Scientific literacy is the ability needed to

*Email: andriani@student.uns.ac.id

understand and engage in critical discussions on issues which include the ability to explain natural phenomena and their implications for society, the ability to use knowledge and understanding of scientific inquiry to identify questions, interpret and evaluate data and evidence scientifically (PISA , 2018). Scientific literacy is very important for students to be able to apply science in everyday life and not just understand science as a concept. In an effort to be scientifically literate, students must be able to build and apply logical, critical, innovative knowledge information and be able to analyze and utilize the surrounding natural phenomena as a meaningful learning resource which is then applied contextually in everyday life.

On the other hand, the low scientific literacy of students also occurs at the school level. Based on the results of initial observations of students and teachers, in the implementation of learning activities there are still many students who have difficulty understanding the concept of physics. Students assume that temperature and heat are difficult materials to understand. This is supported by the results of the initial profile test of students' scientific literacy abilities which obtained an achievement of 41% which indicates that achievement is still low. The low scientific literacy of students is due to the fact that at the time of learning activities students receive more material that is lectures so that the learning process received is still teacher-centered. Many students have difficulty in building their own knowledge in using science concepts in a meaningful way.

Several other factors that influence the low scientific literacy of students in learning activities, namely teachers still have difficulty in developing learning tools such as presenting scientific literacy questions and the less optimal integration of technology in science learning. Meanwhile, schools have facilitated adequate facilities and infrastructure to support learning, including science laboratories, LCDs, and computer laboratories but have not been used to their full potential. Then, the teaching materials used in learning are still limited and students only use printed teaching materials for learning. Printed teaching materials such as books and Student Worksheets have limitations in their use, namely they are not able to display phenomena or events dynamically, interactively, and do not support multi-source learning (Aulia & Andromeda, 2019). The low scientific literacy of students must of course be trained and improved by providing the widest possible opportunity for students so that students are able to build and develop their own concepts and knowledge and the teacher only acts as a facilitator. Students' scientific literacy skills can be trained by applying appropriate learning models with inquiry-based learning.

One of the appropriate learning models is guided inquiry. The guided inquiry learning model is learning that maximally involves all students' abilities in finding and investigating concepts and relationships between concepts in a systematic and logical manner (Zaini, 2018). Guided inquiry learning is considered a place if it is applied to seventh-grade junior high school students because it can motivate students to raise questions, formulate problems, analyze data and conclude but is still under the guidance of the teacher. Through guided inquiry students can learn like a scientist, namely through investigation and experiment activities (Zulaichah, et al., 2021). The syntax of guided inquiry according to Llewellyn includes: (1) investigating a phenomenon, (2) focusing on questions, (3) planning an investigation, (4) carrying out an investigation, (5) analyzing data and evidence (6) building new knowledge, (7) communicate new knowledge (Prasetiyo & Rosy, 2020).

Guided inquiry learning has several shortcomings that were found during research, one of which is that it requires a long time and takes a lot of time (Rosmala, 2021). These weaknesses can be overcome by developing guided inquiry-based learning E-modules that can be used by teachers as supporters in the learning process as well as to train and improve students' scientific literacy skills. E-modules have the advantage of being able to present complete elements including audio, video, text, and graphics that allow users to interact interactively through the available features (Aulia & Andromeda, 2019). The learning activities presented in the guided inquiry E-module are to train and improve students' scientific literacy skills which include identifying scientific issues, explaining scientific phenomena, and identifying scientific evidence.

The materials used in the development of the guided inquiry E-module are temperature and heat. Temperature and heat are some of the physical concepts that are often encountered in everyday life (Rahayu, et al., 2019). However, there are still students who have difficulty understanding the concept. At the time of learning activities, students were still burdened with memorizing formulas that only relied on the ability to remember and had not directed students to learn independently in finding concepts so that temperature and heat material became one of the materials considered difficult by students. Therefore, it is necessary to develop an E-module based on guided inquiry on temperature and heat material which is expected to improve students' scientific literacy. In this study, the formulation of the problems included: (1) the characteristics of the guided inquiry-based science E-

module, (2) the feasibility of the guided inquiry-based science E-module, 3) the effectiveness of the guided inquiry-based science e-module to improve students' scientific literacy.

Method

This research is a type of research and development or Research and Development using the Borg and Gall development model which has been modified into 9 stages, namely: (1) preliminary research and information gathering, (2) planning, (3) initial product development, (4) initial product trial, (5) initial product revision, (6) limited trial phase, (7) second product revision, (8) operational trial, (9) final product revision (Arifin, 2018). The preliminary research stage and initial information collection, the planning stage, and the initial product development stage were made a draft of an E-module with characteristics according to the guided inquiry model that was integrated with students' scientific literacy.

The initial trial phase was carried out to obtain a qualitative evaluation of the E-module draft that had been designed by validators of material, media, language, and learning experts. Then a limited trial was conducted on 23 grade VII A students of SMP N 1 Gunem to test the usability and readability of the developed E-module. The operational field trial phase was conducted to determine the effectiveness of guided inquiry-based E-modules in improving students' scientific literacy. The subjects of the operational field trial were 48 students of class VII SMP N 1 Gunem and 48 students of class VII MTs. Manbaul Ulum Pancur. Operational field trials using a one-group pretest-posttest design. The operational field trial design is presented in Table 1.

Table 1. One group pretest – posttest Design

Pretest	Treatment	Posttest
O_1	X_1	O_2

(Zulaichah, et al., 2021)

Description:
X_1 = Treatment using the guided inquiry E-module
O_1 = Pretest
O_2 = Posttest

The characteristics of the developed E-module were analyzed using a descriptive method. While the feasibility of the E-module is analyzed based on the results of validation by material, linguists, media, and learning experts. E-module eligibility criteria are presented in Table 2.

Table 2. E-Module Eligibility Criteria

Percentage (%)	Criteria
0-20	very Eligibility
21-40	not Eligibility
41-60	Eligibility enough
61-80	Eligibility
81-100	Very Eligibility

(Putra, 2021)

The effectiveness of the E-module was obtained based on the results of operational field trials to determine the increase in students' scientific literacy. Changes before and after were calculated using the N-gain test with the SPSS application developed by Hake (March, 2021). The N-gain score can be calculated as follows.

$$\text{N gain} = \frac{S\ post - S\ pre}{S\ maks - S\ pre} \times 100 \quad \text{..... (1)}$$

To determine the effectiveness of the e-module, the interpretation criteria for the N-gain score are presented in Table 3.

Table 3. Criteria for N-Gain Interpretation.

N-gain value	Criteria
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

Hake (Donna, et al., 2021)

Furthermore, guided inquiry-based electronic temperature and heat modules are said to be effective if they have an N-gain score in the medium or high category.

Result and Discussion

The e-module developed is on temperature and heat material which refers to Basic Competencies 3.4 understanding the concepts of temperature, expansion, heat, heat transfer, and their application in daily life including mechanisms to maintain body temperature stability in humans and animals as well as Basic Competencies 4.4 Perform An experiment to investigate the effect of heat on the temperature and shape of objects as well as heat transfer. The e-module is organized into 3 learning activities including: (1) temperature, (2) heat and heat transfer, (3) the effect of heat on changes in the shape of objects.

The characteristics of the developed E-module that follows the guided inquiry learning syntax include: (1) investigating a phenomenon, (2) focusing on questions, (3) planning an investigation, (4) conducting investigations, (5) analyzing data and evidence (6)

build new knowledge, (7) communicate new knowledge. In each syntax, activities are inserted to train students' scientific literacy including indicators: (1) identifying scientific issues, (2) explaining scientific phenomena, (3) using scientific evidence. The relationship between the guided inquiry learning model and scientific literacy is shown in Table 4.

Table 4. Patterns of Relationship between Guided Inquiry and Students' Scientific Literacy

Scientific Literacy Indicator	Guided Inquiry Syntax	E-Modul
- Identify issues of scientific problems	- Investigate a phenomenon	- Presenting scientific phenomena and problems in everyday life
	- Focus on the question	- Presenting questions to answer the formulation of the problem
	- Planning an investigation	- Experiment activities
	- Carry out investigations	- Entering the experimental results into the table
	- Analyze data and evidence	- Problem-solving activities based on the results of data analysis and evidence after conducting experiments
- Explain scientific phenomena	- Build new knowledge	- Directions to be able to conclude based on knowledge
- Interpret data and evidence scientifically	- Communicating new knowledge	- Directions for communicating the results of the investigation

Source: (Rini,. et al, 2021)

The draft of the Science E-module which has been developed according to the characteristics of guided inquiry and scientific literacy indicators is then used for the initial trial stage. The initial trial was used to determine the feasibility of the E-module through validation by material expert lecturers, language experts, media experts, and learning experts. The following are the validation results presented in Table 5.

Table 5. E-Module Validation Results

Validator	Score (%)	Qualification
Materi	89	Very Worthy
	87	Very Worthy
Language	95	Very Worthy
	85	Very Worthy
Media	86	Very Worthy
	100	Very Worthy
Learning	91	Very Worthy
	92	Very Worthy

Based on the results of validation by experts contained in Table 5. E-modules were declared very feasible to be used in learning activities. The feasibility of the E-module is indicated by the material that is complete, extensive, in-depth and accurate. The e-module is also equipped with sample questions and quizzes for each learning activity as well as material components that can stimulate students to build their own knowledge. The feasibility of the E-module language is demonstrated by the use of communicative, dialogical, and interactive language that can be used according to student development and the use of language and terms that are in accordance with the General Guidelines for Indonesian Spelling. The feasibility of the E-module media is shown by the presentation technique and the completeness of the presentation, including the cover design and the excellent content design of the E-module. Systematic and sequential e-modules make it easier for students to learn. The feasibility of learning in the E-module is shown by the complete components, the fulfillment of guided inquiry characters, and learning activities that can train students' scientific literacy.

After the e-module was validated and improved according to the advice of learning experts, linguists, media experts, and material experts, a limited trial was then carried out on 23 grade VII A students of SMP N 1 Gunem to test the readability and usability of the e-module. The results of the limited test obtained an average value of 91% indicating that the e-module is very feasible and can be used for operational trials using a one-group pretest-posttest design.

Operational field trials were conducted to determine the effectiveness of guided inquiry-based e-modules in improving students' scientific literacy. Operational field trials using a one-group pretest-posttest design. Guided inquiry-based e-modules can be used by students to support independent learning activities both at home and at school. Before being given learning, students are given a pretest to determine the students' initial scientific literacy ability. Then after learning, students are given a posttest of scientific literacy so that it can be seen the increase in students' scientific literacy. Learning using the guided inquiry e-module is carried out in groups consisting of 4 to 5 students. Students carry out every learning

activity starting from investigating a phenomenon, focusing on questions, planning investigations, carrying out investigations, analyzing data and evidence, building new knowledge, and communicating new knowledge gained. The tabulation of students' pretest and posttest scores can be seen in Figure 1.

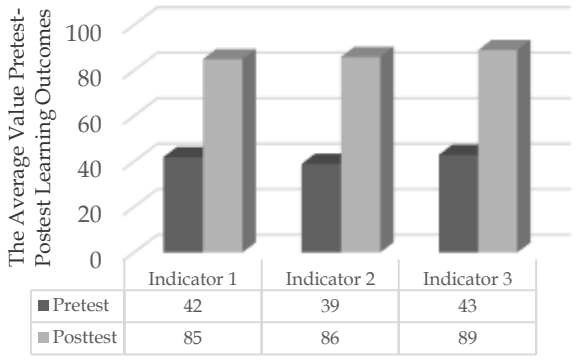

Figure 1. Pretest-Posttest scores of students' scientific literacy

The results of the initial test of scientific literacy for students at SMP N 1 Gunem and MTs. Manbaul Ulum Pancur obtained an average achievement of 41% in every aspect of scientific literacy competency indicator, this shows that students still have difficulty in applying scientific knowledge and difficulties in solving scientific literacy problems on material concepts. The low scientific literacy of students is influenced by the learning model, the method used in the learning process. As well as the inability of students to work on scientific literacy questions that require an understanding of the problem.

Furthermore, based on Figure 1. it can be seen that the posttest score is better than the pretest score covering aspects of competence in explaining scientific phenomena, the ability to identify scientific issues, and the ability to interpret data and evidence.

The pretest and posttest scores were used to calculate the N-gain value which interpreted the effectiveness of the e-module in improving students' scientific literacy. The results of the N-gain score are presented in Table 6.

Table 6. Results of N-gain Student Science Literacy

Scientific Literacy Indicator	MTs N-Gain Score. Manbaul Ulum	MTs N-Gain Score. Manbaul Ulum	Criteria
Explain scientific phenomena	0.72	0.72	High
Identify scientific issues questions	0.73	0.79	High
Interpret data and evidence scientifically	0.76	0.82	High

The average N-gain score of MTs students' scientific literacy. Manbaul Ulum Pancur is 0.74 and the average N-gain of science literacy for students of SMP N 1 Gunem is 0.78. So, it can be concluded that learning using guided inquiry-based temperature and heat e-modules is effective in improving the scientific literacy of students with high N-gain categories. In Table 6. the largest N-gain score is found in the aspect of indicator competence in interpreting scientific data and evidence. The achievement of literacy skills on these indicators is reflected in the ability of students to interpret scientific problems as evidence in making a conclusion and understand the reasons behind the conclusions that students get.

Aspects of competence on indicators of ability achieved by students in explaining phenomena scientifically amounted to 0.72 for MTs students. Manbaul Ulum Pancur and SMP N 1 Gunem. One of the scientific literacy questions on the indicator is presented with questions relating to everyday events about radiation heat transfer and the reasons why a person is not recommended to wear black clothes during the day. Students' abilities on these indicators relate to aspects of students' scientific knowledge in solving problems on material concepts which include the ability to describe or interpret scientific phenomena.

Aspects of competence indicators of the ability achieved by students in identifying questions on scientific issues amounted to 0.73 in MTs. Manbaul Ulum Pancur and 0.79 at SMP N 1 Gunem. The ability achieved by students on these indicators is related to the aspects of scientific knowledge they understand related to the basic concepts of science. The analytical questions on the items of scientific literacy ability contained in this study connect cognitive aspects with examples of events encountered in everyday life, such as the hydrological cycle and its relation to temperature and heat. In these indicators, the cognitive quality contained in students' memory affects students' ability to identify scientific issues.

Aspects of competence on the indicator of the ability to interpret data and scientific evidence of 0.76 in MTs. Manbaul Ulum Pancur and 0.82 at SMPN 1 Gunem. One of the scientific literacy questions on the indicator is presented with questions related to everyday events about heat and changes in the state of matter such as why ice that falls on the floor turns into water. This indicator requires students to be able to use the findings as evidence in making a conclusion and communicating the reasons behind the conclusion (Rini, et al., 2021).

By comparing the pretest and posttest answers, it can be seen that students' scientific literacy has increased after learning using guided inquiry-based temperature and heat E-modules. One of the cores in

inquiry learning activities is that students conduct experimental activities in groups to obtain the concepts of temperature and heat. Scientific literacy can improve well if using several strategies that have aspects of scientific literacy, including teaching material with experiments that can stimulate high-level thinking and are contextual in nature. This is a step-in inquiry learning, namely planning and carrying out investigations so that they can train students' scientific literacy in the aspect of identifying indicators of scientific problem issues. The resulting electronic module can be seen in the following image example.

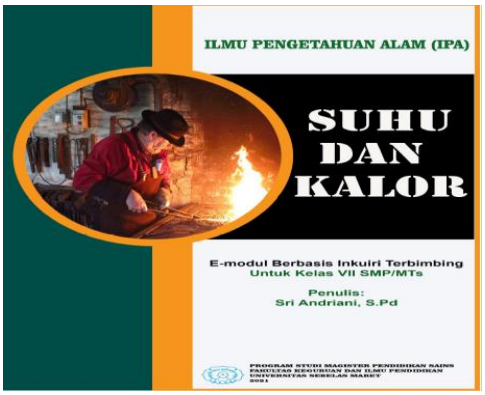

Figure 2. E-module cover

Figure 3. Introduction of electronic E-modules

Figure 4. Contents of the E-module

Figure 5. Activity in E-module

Guided inquiry-based learning can build the basic elements, construction, and knowledge in scientific literacy (Schiefer, et al., 2020). In inquiry learning students will be physically and mentally involved in solving problems to be able to draw conclusions (Putri & Aznam, 2020). Problems related to temperature and heat in everyday life are presented in e-modules to be solved by students so that students get their own concepts and discoveries. This is supported by the results of research which states that inquiry-based e-modules are effective in increasing students' scientific literacy in terms of the N-gain score with an average posttest of scientific literacy of 76.09 which is greater than the minimum determination of the Benchmark Reference Assessment of 66, so it is stated effectively (Mijaya, et al., 2021)

In the guided inquiry-based e-module is also equipped with videos, animations, pictures, along quizzes to measure understanding of concepts and materials on temperature and heat. The developed guided inquiry e-module can be run through Android so that it helps students increase learning independence in understanding concepts. In guided inquiry-based E-modules students are given the widest opportunity to express ideas by answering discussion questions in the e-module. Thus, through the application of guided inquiry-based e-modules, students can improve scientific literacy.

Conclusion

The results of this study indicate that an e-module of temperature and heat has been developed which has characteristics that are in accordance with the syntax of guided inquiry learning to improve students' scientific literacy. Based on the results of the validation of expert lecturers, the e-module developed is very feasible to support student learning activities. The results of the operational field trials show that guided inquiry-based science e-modules are effective in improving students' scientific literacy with each

scientific literacy indicator including, explaining scientific phenomena, identifying questions about scientific issues, and interpreting data and evidence scientifically.

Acknowledgments

Thank you to the principal of SMPN 1 Gunem and MTs. Manbaul Ulum Pancur, along with teachers and students who have given researchers the opportunity to conduct research on the development of guided inquiry-based e-modules on temperature and heat materials.

References

Aulia, A., & Andromeda, A. (2019). Pengembangan E-Modul Berbasis Inkuiri Terbimbing Terintegrasi Multirepresentasi dan Virtual Laboratory pada Materi Larutan Elektrolit dan Nonelektrolit untuk Kelas X SMA/MA. *Edukimia*, 1(1), 94–102. https://doi.org/10.24036/ekj.v1.i1.a34 [Indonesian]

Rini, C. P., Hartantri, D.S., & Amaliyah, A. (2021). Analisis Kemampuan Literasi Sains Pada Aspek Kompetensi Mahasiswa PGSD FKIP Universitas Muhammadiyah Tangerang. *Jurnal Pendidikan Dasar Nusantara*, *6*(2), 166-179. https://doi.org/10.29407/jpdn.v6i2.15320 [Indonesian]

Donna, R., Egok, A. S., & Febriandi, R. (2021). Pengembangan Multimedia Interaktif Berbasis Powtoon pada Pembelajaran Tematik di Sekolah Dasar. Jurnal Basicedu, 5(5), 3799–3813. http://www.jbasic.org/index.php/basicedu/article/view/1347 [Indonesian]

Zulaichah, S., Sukarmin, S., & Masykuri, M. (2021). Pengembangan Modul Ipa Berbasis Inquiry Lesson Pada Materi Usaha Dan Pesawat Sederhana Untuk Meningkatkan Kreativitas Ilmiah Siswa. *Edusains, 13*(1), 64-72. doi:https://doi.org/10.15408/es.v13i1.17389 [Indonesian]

Mijaya, N.P.A.P., Sudiatmika, A.A.I.A.R., & Suardana, I.N. (2021). Pengembangan E-Modul Pembelajaran Ipa Smp Kelas Vii Berbasis Model Pembelajaran Levels Of Inquiry Untuk Meningkatkan Literasi Sains Siswa. *QUANTUM: Jurnal Inovasi Pendidikan Sains.* 12(2), 220–237. [Indonesian]

OECD. (2019). *Skills Strategy 2019 Skills to Shape a Better Future: Skills to Shape a Better Future*. OECD Publishing. https://books.google.co.id/books?id=l8SZDwAAQBAJ

PISA. (2020). *For Development Assessment and Analytical Framework Reading, Mathematics and Science: Reading, Mathematics and Science*. OECD Publishing. https://books.google.co.id/books?id=wWWQDwAAQBAJ

Prasetiyo, M. B., & Rosy, B. (2020). Model Pembelajaran Inkuiri Sebagai Strategi Mengembangkan Kemampuan Berpikir Kritis Siswa. *Jurnal Pendidikan Administrasi Perkantoran (JPAP*), 9(1), 109–120. Retrieved from: https://journal.unesa.ac.id/index.php/jpap/article/view/9318 [Indonesian]

Putra, A., & Susilowibowo, J. (2021). E-Modul Berbasis Android Mata Pelajaran Komputer Akuntansi Program Aplikasi Accurate Accounting V5 untuk Siswa Kelas XI. *Jurnal Penelitian dan Pengembangan Pendidikan, 5*(2), 250-256. http://dx.doi.org/10.23887/jppp.v5i2.36500 [Indonesian]

Putri, A. S., & Aznam, N. (2020). Web Modul Ipa Berbasis Inkuiri Terbimbing Untuk Meningkatkan Thinking Skill. *Edusains*, 12(1), 47–53. https://doi.org/10.15408/es.v12i1.11034 [Indonesian]

Rahayu, P., Prastowo, S., & Harijanto, A. (2018). Indentifikasi pemahaman konsep fisika pokok bahasan suhu dan kalor melalui three tier test pada siswa sma kelas xi. *Fkip e-proceeding, 3*(1), 226-230. Retrieved from https://jurnal.unej.ac.id/index.php/fkip-epro/article/view/7402 [Indonesian]

Rosmala, A. (2021). *Model-Model Pembelajaran Matematika*. Bumi Aksara. https://books.google.co.id/books?id=5xwmEAAAQBAJ [Indonesian]

Schiefer, J., Golle, J., Tibus, M., Herbein, E., Gindele, V., Trautwein, U., & Oschatz, K. (2020). Effects of an extracurricular science intervention on elementary school children's epistemic beliefs: A randomized controlled trial. *British Journal of Educational Psychology*, 90(2), 382–402. https://doi.org/10.1111/bjep.12301

Sutrisna, N. (2021). Analisis Kemampuan Literasi Sains Peserta Didik Sma Di Kota Sungai Penuh. *Jurnal Inovasi Penelitian*, *1*(12), 2683-2694. https://doi.org/10.47492/jip.v1i12.530. [Indonesian]

Zaini, M. (2018). Development of Guided Inquiry Based Learning Devices To Improve Student Learning Outcomes in Science. *European Journal of Alternative Education Studies,* 2000, 107–117. https://doi.org/10.5281/zenodo.2261027