Online Learning in Educational Research
Volume 2, Issue 2, 57-66.
e_ISSN: 2798-2351
https://www.journal.foundae.com/index.php/oler/index

POE-Based E-Module (Predict, Observe, and Explain): Improving Students' Critical Thinking Skills on Kinetic Theory of Gases

Maryam Aulia
Institut Agama Islam Negeri (IAIN) Palangka Raya, INDONESIA

Hadma Yuliani*
Institut Agama Islam Negeri (IAIN) Palangka Raya, INDONESIA

Article Info

Article history:

Received: October 3, 2022
Revised: November 11, 2022
Accepted: December 10, 2022

Keywords:

Critical Thinking;
E-module- Kinetic gases;
E-module-based POE;
E-module for the student.

Abstract

Based on interviews and observations, students' critical thinking skills at SMAN 5 Palangka Raya could have been more optimal. Therefore, the researchers offer a solution by using POE-based e-modules. This study aimed to see the improvement in critical thinking skills after using the POE-based e-modules in physics learning. This research method is quantitative with a one-group pretest-posttest design. Students' critical thinking skills were determined using a description test and analyzed using the N-Gain calculation. Based on the purposive sampling technique, the sample of this study was class XI MIPA 2 with 25 students. The result of this study was an increase in critical thinking skills after implementing a POE-based e-module, as indicated by an N-Gain of 0.73 (high category). This study concludes that POE-based e-modules can improve students' critical thinking skills.

To cite this article: Aulia, M., & Yuliani, H. (2022). POE-based e-module (predict, observe, and explain): Improving students' critical thinking skills on kinetic theory of gases. *Online Learning in Educational Research, 2*(2), 57-66

INTRODUCTION

Technological and information advances in the twenty-first century undoubtedly impact the field of education (Ardimas et al., 2021; Jamun, 2018). To improve educational quality, today's educational world must adapt to changes in technology and information(Salsabila et al., 2020). In particular, they adapt technology and information in the learning process (Nafi'a et al., 2020). The use of technology and information in the learning process is done to raise the learning process's effectiveness and improve students' capacity and quality in using technology responsibly (Lestari, 2018; Noor et al., 2021). Learning will be effective if students interact with diverse learning resources to attain learning objectives (Aspi & Syahrani, 2022). If learning objectives are met, the effectiveness of the learning that occurs is also met.

Effective learning must take place across all subjects. Physics is a lesson that takes more work to learn effectively (Rohim & Susanto, 2012). Physics' nature is to contain processes, products, and attitudes (Tanti et al., 2017). Students need help understanding the physics concept when learning it (Azizah et al., 2015). This challenge is also caused by a need for more learning facilities as a learning resource for students, who often use only full-text textbooks.

Physics is notorious for its challenging mathematics and abstract concepts (Yoto & Wiyono, 2015). Gas kinetic theory is a physics material with abstract notions (Tani & Ekawati, 2017). The gas kinetic theory is a microscopic physics event requiring abstract reasoning (Nurjanah & Purnomo, 2016). Gas kinetic theory investigates physical objects up to the arrangement of atoms in an ideal gas, which cannot be directly observed (Putri et al., 2020). The absence of teaching materials utilized to study the material and the applicable rules adds to the difficulty of learning gas kinetic theory material (Santofani & Rosana, 2016). The teacher's issue in explaining the kinetic gas theory material is describing the abstract idea of gas kinetic theory so that it appears real in real life.

***Corresponding author:**
Hadma Yuliani, IAIN Palangka Raya, Indonesia. ✉ hadma.yuliani@iain-palangkaraya.ac.id

To achieve the best results, physics lectures, particularly those based on gas kinetic theory material, necessitate students' critical thinking abilities (Aslinda et al., 2017; Martanti et al., 2013). Critical thinking is achieved through activities to evaluate what is done when gathering factual knowledge (Priyadi et al., 2018). Students with critical thinking abilities will be able to solve problems, gather relevant information, consider multiple problem-solving options, complete reviews, dare to articulate conclusions, and assess these conclusions (Luthvitasari & Linuwih, 2012; Nasution, 2018). Students must have critical thinking abilities when learning physics to locate and verify the truth of the information to make judgments about whether or not the information is useful to solve problems efficiently (Priyadi et al., 2018).

According to observations and conversations with SMAN 5 Palangka Raya teachers, students' critical thinking skills in physics learning have yet to be optimized. The teacher made an effort during the learning process by using teaching materials: PowerPoint, Kemendikbud Module, e-module, and worksheets. The endeavor still needed to develop students' critical thinking skills fully. In a study conducted by Sundari and Sarkiti (2021), students' critical thinking abilities were still inadequate in physics learning due to students' misconceptions, particularly when requested for further explanation and drawing conclusions in the indicators of critical thinking skills (Sundari & Sarkity, 2021). As a result, researchers offer solutions in the form of instructional materials based on learning models, namely e-modules based on POE (Predict, Observe, Explain), to structure learning and develop students' critical thinking skills.

E-modules are educational resources in photos, videos, animations, and simulations. They may be opened anytime and from any location if they have a supporting device (Puspitasari, 2019). E-modules are interactive, structured, communicative, and content knowledge and skills. They can be used remotely or online (Herawati & Muhtadi, 2018). E-modules also include practice questions at the end of the lesson that serves as a benchmark for student comprehension of the content taught. The electronic module must be linked with a learning model to ensure that learning is structured.

POE is one of the appropriate learning models to combine with e-modules to increase students' critical thinking skills. As the name says, POE-based e-modules involve three activities: predicting, observing, and concluding, which can make students more engaged and independent during the learning process (Aulia et al., 2022). Students gain hands-on experience in the learning process through these activities (Kasih et al., 2021). Students predict what will happen or the answer to an issue, make observations to prove what happened and explain or deduce the suitability between predictions and observations (Hasanah et al., 2021). If the observed outcomes do not match the predictions, students are tasked with determining the cause.

Previous research to develop critical thinking abilities has used e-modules based on CTL (Desnita et al., 2022), scientific approaches (Haryanto et al., 2021), ethnoscience-based guided inquiry (Kurniawan & Syafriani, 2021), STEM (Handayani et al., 2021), and Problem-based Learning (Sujanem et al., 2020). Nevertheless, research using e-modules based on the POE learning model has yet to be conducted to increase critical thinking skills. A POE-based student worksheet is only available (Taqwa et al., 2019). Based on the reviews above, this study was designed to examine the improvement of students' critical thinking skills following the usage of POE-based e-modules in physics learning. This learning model's teaching materials are expected to meet learning objectives by maximizing students' critical thinking skills.

METHOD

This research employed the quantitative approach. Quantitative research is a study based on the positivist philosophy used to evaluate a population or sample, gather data using research instruments, and analyze quantitative or statistical data to describe and evaluate prepared hypotheses (Sugiyono, 2019).

The quantitative research method employed was of the pseudo-experimental (Pre-Experimental design) type. Based on variations in pretest and post-test data, one group pretest-posttest method was employed to investigate improving students' critical thinking skills when learning physics using POE-based e-modules. One experimental class was given a pretest before

being treated with POE-based e-modules. Following that, a final test (post-test) was performed, which is a comparison of the previous test. Table 1 shows the research plan for this research.

Table 1. One Group Pretest-Posttest Design

P_1	X_1	P_2

(Sugiyono, 2019)
Description:
P_1 : Pretest P_2 : Posttest X_1: The treatment of POE-based e-module

This sample was class XI MIPA 2, which was determined using purposive sampling. The instrument employed was description questions with up to 15 elements. The critical thinking indicators tested in this study were Ennis's (1985) adaptations, which may be found in table 2.

Table 2. Indicators of Critical Thinking Skills According to Hammer

No	Indicators
1	Elementary clarification
2	Advance clarification
3	Strategies and tactics
4	Inference

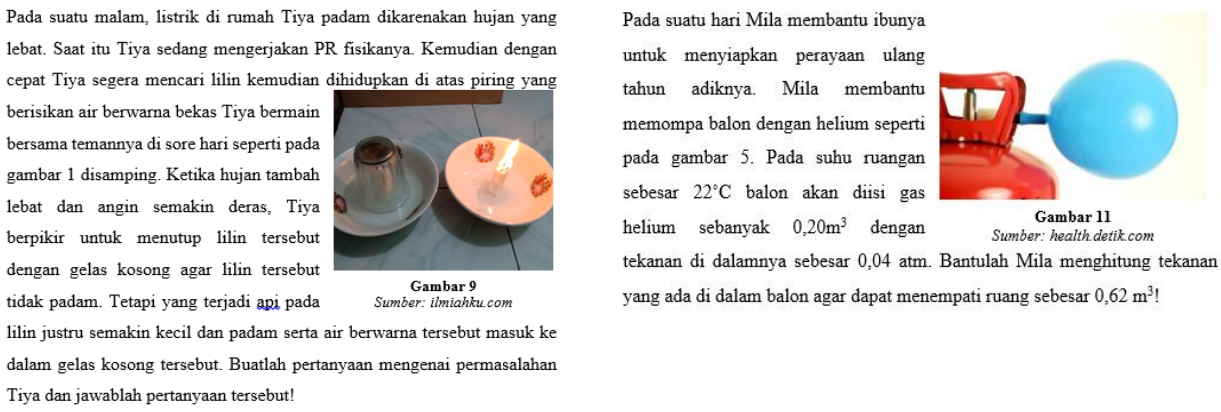
Students predict and investigate a problem using indicators of critical thinking abilities to provide simple clarifications. Students provide a deeper explanation related to the theory in the indicator of providing clarification. Students develop strategies and techniques to tackle existing problems in the determining strategies and techniques and reach final findings in the conclusion indicator. A test was given to pupils to assess their critical thinking abilities. First, the instrument validity of the question items was verified. Table 3 shows the grids and outcomes of the instrument trials.

Table 3. Critical Thinking Skills Test Grids

No	Material Indicator	Sub-material	Critical Thinking Indicator	Aspect	Item
1.	Explain the properties of an ideal gas	Properties of an ideal gas	Inference	C_5	4
2.	Understand the law and ideal gas in everyday life.	Ideal gas	Elementary clarification	C_3	1, 2*
			Advance clarification	C_4	3*, 6*, 8
		Boyle's law	Advance clarification	C_4	5
		Charles' law	Inference	C_5	13
		Boyle-Gay Lussac law	Elementary clarification	C_3	11
			Inference	C_5	12
3.	Understand gas pressure in a closed container.	Gas pressure in a closed container	Elementary clarification	C_3	10
			Advance clarification	C_4	7, 9
4.	Formulate the kinetic energy and average velocity of gas particles in a problem.	Average velocity	Advance clarification	C_4	14
		Kinetic energy	Strategies and tactics	C_5	15
5.	Analyze the energy equipartition theorem in a problem	Relative velocity	Advance clarification	C_4	16
		Energy in	Advance clarification	C_4	17
		Gas particle velocity	Elementary clarification	C_3	18

Description: * are items that were rejected during the try-out.
C_3 = Applying C_4 = Analyzing C_5 = Evaluating

The excerpt of the instrument used is shown in figure 1.


Pada suatu malam, listrik di rumah Tiya padam dikarenakan hujan yang lebat. Saat itu Tiya sedang mengerjakan PR fisikanya. Kemudian dengan cepat Tiya segera mencari lilin kemudian dihidupkan di atas piring yang berisikan air berwarna bekas Tiya bermain bersama temannya di sore hari seperti pada gambar 1 disamping. Ketika hujan tambah lebat dan angin semakin deras, Tiya berpikir untuk menutup lilin tersebut dengan gelas kosong agar lilin tersebut tidak padam. Tetapi yang terjadi api pada lilin justru semakin kecil dan padam serta air berwarna tersebut masuk ke dalam gelas kosong tersebut. Buatlah pertanyaan mengenai permasalahan Tiya dan jawablah pertanyaan tersebut!

Gambar 9
Sumber: ilmiahku.com

Pada suatu hari Mila membantu ibunya untuk menyiapkan perayaan ulang tahun adiknya. Mila membantu memompa balon dengan helium seperti pada gambar 5. Pada suhu ruangan sebesar 22°C balon akan diisi gas helium sebanyak 0,20m^3 dengan tekanan di dalamnya sebesar 0,04 atm. Bantulah Mila menghitung tekanan yang ada di dalam balon agar dapat menempati ruang sebesar 0,62 m^3!

Gambar 11
Sumber: health.detik.com

Figure 1. The Research Instrument

The pretest and post-test analysis of the description question uses the following equation (Firdaus & Wilujeng, 2018).

$$Score = \frac{obtained\ score}{total\ maximum\ score} \times 100 \qquad (1)$$

The scores obtained are then interpreted in the critical thinking ability category according to table 4 below.

Table 4. Interpretation of Critical Thinking Skills Scores

No	Score	Category
1.	81,25 < n ≤ 100	Highly critical
2.	62,50 < n ≤ 81,25	Critical
3.	43,75 < n ≤ 62,50	Less critical
4.	n ≤ 43,75	Non-critical

(Yuliati et al., 2011)

To determine the magnitude of the increase in critical thinking skills after using POE-based e-modules to analyze the N-gain value. Normalized N-gain (g factor) describes the difference in quality between before and after treatment. The equation used is found in equation 2 below (Rosida et al., 2017).

$$< g > = \frac{post\text{-}test\ score - pretest\ score}{maximum\ score - pretest\ score} \qquad (2)$$

The <g> value obtained is then interpreted according to table 5 below.

Table 5. Normalized Gain Interpretation

Score (<g>)	Normalized Category
(<g>) > 0,7	High
0,3 ≤ (<g>) ≤ 0,7	Moderate
(<g>) < 0,3	Low

(Wahab et al., 2021)

RESULTS AND DISCUSSION

Result

The study began with a pretest before implementing a POE-based e-module. A post-test was given to examine how students' critical thinking skills developed using the e-module. This study was undertaken online to break the covid-19 spread, which was rising at the time. The data in table 6 is derived from the pretest and post-test data analyzed using equations 1 and 2.

Table 6. The Data of Critical Thinking Skills Analysis

Source	N	Average Score
Pretest	25	36,48
Post-test		82,86
N-Gain		0,73
N-Gain category		High

The findings of the average value of students' critical thinking skills after using POE-based e-modules are shown in Table 6. Before using the POE-based e-module, the average pretest critical thinking ability score was 36.48, classified as non-critical. However, the average post-test critical thinking score after utilizing POE-based e-modules is 82.86, classified as highly critical. The N-Gain result in the class taught utilizing the POE-based e-module is 0.73, considered high. Figure 2 depicts the difference between pretest and post-test data values.

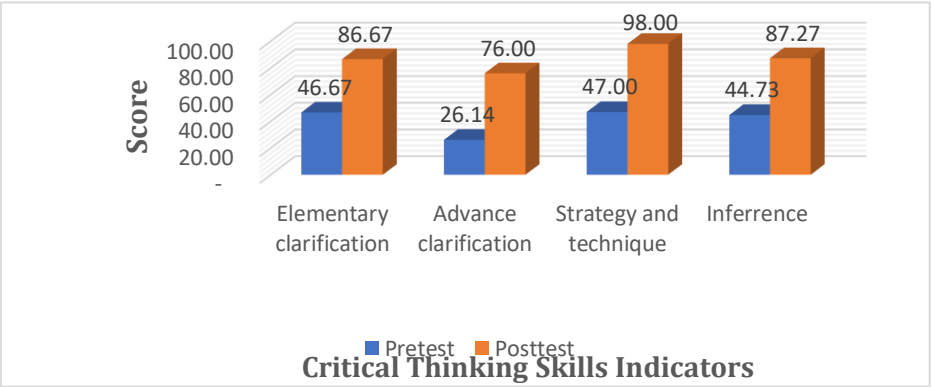


Figure 2. Pretest and Post-test Indicators of Students' Critical Thinking Skills

Figure 2 depicts each indicator's average value of pretest and post-test critical thinking skills. In indicator 1, elementary clarification received an average pretest value of 46.67, which falls into the less critical category, and an average post-test value of 86.67, which falls into the highly critical category. In indicator 2, advance clarification, the average pretest value is 26.14, which falls into the non-critical category, and the post-test average value is 76.00, which falls into the crucial category. In indicator 3, defining strategies and techniques, the average pretest score was 47.00, classified as less critical, while the post-test average score was 98.00, classified as highly critical. In indicator 4, the average pretest score was 44.73, included in the less critical category, and the average post-test score was 87.27, included in the highly critical category.

Discussion

POE-based e-modules are used as instructional tools to develop student's critical thinking skills in predicting and addressing problems in theory or practice. This critical thinking emerges when students attempt to evaluate an issue, determine the facts, and draw conclusions based on conjectures or predictions. Students can guess the truth based on their investigative method. According to Wilujeng & Putri (2020), POE-based e-modules develop students' critical thinking skills in predicting and addressing problems in theory or practice. This critical thinking emerges when students attempt to evaluate an issue, determine the facts, and draw conclusions based on conjectures or predictions. Students can guess the truth based on their investigative method. According to Wilujeng and Putri's (2020) research, POE-based e-modules in each activity can increase students' critical thinking skills in learning.

The first POE-based e-module activity is predict, in which students are given a problem and must assume the cause and progression of the problem based on their knowledge. Students attempt to examine when predicting to create elementary clarifications in critical thinking skills. Figure 3 depicts the predict activity on the indicator of critical thinking skills to make elementary clarifications.

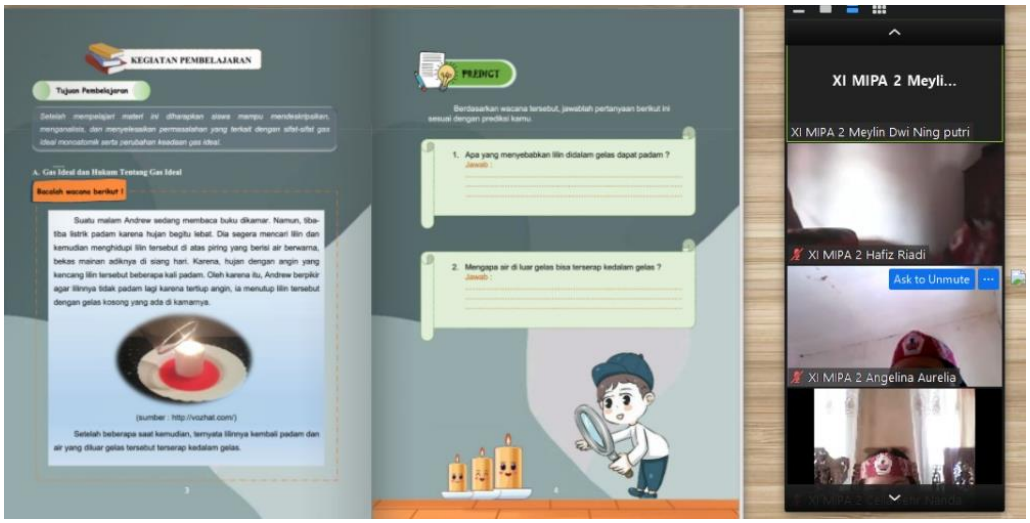


Figure 3. Predict Activity of the Elementary Clarification Indicator

Figure 3 depicts the predict activity on the critical thinking skills to make elementary clarifications. Students did not evaluate the problem as a whole during the pretest, and the review provided did not address the entire problem. In contrast, during the post-test, students theoretically assessed the flaws in the question and the causes of their occurrence, unlike the pretest answers that were not in detail. Using predict exercises in e-modules, critical thinking skills on indicators of elementary clarification obtained a high category N-gain values. Students actively participated in their learning by studying a situation to determine the causes. This finding is consistent with research by Yazidah et al. (2020), who found that when undertaking elementary clarification, students make initial predictions about a problem and subsequently determine the causes.

Students undertook experiments to discover the facts in the second POE-based e-module activity, namely, observe. As students conducted this experiment, they provided advance clarification and strategy and techniques in critical thinking skills. Figure 4 depicts the activities.

Figure 4. Observe Activities on Indicators of Providing Advance Clarification and Determining Strategies and Techniques

Figure 4 depicts the activity on the indicator of offering advance clarification and determining strategies and techniques. During the pretest, students could only rewrite the information gained from the problem, deconstruct the equation appropriately once the solution was discovered, and write the unit in the final result. Students presented their responses in greater depth during the post-test, beginning with writing known as the information collected, finding the equation employed, decomposing the equation to obtain the final result along with the unit, and drawing conclusions from the solution gained. This finding is consistent with earlier studies; when providing advance clarification, students can connect the problems with the mathematical equations that provide the answer (Ritdamaya & Suhandi, 2016).

Observe activities in the e-module provided critical thinking skills on the indicator of advance clarification with an N-gain value in the moderate category. In this indicator, the disparity between pretest and post-test results was moderate, indicating that students needed to optimize their ability

to derive equations to find the answer to a problem. As a result, the growth of students' critical thinking skills was minimum. Routine activities are required to get students habituated to solving problems using equation derivation.

During the pretest of the observe activities on indicators of determining strategies and techniques, the students needed to provide more clarification for their answers. Therefore, their solutions were inappropriate. Then, during the post-test, students answered properly and provided explanations for their responses, which were linked to the theory. This finding suggests that students begin to think critically by selecting one solution from many options.

Observe exercises in the e-module helps students develop critical thinking skills on indicators of selecting strategies and techniques with N-gain values in the high category. The students took an active role in their learning by devising strategies and ways to tackle an issue. They utilized proper strategies to solve an issue while selecting strategies and procedures which were theoretically linked (Apiati & Hermanto, 2020). Figure 5 depicts the explained activity on the conclusion indicator.

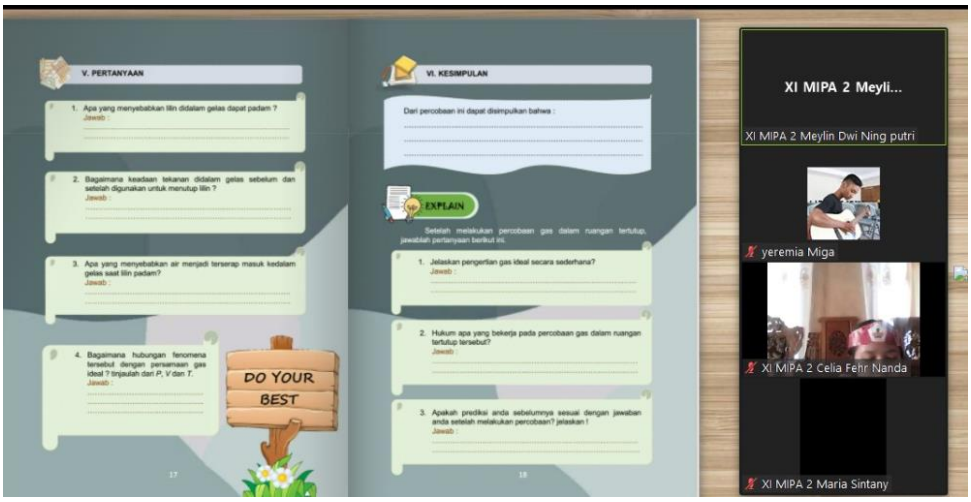


Figure 5. The Explain Activities of the Inferring Indicators

Figure 5 depicts the explain activity; during the pretest, students did not conclude problems by connecting reality and theory; instead, they just acknowledged the theory numerically. Meanwhile, students presented their responses in greater detail during the post-test, beginning with summarizing the events in the problem and coupled with the theory relevant to the problem.

During the explain activity in the e-module, critical thinking skills were gained on inferring with an N-gain value in the high category. Students took an active role in their learning by making inferences when they discovered a truth and adjusting it to previous predictions. According to Firdaus et al. (2019), when students conclude, a conclusion is made from a problem that becomes a solution by relating it to the theory (Firdaus et al., 2019).

Even when not treated, the students could not tackle the problems in detail. After being treated, they began to understand the topic so that they could solve the problem well per the requirements for critical thinking assessment standards. This finding suggests that learning with POE-based e-modules can cause students' critical thinking skills to improve.

The problems offered are simple events that are closely related to the topic. The problems increased students' interest and curiosity in finding solutions, increasing their critical thinking skills. E-modules with activities based on the POE stage include simple experiments that do not need to be carried out in the school laboratory but may be done independently at home because the instruments and materials required are readily available. Learning with educational materials of e-modules engages students to the greatest extent possible and makes learning more enjoyable (Sari & Alarifin, 2016).

The correct instructional materials increase students' excitement for learning and make it easier to achieve their learning objectives. To accomplish maximum learning objectives, selecting instructional materials can be tailored to the characteristics of students, teachers, and the information given. Meeting learning objectives for selecting acceptable instructional materials

implies that the materials are useful. This research was undertaken as part of a teacher's endeavor to develop critical thinking abilities in students to maximize learning outcomes.

CONCLUSION

The N-Gain of 0.73 (high category) indicates increased critical thinking skills after applying the POE-based e-modules. This finding indicates that POE-based e-modules can help students enhance their critical thinking skills. Recommendations for future research, throughout learning, rather intense practice in solving issues utilizing equation reduction is required for the outcomes produced to be even better.

REFERENCES

Apiati, V., & Hermanto, R. (2020). Kemampuan berpikir kritis peserta didik dalam memecahkan masalah matematik berdasarkan gaya belajar. *Mosharafa: Jurnal Pendidikan Matematika*, *9*(1), 167-178. https://doi.org/10.31980/mosharafa.v9i1.630

Ardimas, A., Basith, A., Priyasmika, R., Annovasho, J., & Risdianto, N. S. (2021). Dynamic electrical subject for senior high school:Developing interactive tutorial method animation. *Online Learning in Educational Research, 1*(2). 103-111.

Aslinda, N., Hufri, H., & Amir, H. (2017). Design LKPD terintegrasi inkuiri terbimbing berbantuan virtual laboratory pada materi fluida dinamis dan teori kinetik gas dalam pembelajaran fisika kelas XI SMA. *Pillar Of Physics Education*, *10*(1), 57-64.

Aspi, M., & Syahrani, S. (2022). Profesional guru dalam menghadapi tantangan perkembangan teknologi pendidikan. *Adiba: Journal of Education*, *2*(1), 64–73.

Aulia, M., Yuliani, H., Inayah Syar, N., & Azizah, N. (2022). Effectiveness of POE-based e-modules (predict, observe, explain) on critical thinking ability. *Jurnal Riset Fisika Edukasi dan Sains*, *9*(1), 1–9. https://doi.org/10.22202/jrfes.2022.v9i1.5664

Azizah, R., Yuliati, L., & Latifah, E. (2015). Kesulitan pemecahan masalah fisika pada siswa SMA. *Jurnal penelitian fisika dan aplikasinya (JPFA)*, *5*(2), 44–50.

Desnita, D., Festiyed, F., Novitra, F., Ardiva, A., & Navis, M. Y. (2022). The effectiveness of CTL-based physics e-module on the improvement of the creative and critical thinking skills of senior high school students. *TEM Journal, 11*(2), 802–810.

Ennis, R. (1985). A logical basis for measuring critical thinking skills. *Educational Leadership*, *43*(2), 44–48.

Firdaus, A., Nisa, L. C., & Nadhifah, N. (2019). Kemampuan berpikir kritis siswa pada materi barisan dan deret berdasarkan gaya berpikir. *Kreano, Jurnal Matematika Kreatif-Inovatif*, *10*(1), 68-77. https://doi.org/10.15294/kreano.v10i1.17822

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.

Hafsah, N. R., Rohendi, D., & Purnawan, P. (2016). Penerapan media pembelajaran modul elektronik untuk meningkatkan hasil belajar siswa pada mata pelajaran teknologi mekanik. *Journal of Mechanical Engineering Education*, *3*(1), 106–112.

Handayani, E. S., Yuberti, Y., Saregar, A., Wildaniati, Y. (2021). Development of STEM-integrated physics e-module to train critical thinking skills: The perspective of preservice teachers. *Journal of Physics: Conference Series, 1796*, 012100.

Haryanto, A., Sunaryo, S., & Rustana, C. E. (2021). Development of e-module with a scientific approach to improve the student's critical thinking skills at class XI student high school in optical tools material. *Journal of Physics: Conference Series, 2019*, 012002.

Hasanah, S. R., Yuliani, H., Syar, N. I., Nengsih, E. W., & Annovasho, J. (2021). Analisis kebutuhan pengembangan e-module berbasis POE (Predict, Observe, Explain). *Jurnal Pendidikan MIPA*, *11*(2), 1–4.

Herawati, N. S., & Muhtadi, A. (2018). Pengembangan modul elektronik (e-modul) interaktif pada mata pelajaran Kimia kelas XI SMA. *Jurnal inovasi teknologi pendidikan*, *5*(2), 180–191.

Jamun, Y. M. (2018). Dampak teknologi terhadap pendidikan. *Jurnal Pendidikan dan Kebudayaan Missio*, *10*(1), 48–52.

Kasih, A. N. I. E., Sundaryono, A., & Nursa'adah, E. (2021). Development of electronic module based on POE (Prediction, Observation, Explanation) in natural organic chemistry learning. *EduChemia (Jurnal Kimia dan Pendidikan)*, *6*(2), 231–242.

Kurniawan, R., & Syafriani, S. (2021). The validity of e-module based on guided inquiry integrated ethnoscience in high school physics learning to improve students' critical thinking. *Journal of Physics: Conference Series, 1876*, 012067.

Lestari, S. (2018). Peran teknologi dalam pendidikan di era globalisasi. *EDURELIGIA: Jurnal Pendidikan Agama Islam*, *2*(2), 94–100.

Luthvitasari, N., & Linuwih, S. (2012). Implementasi pembelajaran fisika berbasis proyek terhadap keterampilan berpikir kritis, berpikir kreatif dan kemahiran generik sains. *Journal of innovative Science education*, *1*(2), 92-97.

Martanti, A. P., Hardyanto, W., & Sopyan, A. (2013). Pengembangan media animasi dua dimensi berbasis java scratch materi teori kinetik gas untuk meningkatkan pemahaman konsep siswa SMA. *UPEJ Unnes Physics Education Journal*, *2*(2), 19-25.

Nafi'a, M. Z. I., Degeng, I. N. S., & Soepriyanto, Y. (2020). Pengembangan multimedia interaktif materi perkembangan kemajuan teknologi pada mata pelajaran ilmu pengetahuan sosial. *Jurnal Kajian Teknologi Pendidikan*, *3*(3), 272–281.

Nasution, S. W. R. (2018). Penerapan model inkuiri terbimbing (guided inquiry) dalam meningkatkan kemampuan berpikir kritis pada pembelajaran fisika. *Jurnal Education and Development*, *3*(1), 1–5.

Noor, R. N. F., Zainuddin, Z., Misbah, M., Hartini, S., Dewantara, D. (2021). Blended learning with schoology in impulse and momentum materials: The development of physics teaching materials. *Online Learning in Educational Research, 1*(2), 63-73.

Nurjanah, S., & Purnomo, J. B. (2016). Efektivitas model pembelajaran kooperatif tipe TTW dengan TSTS terhadap hasil belajar materi teori kinetik gas. *Phenomenon: Jurnal Pendidikan MIPA*, *5*(2), 87–94.

Priyadi, R., Mustajab, A., Tatsar, M. Z., & Kusairi, S. (2018). Analisis kemampuan berpikir kritis siswa SMA kelas X MIPA dalam pembelajaran fisika. *JPFT (Jurnal Pendidikan Fisika Tadulako Online)*, *6*(1), 53–55.

Puspitasari, A. D. (2019). Penerapan media pembelajaran fisika menggunakan modul cetak dan modul elektronik pada siswa SMA. *JPF (Jurnal Pendidikan Fisika), 7*(1), 17–25.

Putri, I. T., Aminoto, T., & Pujaningsih, F. B. (2020). Pengembangan e-modul fisika berbasis pendekatan saintifik pada materi teori kinetik gas. *EduFisika*, *5*(1), 52–62.

Ritdamaya, D., & Suhandi, A. (2016). Konstruksi instrumen tes keterampilan berpikir kritis terkait materi suhu dan kalor. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *2*(2), 87-96. https://doi.org/10.21009/1.02212

Rohim, F., & Susanto, H. (2012). Penerapan model discovery terbimbing pada pembelajaran fisika untuk meningkatkan kemampuan berpikir kreatif. *UPEJ Unnes Physics Education Journal*, *1*(1). 1-5.

Rosida, R., Fadiawati, N., & Jalmo, T. (2017). Efektivitas penggunaan bahan ajar e-book interaktif dalam menumbuhkan keterampilan berpikir kritis siswa. *Jurnal Pembelajaran Fisika*, *5*(1), 35-45.

Salsabila, U. H., Fitrah, P. F., & Nursangadah, A. (2020). Eksistensi teknologi pendidikan dalam kemajuan pendidikan islam abad 21. *Jurnal Eduscience (JES)*, *7*(2), 78–89.

Santofani, A., & Rosana, D. (2016). Pengembangan tes kreativitas pada pembelajaran fisika dengan pendekatan inkuiri pada materi teori kinetik gas. *Jurnal Inovasi Pendidikan IPA*, *2*(2), 134–144.

Sari, A. T. W., & Alarifin, D. H. (2016). Pengembangan modul berbasis poe (predict, observe, explain) materi usaha dan energi ditinjau dari kemampuan kognitif. *Jurnal Pendidikan Fisika*, *4*(2), 124-136. https://doi.org/10.24127/jpf.v4i2.531

Sugiyono. (2019). *Metode penelitian pendidikan (kuantitatif, kualitatif, kombinasi, R&D dan penelitian pendidikan)*. Alfabeta.

Sujanem, R., Suwindra, I. N. P., & Suswandi, I. (2020). The effectiveness of problem-based interactive physics emodule on high school students' critical thinking. *Journal of Physics: Conference Series, 1503*, 012025.

Sundari, P. D., & Sarkity, D. (2021). Keterampilan berpikir kritis siswa SMA pada materi suhu dan kalor dalam pembelajaran fisika. *Journal of Natural Science and Integration*, *4*(2), 149–161.

Tani, S., & Ekawati, E. Y. (2017). Peningkatan kemandirian belajar peserta didik pada materi teori kinetik gas melalui penerapan media pembelajaran interaktif berbasis ispring suite 8. *Jurnal Materi dan Pembelajaran Fisika*, *7*(2), 13–16.

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), 23-36.

Taqwa, M. R. A., Faizah, R., & Rivaldo, L. (2019). Pengembangan lembar kerja mahasiswa berbasis POE dan kemampuan berpikir kritis mahasiswa pada topik fluida statis. *EduFisika*, *4*(1), 6–13.

Wahab, A., Junaedi, J., & Azhar, M. (2021). Efektivitas pembelajaran statistika pendidikan menggunakan uji peningkatan n-gain di PGMI. *Jurnal Basicedu*, *5*(2), 1039–1045.

Wilujeng, I., & Putri, T. S. Y. (2020). Development of SETS e-module integrated with POE model for science learning. *Journal of Educational Science and Technology (EST)*, *6*(3), 252-264. https://doi.org/10.26858/est.v1i1.14735

Yazidah, I., Irawan, E. B., & Sulandra, I. M. (2020). Pembelajaran berbasis inkuiri untuk meningkatkan kemampuan berpikir kritis. *Jurnal Kajian Pembelajaran Matematika*, *4*(1), 13-19. https://doi.org/10.17977/um076v4i12020p13-19

Yoto, Y., & Wiyono, K. (2015). Pengembangan multimedia interaktif pembelajaran teori kinetik gas berbantuan Lectora Inspire untuk Siswa Sekolah Menengah Atas (SMA). *Jurnal Inovasi Dan Pembelajaran Fisika*, *2*(2), 211–219.

Yuliati, D. I., Yulianti, D., & Khanafiyah, S. (2011). Pembelajaran fisika berbasis hands on activities untuk menumbuhkan kemampuan berpikir kritis dan meningkatkan hasil belajar siswa SMP. *Jurnal Pendidikan Fisika Indonesia*, *7*(1), 23-27. https://doi.org/10.15294/jpfi.v7i1.1064