



The Impact of Static Fluid E-Module by Integrating STEM on Learning Outcomes of Students

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ABSTRAK

Keberhasilan siswa dalam belajar dapat dilihat dari pencapaian kompetensi siswa. Hal ini berarti ada beberapa factor yang mempengaruhi hasil belajar siswa seperti bahan ajar atau E-Modul. E-Modul adalah modul yang dikemas dalam bentuk elektronik atau digital yang memuat berbagai variasi media interaktif. Keadaan yang ditemukan dilapangan adalah bahan ajar yang digunakan masih dalam bentuk cetak atau buku ajar dan hasil belajar siswa masih dalam kategori rendah. Tujuan penelitian ini yaitu menganalisis tingkat efektivitas penggunaan E-Modul terintegrasi STEM pada materi fluida statis. Penelitian ini adalah penelitian eksperimental semu dengan desain rancangan analisis data single factor independent groups design. Metode penelitian yang digunakan yaitu metode pengembangan dengan model pengembangan instruksional Hannafin dan Peck difokuskan pada desain pembelajaran berorientasi produk. Instrumen yang digunakan dalam penelitian adalah tes akhir, observasi dan lembar kerja. Teknik analisis data yang digunakan dalam penelitian ini adalah analisis statistik deskriptif, uji normalitas, uji homogenitas, uji t untuk 2 sampel tidak berhubungan. Analisis data menunjukkan bahwa adanya perbedaan hasil belajar pada kelompok eksperimen dibandingkan dengan kelompok kontrol. Hal ini menyatakan adanya pengaruh E-Modul fluida statis terintegrasi STEM terhadap hasil belajar siswa. Oleh karena itu, desain modul elektronik materi fluida statis terintegrasi STEM dapat meningkatkan hasil belajar siswa.

ABSTRACT

Students' success in learning can be seen from the achievement of student competencies. This means that several factors affect student learning outcomes, such as learning materials or e-module. E-module is a module packaged in electronic or digital form that contains a variety of interactive media. The situation found in the field is that the teaching materials used are still in printed form or textbooks and student learning outcomes are still in the low category of students. This study aims to analyze the effectiveness of using STEM integrated e-module on static fluid materials. This research was quasi-experimental research with a single factor independent groups design. The research method used was the development method with the Hannafin and Peck instructional development model focused on product-oriented learning design. The instruments used in the study were final tests, observations, and worksheets. The data analysis techniques used in this research were descriptive statistical analysis, normality test, homogeneity test, t-test for two unrelated samples. Data analysis showed differences in learning outcomes in the experiment group compared to the control group. This indicates the influence of the STEM-integrated static fluid E-Module on student learning outcomes. Therefore, the STEM-integrated static fluid material electronic module design can improve student learning outcomes.

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1. INTRODUCTION

Students' success in learning can be seen from the achievement of student competencies. This means that several factors affect student learning outcomes, such as teaching materials or E-Module. E-Module is a module packaged in electronic or digital form that contains a variety of interactive media (Sidiq & Suhendro, 2017; ElAdli & Musawi, 2020). E-Module learning materials that are made systematically to support the learning process. Teachers and students can use E-Module easily through gadgets (Dore et al., 2018)(Ramirez & Mercado, 2019). E-Module can be designed in various formats as needed by adding many features (Alshaya & Oyaid, 2017; Sriyanti et al., 2020). E-module can indirectly help readers reduce paper or paperless use (Prabhasawat et al., 2019). E-Module is usually displayed in PDF form to make them easier to access (Rahmatika et al., 2020; Raynaudo et al., 2018). Therefore, E-Module becomes learning tools that can improve student competence. There are several advantages and disadvantages of E-Module. The advantages of E-Module

includes; easily accessible (Abidin & Walida, 2019), can be designed with multiple media or multimedia (Suwatra et al., 2018), greater interactivity (Boticki et al., 2019), and being very affordable economically due to E-Module do not need to print. Other advantages of the E-module are Narration (text can be added with or highlighted) (Hsieh & Huang, 2020), Hot Spots (possibility of images, graphics, or text provided with a link with practice questions links), Audio (sound effects that can be included in the text), and Visual (images can be added with animation or video) (Bates et al., 2016; Ormançı & Çepni, 2020). In general, E-Module can be accessed by smartphones, laptops, or PCs (Handayani et al., 2021). E-Module also has the drawback that it must be accessed with good internet. Currently, the internet is no longer a problem for students, especially in the conditions of covid-19, the government has provided assistance internet quota according to student needs.

E-Module also needs to be integrated with STEM. STEM stands for Science, Technology, Engineering, and Mathematics (Clarke et al., 2021; Emery et al., 2019; McGee, 2020). STEM provides hands-on experience to students from science and technology engineering (Vennix et al., 2018). STEM integration in learning can unite at least four of these fields of science with a meaningful method (Bassham et al., 2011; Glaze-crampes, 2020; Stohlmann, 2019). A unique feature of the STEM approach is innovative approaches to educating students who are literate in science and technology. In addition, the integration of STEM in learning can provide students with basic skills before becoming scientists (Kusumah, 2020), accustomed to solving problems (Chonkaew et al., 2019). Students will be familiarized with the investigation and creation of simple technology designs (Kelley & Knowles, 2016). Therefore, E-Module STEM integration is essential so that the educational curriculum can be achieved. Several gaps were found in the field during the COVID-19 pandemic. The first situation is that the learning materials used are still in printed form or textbooks. Students cannot use printed books effectively because they are only available in schools while learning is carried out online. The second situation is using STEM integrated teaching materials using the observation sheet instrument obtained a value of 52, which is in the low category. STEM graduates have a 46% job probability while non-STEM graduates are only 13%. The third situation is the student learning outcomes in the odd semester exams for class XI SMA obtained an average score of 62 out of five groups, which are in the good category (White, 2019). Based on the problems in the field, it can be concluded that teachers have not maximized E-Module in the learning process. In addition, minimal STEM integration can reduce students' interest in learning. This gap must be found a solution so that student achievement does not decline.

E-module is known as electronic teaching material and a student learning resource (Yaniawati et al., 2021). The development of STEM integrated e-modules can improve the quality of student questions (Nurramadhani et al., 2020). Students are familiar with STEM fields and discover the relationships between these fields of science. The existence of E-Module can make the learning process more quality and interactive (Serevina & Sari, 2018). This is because the E-Module is designed with an attractive layout and diverse learning media so that the learning process is more meaningful if there is a change in student competence (Asrizal, et al., 2018). In addition, the STEM integrated E-module improves academic achievement and students' scientific literacy skills (Prasetyo et al., 2021). The role of technology in E-Module makes students more flexible in finding information about learning. This is in line with research that the development of E-Module by integrating STEM can support learning and increase student learning motivation (Astalini et al., 2021). Students are given problems related to the real world and trained to find solutions to these problems. Teachers can make various efforts to improve student learning outcomes, both implementing learning strategies (Adnan et al., 2020), media and e-module development. E-Module also trains students' creative thinking skills because they are equipped with interactive simulations (Puspitasari et al., 2020).

This research has differences from previous research. First, physics teaching materials were developed in the form of E-Module. The application used is Flip PDF Professional. Second, the physics learning material in the E-Module includes static fluid material. Third, the E-Module integrates STEM (Science, Technology, Engineering, and Mathematics) in its application. Fourth, the development of an integrated STEM E-Module to determine the improvement of student learning outcomes in three aspects, namely aspects of knowledge, aspects of attitudes, and aspects of skills. The purpose of this study was to analyze the effectiveness of using STEM integrated E-Module on static fluid materials.

2. METHOD

This research is quasi-experimental research with a single factor independent groups design. Quasi-experimental research aims to obtain information that is an approximation to the data obtained by actual experimentation under conditions that do not allow controlling and/or manipulating all relevant variables. This research develops an integrated STEM E-Module by applying the development of Hanafin and Peck. There are three stages in this research, including: (1) needs analysis; (2) Design; and (3) Development and implementation. The sample of this study was obtained using cluster random sampling technique, got 2 sample groups from the population consisting of 5 classes XI SMA N 1 Pasaman. The experimental group was given an action in the

form of applying the STEM integrated static fluid E-Module during the learning process, while the control group without using the STEM integrated static fluid E-Module was given. Both the experimental and control groups have a population of 68 students. The development of an integrated STEM E-Module resulted in a product. The STEM integrated E-Module was validated in advance by a five-person team of experts. Then, the E-Module was improved according to the input and suggestions from the expert team. One component of the STEM integrated E-Module is the cover. The STEM integrated E-Module cover contains information on module material and module identity. This STEM integrated E-Module cover is designed using the word. On the cover, there is a description of the STEM integrated E-Module, static fluid material, class XI, the name of the author, and the university. The dominant colors on the cover are white and blue, a submarine as an example of static fluid, and a picture of a thinking child express students' curiosity about the contents of the E-Module.

Data collection using the google form application for all aspects tested. The collecting data on the knowledge aspect was done by giving post-test questions. The method of collecting data on the attitude aspect uses an attitude observation sheet during the learning process. The technique of collecting data on the skills aspect was an assessment of science process skills in the experimental group through PHeT experiments and simple experiments, while the assessment of the control group was only an assessment of simple experiments. The data analysis technique used in this research was descriptive statistical analysis, normality test, homogeneity test, t-test for two unrelated samples. Descriptive statistical analysis is statistics used to analyze data by describing or describing the data that has been collected as is without making conclusions that apply to the public (Sugiyono, 2012). The normality test aims to see whether the sample comes from a normally distributed population or not. Normality test used Lilliefors test. The homogeneity test aims to see whether the two-sample data have a homogeneous variance or not. For the homogeneity test, the f-test was carried out. After obtaining the normally distributed and homogeneous data, a t-test was performed for the two unrelated samples. The t-test is carried out by comparing or testing the average difference between the experiment and control groups (Sundayana, 2016).

3. RESULT AND DISCUSSION

Result

The effectiveness of using the STEM integrated static fluid E-Module to improve student learning outcomes in class XI SMA are divided into three aspects: the effectiveness of the knowledge aspect, the effectiveness of the attitude aspect, and the effectiveness of the skill aspect. The effectiveness test results of using the first integrated STEM E-Module are aspects of student knowledge. The effectiveness of knowledge was obtained from the final test via google form for the experimental and control groups. Overall, the statistical data on the effectiveness test results on the knowledge aspect can be seen in Table 1.

Table 1. Statistical Parameter of Knowledge Aspects

No	Statistical Parameter	Experimen Group	Control Group
1	Average	83	77
2	Standard Deviation	11	14
3	Varians	131	202
4	Minimum Value	44	36
5	Maximum value	100	92
6	Median	84	80
7	Modus	88	84
8	Range	44-100	36-92

Table 1 shows the difference between the average value of students' knowledge in the experiment and control groups. The average value of knowledge of the experiment group students is 83, while the average value of the control group is 77. Furthermore, other differences are also seen in the range of values in the experiment group, 44 to 100, while the range of values in the control group is 36 to 92. There is a difference between the experiment and control groups, which states that the minimum is in the control group and the maximum is in the experiment group. The median and mode values in the experiment group were higher than in the control group. This difference indicates a significant increase in student learning outcomes in the aspect of knowledge with the use of the STEM integrated static fluid E-Module. The normality test on the knowledge aspect was carried out in each group. The L_o value for the knowledge of the control group is 0.14, while the L_o value for the knowledge of the experiment group is 0.10. From the data obtained, the value of $L_o < L_t$ means that the knowledge value data of the experiment group and control group in using the STEM integrated static fluid E-Module is normally distributed. Furthermore, the homogeneity test was carried out with 33 degrees of freedom. The analysis results

obtained the F_h value of 1.55 for the experiment and control groups, while the F_t was 1.84. The results of these data clearly show that $F_t > F_h$. This indicates that the two groups are homogeneous. Then, the effectiveness test was carried out based on the results of the normality and homogeneity tests. At the significant level of 0.05 and dk, 33 obtained $t_t < t_h$. The results of the analysis of the effectiveness of the experiment group and control group are 2.12. Data analysis shows that $t_t < t_h$. This shows that the STEM integrated E-Module can significantly improve student learning outcomes.

The second test of the effectiveness of using the integrated STEM E-Module is on the aspect of student attitudes. Data were analyzed based on student attitude observation sheets for each meeting. Attitude indicators observed during learning activities using the STEM-integrated static fluid E-Module include discipline (DC), confidence (CF), hard work (HW), cooperation (CP), responsibility (RP), and tolerance (TL). The graph of differences in student attitudes in the experimental and control groups can be seen in Figure 1.

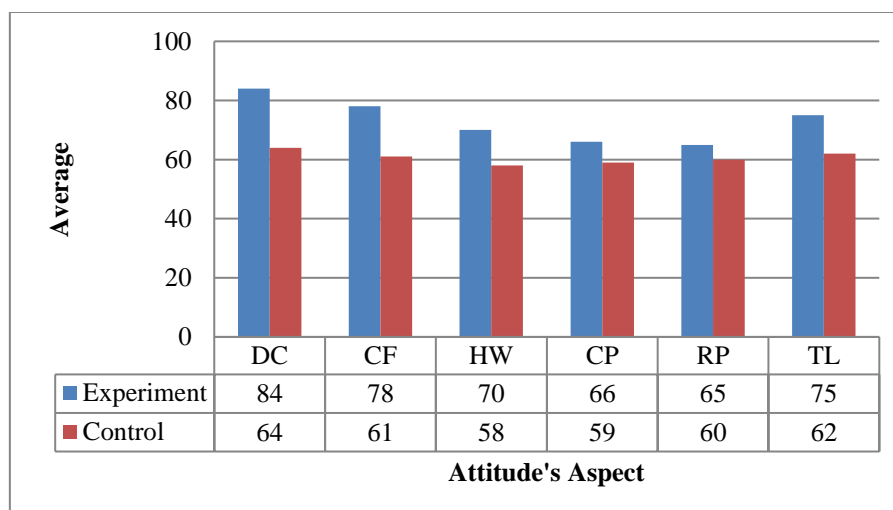


Figure 1. The Result of Students' Attitudes

Based on Figure 2, it can be explaining the differences in student attitudes between the experiment group and the control group. The highest score is seen in the experiment group, 84 on the indicator of discipline, while the lowest is found in the control group, which is 58 on the indicator of hard work. From all attitude indicators, it can be seen that there is a significant difference in scores between the experiment group using the STEM integrated E-Module and the control group using ordinary teaching materials. Students in the experiment group can cooperate reasonably between group members, tolerate and are responsible for group assignments. In addition, the use of integrated STEM E-Module trains students' discipline, self-confidence, and hard work. Therefore, the integrated STEM E-Module can increase students' positive attitudes following the demands of the 2013 curriculum. The effectiveness test results of students' attitudes were also seen based on parametric statistical analysis. The value of the effectiveness of students' attitudes was observed during the physics learning process. The difference in the value of the student attitude aspect using the STEM integrated static fluid E-Module for the experimental and control group can be seen in Table 2.

Table 2. Statistical Parameter of Attitude's Students

No	Statistical Parameter	Experimen Group	Control group
1	Average	73	61
2	Standard Deviation	8	6
3	Varians	67	39
4	Minimum Value	56	50
5	Maximum Value	86	75
6	Median	73	60
7	Modus	82	60
8	Range	56- 86	50-75

Based on the attitude aspect data analysis in Table 2, it can be explaining that there are differences in values in the experiment group and the control group. The average value in the experiment group is 73, and the average value in the control group is 61. The average value of the attitude aspect in the experiment group is

higher than in the control group. The range in the experiment group is the highest at 56-86, while the range of values in the control group is 50-75. The median and mode values in the experiment group were higher than in the control group. The difference in statistical parameter data for the experiment and control groups is significant. This explains that integrated STEM E-Module can improve student discipline, hard work, cooperation, tolerance, self-confidence, and responsibility.

The normality test on the knowledge aspect was carried out in each group. The L_o value for the knowledge of the control group is 0.11, while the L_o value for the knowledge of the experiment group is 0.09. From the data obtained, the value of $L_o < L_t$, mean that the experiment and control group's knowledge value data in using the STEM integrated static fluid E-Module are normally distributed. Furthermore, the homogeneity test was carried out with 33 degrees of freedom. The analysis results obtained the F_h value of 1.71 for the experiment and control groups, while the F_t was 1.84. The results of these data clearly show that $F_t > F_h$. This indicates that the two groupes are homogeneous. Then, the effectiveness test was carried out based on the results of the normality and homogeneity tests. At the significant level of 0.05 and dk 33 obtained tt 2.04. The results of the analysis of the effectiveness of the experiment group and control group are 7.09. Data analysis shows that $t_t < t_h$. This shows that the STEM integrated E-Module can significantly increase students' positive attitudes in learning. The third test results of using the integrated STEM E-Module are aspects of student skills. The value of the effectiveness of students' skills was obtained from student worksheets in carrying out simple experiments in the control group and experiments using PHeT simulations for the experiment group. The indicators of student skills measured include: observing (OB), asking questions (AQ), formulating hypotheses (FH), measuring and processing data (MP), and reporting experimental results (RE). The analysis of student skills indicators can be seen in Figure 2.

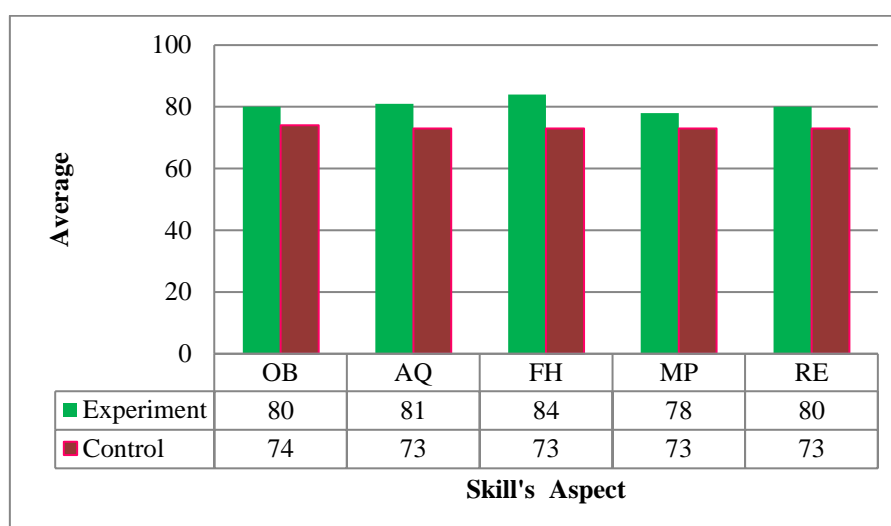


Figure 3. The Result of Students' Skills

Based on Figure 2, there are differences in student skills in the experiment and control groups. The experiment group has an average value of 81, while the control group has 73. Students' skills in the experiment group are very prominent in formulating hypotheses, namely 84. In addition, other skills such as observing and reporting experiment results are on the graph of the same value, which are 80. Meanwhile, the student's skills in the control group were almost evenly distributed in each indicator. Therefore, using STEM integrated E-Module can significantly improves students' science process skills. The effectiveness of the experiment group and control group students' skills using the integrated STEM e-module is carried out during the learning process, including practicum activities. The results of the statistical data analysis of the skill aspects can be seen in Table 3.

Table 3. Statistical Parameter of Skills Aspects

No	Statistical Parameter	Experiment Group	Control Group
1	Average	81	73
2	Standard Deviation	7	8
3	Varians	53	57
4	Minimum Value	67	60
5	Maximum Value	95	90
6	Median	80	72

No	Statistical Parameter	Experiment Group	Control Group
7	Modus	87	72
8	Range	67-95	60-90

Based on the data analysis on the skills aspect in table 3, it can be explained that there is a difference in value between the experiment group and the control group. The average value of the experiment group is 81, which is higher than the control group, which are 73. The highest score is in the experimental group, 95, and the maximum value is in the control group, which are 90. Significant differences are also seen in the mode values of the experiment group and control group, namely 87 and 72. Students in the experiment group get a meaningful experience. Students experiment with PHeT smoothly and systematically. So, using STEM integrated E-Module can improve students' skills, especially in science process skills. The normality test on the knowledge aspect was carried out in each group. The L_o value for the knowledge of the control group is 0.12, while the L_o value for the knowledge of the experiment group is 0.12. From the data obtained, the value of $L_o < L_t$ means that the knowledge value data of the experiment group and control group in using the STEM integrated static fluid E-Module are normally distributed. Furthermore, the homogeneity test was carried out with 33 degrees of freedom. The analysis results obtained the F_h value of 1.07 for the experiment and control groups while the F_t was 1.84. The results of these data clearly show that $F_t > F_h$. This indicates that the two groups are homogeneous. Then, the effectiveness test was carried out based on the results of the normality and homogeneity tests. At the significant level of 0.05 and dk 33 obtained t_t 2.04. The results of the analysis of the effectiveness of the experiment group and control group are 4.25. Data analysis shows that $t_t < t_h$. This shows that the STEM integrated E-Module can significantly improve students' science process skills.

Discussion

The first research is that the integrated STEM E-Module can improve aspects of students' knowledge. This is in line with research that the development of E-Module by integrating STEM can make it easier for students to understand learning concepts (Prasetyo et al., 2021; Sidiq & Suhendro, 2017). Learning with STEM-integrated E-Module is described as very unique and exciting. Various cases in everyday life related to learning materials are explained clearly in E-Module, such as the principle of making dams. It aims to increase students' knowledge and understanding of concepts from the surrounding environment. Students give positive responses such as learning is more accessible, the material provided is obvious, looks attractive, and is related to everyday experiences (Azalia et al., 2020; Rochsun & Agustin, 2020; Triwahyuningtyas et al., 2020). Therefore, the application of the STEM integrated E-Module helps students understand concepts and learning materials to improve learning achievement.

The result of the second study is that the STEM integrated E-Module can increase students' positive attitudes in learning. E-Module directly increases student motivation, such as discipline and confidence in doing assignments, working with groups, and being responsible for lessons given by the teacher. Students are also motivated in learning, so that in learning, students are communicative, diligent, honest, and enjoy reading material (Made et al., 2021; Wu et al., 2018), and 93.24% of students are motivated in conducting experimental activities using e-modules (Harefa & Silalahi, 2021). Students can study independently at home and submit assignments on time because they are used to finding learning materials from various sources such as journals, e-books, articles, etc. This is also supported by the application of ICT in E-Module that it is very easy for students to access the internet. The development of E-Module will continue to improve students' scientific attitudes, especially in the categories of discipline, responsibility, and hard work (Asrial et al., 2019; Fradila et al., 2021).

The third research result is that the STEM integrated E-Module can improve students' science process skills. Students must have some basic skills to face the era of the industrial revolution 4.0. These skills include science process skills. The development of STEM integrated E-Module can improve students' science process skills. Science process skills are students' skills in conducting scientific experiments: observing, asking questions, formulating hypotheses, processing data, and reporting experimental data (Duda & Newcombe, 2019; Juhji & Nuangchalerm, 2020). In addition, E-Module can improve students' problem-solving skills and creative thinking skill (Astra et al., 2020; Cahyanti et al., 2021; Ibrahim & Alqahtani, 2018). Science process skills are essential for students to practice innovation skills and generate creative ideas in learning (Karacop, 2017). To sum up, the development of STEM integrated E-Module can produce experts in science and 21st-century skills. However, the development of this e-module is still limited to one topic, namely static fluid material. Thus, this research can be used as a resource for other researchers in developing e-modules by integrating STEM.

4. CONCLUSION

Based on the research results, the use of STEM-integrated static fluid E-Module in improving student learning outcomes effectively. The research that has been carried out is inseparable from its shortcomings. These

shortcomings include the developed E-Module that only contains one learning material. It is hoped that the development of STEM integrated E-Module is not limited to any material for further research. Another drawback is that the appearance of the E-Module is not perfect in terms of features. This is because the application must be paid for to obtain an extensive and complete menu. The results of this study are expected to assist teachers in designing E-Module, while for researchers, they will become the basis for further research.

5. REFERENCES

- Abidin, Z. S. E. ., & Walida, S. . (2019). Interactive E-Module Model Of Transformation Geometry Based On Case (Creative, Active, Systematic, Effective) As A Practical And Effective Media To Support Learning Autonomy And Competence. *Brazilian Journal of Implantology and Health Sciences*, 1(7), 206–223. <https://doi.org/10.36557/2674-8169.2019v1n7p206-223>.
- Adnan, A., Shukri, M., Nidzam, C., Ahmad, C., & Daud, N. (2020). Integrated STEM-based module: Relationship between students' creative thinking and science achievement. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 6(2), 173–180. <https://doi.org/10.22219/jpbi.v6i2.12236>.
- Alshaya, H., & Oyaid, A. (2017). Designing and Publication of Interactive E-Book for Students of Princess Nourah bint Abdulrahman University : An Empirical Study. *Journal of Education and Practice*, 8(8), 41–57. <https://doi.org/www.iiste.org>.
- Asrial, Syahrial, Kurniawan, D. A., Chan, F., Septianingsih, R., & Perdana, R. (2019). Multimedia innovation 4.0 in education: E-modul ethnoconstructivism. *Universal Journal of Educational Research*, 7(10), 2098–2107. <https://doi.org/10.13189/ujer.2019.071007>.
- Asrizal, A., Amran, A., Ananda, A., F. Festiyed, R. S. (2018). The Development of Integrated Science Instructional Materials to Improve Student Digital Literacy in Scientific Approach. *Jurnal Pendidikan IPA*, 7(4). <https://doi.org/10.15294/jpii.v7i4.13613>.
- Astalini, Darmaji, Kurniawan, D. A., & Chen, D. (2021). Students ' Perceptions of Mathematical Physics E-Module on Multiple Integral Material. *Journal of Education Technology*, 5(4), 531–538. <https://doi.org/10.23887/jet.v5i4.33600>.
- Astra, I. M., Raihanati, R., & Mujayanah, N. (2020). Development of Electronic Module Using Creative Problem-Solving Model Equipped with Hots Problems on The Kinetic Theory of Gases Material. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, 6(2), 181–194. <https://doi.org/10.21009/1.06205>.
- Azalia, I., Sudarmin, & Wisnuadi, A. (2020). International Journal of Active Learning The Effects of Ethnoscience Integrated STEM E-Book Application on Student ' s Science Generic Skills in Chemical Equilibrium Topic. *International Journal of Active Learning*, 5(1), 19–25. <https://doi.org/https://www.learntechlib.org/p/216680/>.
- Bassham, G., Irwin, W., Nardone, H., & Wallace, J. . (2011). *Critical Thinking: A Student's Introduction* (4th ed.). Mc Graw Hill.
- Bates, C. C., Klein, A., Schubert, B., Mcgee, L., Anderson, N., Dorn, L., McClure, E., & Ross, R. H. (2016). E-Books and E-Book Apps: Considerations for Beginning Readers. *The Reading Teacher*, 70(April 2020), 401–411. <https://doi.org/10.1002/trtr.1543>.
- Boticki, I., Akçapınar, G., & Ogata, H. (2019). engagement and reading styles E-book user modelling through learning analytics : the case of learner engagement and reading styles Ivica Boticki , Gökhan Akçapınar & Hiroaki Ogata. *Interactive Learning Environments*, 0(0), 1–12. <https://doi.org/10.1080/10494820.2019.1610459>.
- Cahyanti, A. D., Sudibyo, E., & Rahayu, S. (2021). Effectiveness of Insect Encyclopedia E-Book With Mind Mapping Strategy to Train Students ' Creative Thinking Skills. *IJORER: International Journal of Recent Educational Research*, 2(4), 432–443. <https://doi.org/10.46245/ijorer.v2i4.131>.
- Chonkaew, P., Sukhummek, B., & Faikhamta, C. (2019). STEM Activities in Determining Stoichiometric Mole Ratios for Secondary- School Chemistry Teaching. *Journal of Chemical Education*, 96(6), 1182–1186. <https://doi.org/10.1021/acs.jchemed.8b00985>.
- Clarke, X. M. A., Sharma, N. M., & Schiller, X. A. M. (2021). K-12 Outreach An outreach program with hands-on , physiology-based exercises generates questions about STEM career expectations. *Adv Physiol Educ*, 43(2), 175–179. <https://doi.org/10.1152/advan.00013.2019>.
- Dore, R. A., Hassinger-das, B., Brezack, N., Valladares, T. L., Paller, A., Vu, L., Michnick, R., & Hirsh-pasek, K. (2018). Early Childhood Research Quarterly The parent advantage in fostering children ' s e-book comprehension. *Early Childhood Research Quarterly*, 44(12), 24–33. <https://doi.org/10.1016/j.ecresq.2018.02.002>.
- Duda, H. J., & Newcombe, P. (2019). Enhancing Different Ethnicity Science Process Skills : Problem-Based Learning through Practicum and Authentic Assessment. *International Journal of Instruction*, 12(1),

- 1207–1222. <https://doi.org/10.29333/iji.2019.12177a>.
- ElAdli, A., & Musawi, A. Al. (2020). Effects of Students Attitudes towards Using E- Books on Their Self-efficacy and Academic Motivation. *European Journal of Educational Research*, 9(3), 1167–1176. <https://doi.org/10.12973/eu-jer.9.3.1167>.
- Emery, N., Maher, J. M., & Ebert-may, D. (2019). Studying Professional Development as Part of the Complex Ecosystem of STEM Higher Education. *Innovative Higher Education*, 44, 469–479. <https://doi.org/10.1007/s10755-019-09475-9>.
- Fradila, E., Razak, A., Santosa, T. A., Arsih, F., & Chatri, M. (2021). Development Of E-Module-Based Problem Based Learning (PBL) Applications Using Sigil The Course Ecology And Environmental Education Students Master Of Biology. *International Journal of Progressive Sciences and Technologies (IJPSAT)*, 27(2), 673–682. <https://doi.org/10.52155/ijpsat.v27.2.3248>.
- Glaze-crampes, A. L. (2020). education sciences Leveraging Communities of Practice as Professional Learning Communities in Science , Technology , Engineering , Math (STEM) Education. *Education Sciences*, 10(190), 1–8. <https://doi.org/10.3390/educsci10080190>.
- Handayani, D., Bengkulu, U., & Alperi, M. (2021). Development Of Guided Discovery Based Electronic Module For Chemical Lessons In Redox Reaction Materials. *International Journal of Interactive Mobile Technologies*, 15(7). <https://doi.org/10.3991/ijim.v15i07.21559>.
- Harefa, N., & Silalahi, N. F. D. (2021). Jurnal Pendidikan Kimia Improvement of student ' s learning outcomes and motivation with chemical practicum e-module. *Jurnal Pendidikan Kimia*, 12(1), 10–19. <https://doi.org/10.24114/jpkim.v12i1.17708>.
- Hsieh, Y., & Huang, S. (2020). Using an E-book in the secondary English classroom : Effects on EFL reading and listening. *Education and Information Technologies*, 25(2), 1285–1301. <https://doi.org/10.1007/s10639-019-10036-y>.
- Ibrahim, H., & Alqahtani, A. S. H. (2018). The Impact of Adopting Web 2 . 0-Based E-Book on Student Learning Skills. *Eurasia: Journal of Mathematics, Science, and Technology Education*, 14(6), 2509–2522. <https://doi.org/10.29333/ejmste/90085>.
- Juhji, J., & Nuangchalerm, P. (2020). Interaction between Scientific Attitudes and Science Process Skills toward Technological Pedagogical Content Knowledge. *Journal for the Education of Gifted Young Scientists*, 8(1), 1–16. <https://doi.org/10.17478/jegys.2020.XX>.
- Karacop, A. (2017). The Effects of Jigsaw Technique Based on Cooperative Learning on Prospective Science Teachers ' Science Process Skill 1. *Journal of Education and Practice*, 8(6), 86–97. <https://doi.org/10.1007/s10956-012-9385-9>.
- Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3(11), 1–11. <https://doi.org/10.1186/s40594-016-0046-z>.
- Kusumah, Y. S. (2020). The Effect of GeoGebra in Three-Dimensional Geometry Learning on Students ' Mathematical Communication Ability. *International Journal of Instruction*, 13(2), 895–908. <https://doi.org/10.29333/iji.2020.13260a>.
- Made, N., Sari, A., Bagus, I., & Manuaba, S. (2021). Development of Interactive E-Module Based on Human Digestive System Material Inquiry on Theme 3 About Healthy Foods for Fifth Grade Elementary School. *Indonesian Journal of Educational Research Adn Review*, 5(1), 54–62. <https://doi.org/10.23887/ijerr.v4i1>.
- McGee. (2020). Interrogating Structural Racism in STEM Higher Education. *Educational Researcher*, 49(9), 633–644. <https://doi.org/10.3102/0013189X20972718>.
- Nurramadhani, A., Siti, S., & Permana, I. (2020). Students ' Generated Questions Quality by Developing STEM-based E-Module in Science Learning. *Scientiae Educatia: Jurnal Pendidikan Sains* (, 9(2), 134–152. <https://doi.org/10.24235/sc.educatia.v9i2.7131>.
- Ormançı, Ü., & Çepni, S. (2020). Views on Interactive E-Book Use in Science Education of Teachers and Students Who Perform E-Book Application. *Turkish Online Journal of Qualitative Inquiry*, 11(2), 247–279. <https://doi.org/10.17569/tojq.569211>.
- Prabhasawat, P., Pinitpuwadol, W., Angsriprasert, D., & Chonpimai, P. (2019). Tear film change and ocular symptoms after reading printed book and electronic book : a crossover study. *Japanese Journal of Ophthalmology*, 63(2), 137–144. <https://doi.org/10.1007/s10384-018-00648-1>.
- Prasetyo, D., Marianti, A., & Alimah, S. (2021). Journal of Innovative Science Education Improvement of Students ' Science Literacy Skills Using STEM-Based. *Journal of Innovative Science Education*, 10(37), 216–221. <https://doi.org/10.15294/IJISE.V9I3.43539>.
- Puspitasari, R. D., Herlina, K., & Suyatna, A. (2020). A Need Analysis of STEM-Integrated Flipped Classroom E-Module to improve Critical Thinking Skills. *Indonesian Journal of Mathematics Education*, 3(2), 178–184. <https://doi.org/10.24042/ijmsme.v3i2.6121>.
- Rahmatika, H., Lestari, S. R., & Sari, M. S. (2020). *A PBL-Based Circulatory System E-Module Based on*

- Research Results to Improve Students' Critical Thinking Skills and Cognitive Learning Outcome.* 9(4), 565–575. <https://doi.org/10.23887/jpi-undiksha.v9i4.25647>.
- Ramirez, M. R. B., & Mercado, J. N. L. (2019). Use of E-Book in Science Learning of Junior High Students in The University of Batangas. *IOER International Multidisciplinary Research Journal*, 1(1), 132–142. <https://ssrn.com/abstract=3379282>.
- Raynaudo, G., Scientific, N., Peralta, O., & Scientific, N. (2018). Children learning a concept with a book and an e-book : a comparison with matched instruction Children learning a concept with a book and an e-book : a comparison with matched instruction. *Eur J Psychol Educ*, 34(1), 87–99. <https://doi.org/10.1007/s10212-018-0370-4>.
- Rochsun, & Agustin, R. D. (2020). European Journal of Education Studies The Development Of E-Module Mathematics. *European Journal of Education Studies*, 7(10), 400–412. <https://doi.org/10.46827/ejes.v7i10.3317>.
- Serevina, V., & Sari, I. J. (2018). Development of E-Module Based on Problem Based Learning (PBL) on Heat and Temperature to Improve Student ' s Science Process Skill. *The Turkish Online Journal of Educational Technology*, 17(3), 26–36. <https://eric.ed.gov/?id=EJ1184205>.
- Sidiq, R., & Suhendro, P. (2017). Utilization of Interactive E-Modules in Formation of Students ' s Independent Characters in the Era of Pandemic. *International Journal of Educational Research & Social Sciences*, 2(6), 1651–1657. <https://doi.org/10.51601/ijersc.v2i6.194>.
- Sriyanti, Ida; Almafie, M Rama; Marlina, Leni; Jauhari, J. (2020). The effect of Using Flipbook-Based E-modules on Student Learning Outcomes. *Kasuari: Physics Education Journal*, 3(2), 67–75. <https://doi.org/10.37891/kpej.v3i2.156>.
- Stohlmann, M. (2019). Integrated steM Education through Open-Ended Game-Based Learning. *Journal of Mathematics Education*, 12(1), 24–38. <https://doi.org/10.26711/007577152790036>.
- Sugiyono. (2012). *Metode Penelitian Kuantitatif Kualitatif dan R&B*. Alfabeta.
- Sundayana. (2016). *Statistika Penelitian Pendidikan*. Alfabeta.
- Suwatra, W., Suyatna, A., & Rosidin, U. (2018). Development of Interactive E- Module for Global Warming to Grow of Critical Thinking Skills Development of Interactive E-Module for Global Warming to Grow of Critical Thinking Skills. *International Journal of Advanced Engineering, Management and Science (IJAEMS)*, 4(7), 543–549. <https://doi.org/10.22161/ijaems.4.7.7>.
- Triwahyuningtyas, D., Ningtyas, A. S., & Rahayu, S. (2020). The problem-based learning e-module of planes using Kvisoft Flipbook Maker for elementary school students. *Jurnal Prima Edukasia*, 8(2), 199–208. <https://doi.org/10.21831/jpe.v8i2.34446> This.
- Vennix, J., Brok, P. Den, Taconis, R., & Vennix, J. (2018). *Do outreach activities in secondary STEM education motivate students and improve their attitudes towards STEM?* 0693(May). <https://doi.org/10.1080/09500693.2018.1473659>.
- White, P. (2019). Where do all the STEM graduates go? Higher education , the labour market and career trajectories in the United Kingdom . *J Sci Educ Technol*, 28(1), 26–40. <https://doi.org/10.1007/s10956-018-9741-5>.
- Wu, T., Huang, Y., Su, C., Chang, L., & Lu, Y. C. (2018). Application and Analysis of a Mobile E-Book System Based on Project- Based Learning in Community Health Nursing Practice Courses. *Educational Technology & Society*, 21(4), 143–156. <https://www.learntechlib.org/p/190831/>.
- Yaniawati, P., Al-tammar, J., Osman, S. Z., Supianti, I. I., & Malik, A. S. (2021). Using of sigil software in math education : e-module development and effects on self-regulated learning skills. *Journal for the Education of Gifted Young Scientists*, 9(3), 251–268. <https://doi.org/10.17478/jegys.954829>.