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Development of STEM-based interactive e-module on ecology topic for senior high schools' student

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ABSTRACT

The quality of education must always be improved to get maximum results. One way to improve it is by developing learning media. For this reason, researchers developed an Interactive E-module product containing Ecology topic in Biology Learning as a supplement to learning. An interactive e-module is an electronic module that contains materials, videos, audio, animations, quizzes, and evaluations, which allow students to study independently. This descriptive research consists of three main stages, Planning, Project, Evaluation (PPE). The interactive e-module developed was using the Canva web, then the file was saved as a PDF, after editing was continued using the Flip PDF Professional application. The product was then validated by a material expert and media expert. After going through validation and revision according to the suggestions, the product was tested on Biology teachers and students of class X science. The score from the teacher's assessment is 79.76% in the "Eligible" category. Assessment from students got a score of 80% in the "Eligible" category. Based on the results, the interactive E-module developed by the researcher was feasible to be used in the field in terms of valid and practical feasibility.

INTRODUCTION

Based on field observations by researchers using interviews with Biology teachers, and questionnaires given to class X IPA MA Raudlatus Shibyan students, information was obtained that students' learning resources were unfamiliar with discussing global issues that were currently happening and trying to come up with alternative solutions to solving problems. In addition, in learning the availability of learning resources is still limited to textbooks provided by schools. Meanwhile, it is also known that all students have cell phones but have not been fully utilized to support the learning process. The skills of solving problems, collaborating, and using advances in technology and information for learning need to be provided to students. One approach that can be used in 21st century learning is the STEM approach (Triana et al., 2020; Utomo et al., 2020; Wahono et al., 2020). Mater et al. (2022) stated that through STEM-based learning trains students in solving problems in everyday life, understanding complex concepts and applying them. In addition, students respond positively to STEM learning so that the STEM approach is appropriate in learning science.

The STEM approach also has its own urgency that is relevant to the goals of the 2013 curriculum, because by using STEM as a learning approach, students will have the ability to think critically, creatively, innovatively, and be able to solve problems in their surroundings (Karnuriman et al., 2019; Sartika, 2019). In addition, research shows that STEM education in Indonesia is considered effective for student learning outcomes in scientific literacy skills, creative thinking, critical thinking, and problem-solving skills in everyday life (Amin et al., 2022; Ardianti et al., 2020; Fitriyah & Ramdani, 2021; Khotimah et al., 2021; Ozkan & Umdu, 2021). The term STEM is an acronym for 4 disciplines, namely Science, Technology, Engineering, and Mathematics. STEM learning is a learning process that develops approaches to science, technology, engineering, and mathematics, as a focus for solving problems in everyday life (Hermansyah, 2020). The learning method that can be integrated with the STEM approach is PjBL (Project Based Learning). The syntax for the PjBL-STEM method is reflection, research, discovery, application, communication.

One strategy for introducing and teaching STEM to students is through e-modules. E-modules or electronic modules are independent learning devices that are systematically arranged, displayed in electronic form that contain audio, animation, and navigation (Seruni et al., 2019). Another definition describes the electronic module as an innovation from the development of printed modules, and can be accessed via a computer connected to software that supports access to e-modules. E-modules are considered interactive because there are images, audio, video, animation displays, and are also equipped with tests or quizzes that can be used as evaluation material for teachers. The characteristic of interactive e-modules is that they make students self-instructional because the teaching materials in interactive e-modules can teach students independently (Fausih & Danang, 2015). In addition, interactive e-modules are practical innovations from learning media that contain teaching materials in a more interesting, practical, and efficient manner (Zukmadini et al., 2022). Research by Mutmainnah et al. (2021), states that the use of interactive e-modules shows an increase in learning outcomes and expands student knowledge.

Ecology material is one of the contents in Biology class X SMA/MA equivalent. The sub-materials in ecological material are ecosystem components, energy flows, biogeochemical cycles, and interactions within ecosystems. Delivery of ecological material must be maximized due to the fact that there are still many students who do not understand, and have misconceptions about ecological material. The results of Purwanti & Kuntjoro (2020) research revealed that there were still many students who did not understand and had misconceptions about ecological material, namely 15.21% did not understand, and 61.72% had misconceptions. Similar research by Jahidin & Rabani (2018) showed that 64% of students who were research subjects experienced misconceptions. The highest misconception is in the conservation sub-material, and the lowest is in the symbiosis material. Based on this, it is necessary to develop STEM-based interactive e-

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modules on ecological material which is expected to be a supplement that supports the learning process of ecological material.

METHODS

This research is a descriptive research that describes the e-module development process. Product development is carried out using the Richey & Klein model, namely Planning, Project, and Evaluation (PPE). The description of the development steps in this research is as follows:

a) Planning
The design stage is carried out by analyzing the needs of the field, analyzing the curriculum, and studying the literature. The purpose of the design stage is to find out what products are needed in the field, and the facts supporting these needs, so that they can provide an overview of product designs for researchers to develop.

b) Project
Based on several analyzes that have been carried out by researchers, the next stage is the preparation of interactive e-modules using the Canva and Flip PDF Professional applications. The preparation begins with creating an e-module structure consisting of an initial section, a content section, and a closing section

c) Evaluation
Interactive e-modules that have been designed using the Canva application, and then compiled using the Flip PDF Professional application, are then validated by material experts and media experts, in order to obtain a product validity value. After going through validation and revision according to the suggestions, interactive e-modules were given to biology teachers and students to be assessed, so that teachers and students' responses could be known. Assessment scores by teachers and students are used to determine the practicality of the product.

The data collection instruments used were preliminary study instruments, expert and media validation instruments, teacher trial instruments, and product trial instruments adapted from Prihatiningtyas et al. (2021) (Table 1-2).

Table 1. Likert scale gradations of expert assessment and teacher trials

Quality	Score
Very Good	4
Good	3
Not Good	2
Very Less Good	1

Table 2. Product trial likert scale gradations

Quality	Score
Strongly agree	5
Agree	4
Doubt	3
Disagree	2
Strongly Disagree	1

The data obtained will be added up, compared with the expected score, so that a percentage will be obtained and will be analyzed, using the following formula:

$$\% = \frac{Validation\ result\ score}{Expected\ score} \times 100\%$$

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After getting the percentage results, the data will be qualified for the feasibility level using the feasibility level intervals in the following table 3:

Table 3. Eligibility criteria for assessment by members and teachers

Achievement Level	Qualification	Information
90%-100%	Very Eligible	No Revision Required
75%-89%	Eligible	Revision
65%-74%	Decent Enough	Revision
55%-64%	Less Eligible	Revision
0%-54%	Not Eligible	Revision

RESULTS AND DISCUSSION

The following shows an interactive e-module display on the topic of ecology that was successfully developed in this study.

1) First section
   The initial part of the interactive e-module contains the front cover, preface, instructions for use for teachers and students, table of contents, concept maps, basic competencies (KD) and indicators, and learning objectives. In the table of contents and concept map sections, there is navigation to get to the desired page by clicking on the table of contents or concept map chart (Figure 1).
2) Content section
   The content section of the interactive e-module contains a description of ecological material delivered using the PjBL-STEM syntax, namely Reflection, Research, Discovery, Application, and Evaluation (Figure 2).
3) End section
   The end section of the the interactive e-module consists of a glossary, bibliography, author biography, motivational sentences, and back cover (Figure 3). On the back cover there is a feature for downloading interactive e-modules, so that it can be accessed offline.

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Figure 1. The first part of the interactive e-module

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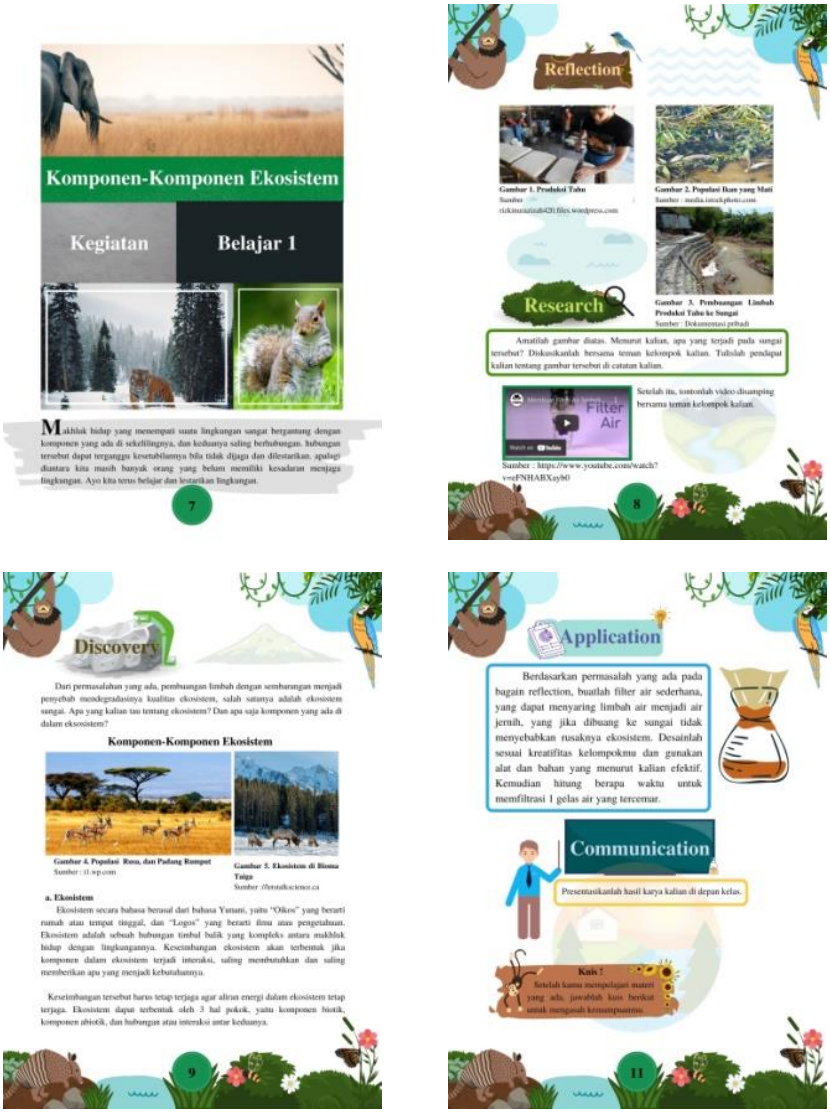

Figure 2. The content section of interactive e-module

(a)

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(b)

(c)

(d)

Figure 3. The closing part of the interactive e-module

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The results of the validity and practicality tests of STEM-based interactive e-modules on the topic of ecology are as follows.

1. Percentage of e-module validation score by material expert
   Material validation was carried out by a lecturer in the Tadris Biology study program, Faculty of Tarbiyah IAIN Kudus. The percentage scores of various indicators are presented in Figure 4. The average score obtained from various aspects is 98.12% with the category "very feasible to use". The conclusion from the material validation stage is that the product is declared fit for use in the field with revisions according to suggestions. The suggestions from material experts are as follows: (1) the abiotic definition is revised; (2) the application syntax is revised to better show the use of the STEM method, and (3) it is also uniform in all learning activities.

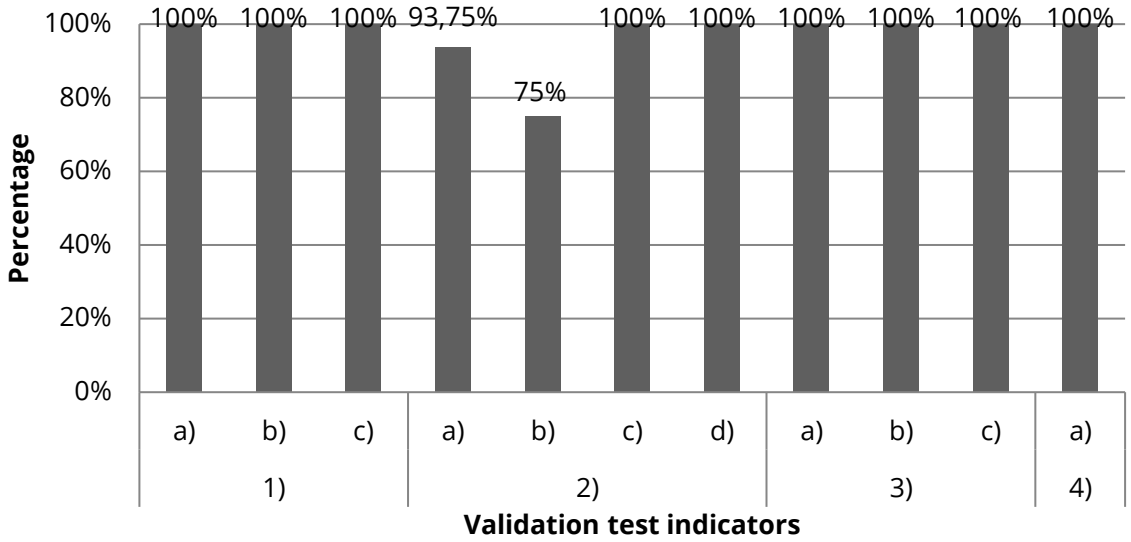

Figure 4. Percentage of ecological interactive e-module validation scores by material experts. Description: 1) Aspects of presentation: a) presentation techniques, b) presentation of learning, c) presentation support; 2) The quality of the content: a) the accuracy of the material, b) the suitability of the material with KD, c) encourages students' curiosity, d) the latest material; 3) Language: a) straightforward, b) communicative, c) effective; 4) Use of the STEM approach: a) components of the STEM approach in the PjBL syntax.

2. Percentage of e-module validation score by media experts
   Media validation was carried out by a Tadris Biology lecturer, Faculty of Tarbiyah IAIN Kudus. The media validation percentage score is presented in Figure 5. The average score obtained from various aspects gets a percentage of 93.25% in the "very feasible to use'' category. The conclusion from the media validation, the product is declared fit for use in the field with revisions according to the suggestions. The suggestions from media experts are as follows: (1) page 4, namely the concept map can be clicked on the chart column to go to the page; (2) the quiz is given a discussion, not just the key answer; (3) on the page of the learning activities sub-chapter, the word "learning activities'' does not need to be separated; and (4) on learning activities, three syntaxes of application add communication.

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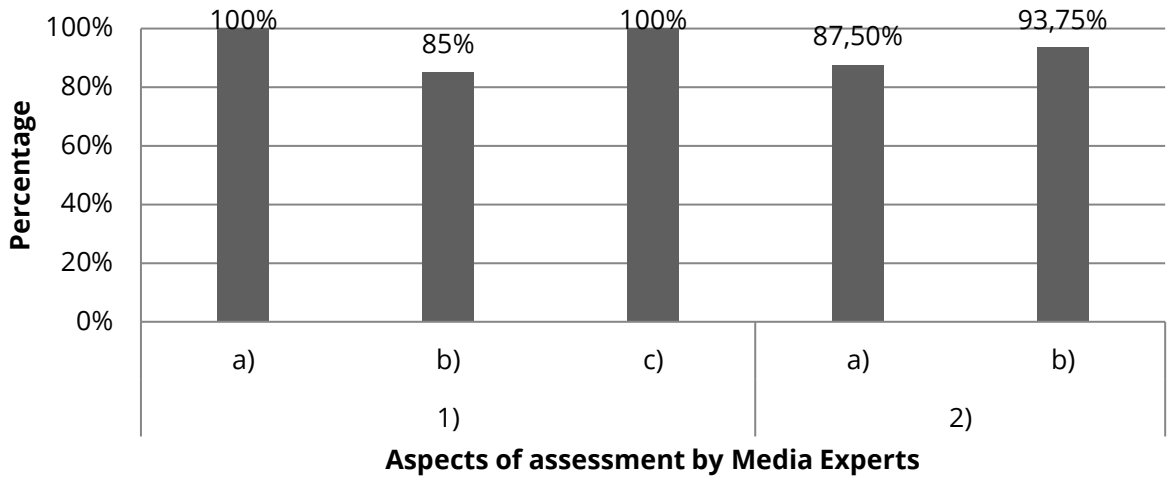

Figure 5. Percentage of ecological interactive e-module validation scores by media experts. Description: 1) Display of teaching materials: a) clarity of use of letters, b) display of videos, pictures, animations, and interactive quizzes, c) attractiveness of appearance; 2) Ease of use: a) practicality, b) convenience.

3. Percentage of e-module assessment scores by teachers

The score for the interactive e-module assessment by biology teacher MA Raudlatus Shibyan is shown in Figure 6. The assessment by teachers serves to find out the teacher's response to the e-module, and solicits input suggestions for product revisions. The average percentage gain from these various aspects is 79.76%, with the category "Decent". For suggestions and input, the teacher does not provide suggestions for revising the e-module. Based on the score obtained and the teacher's response, the interactive e-module for class X ecological material can be used in the field as a learning medium and teaching material.

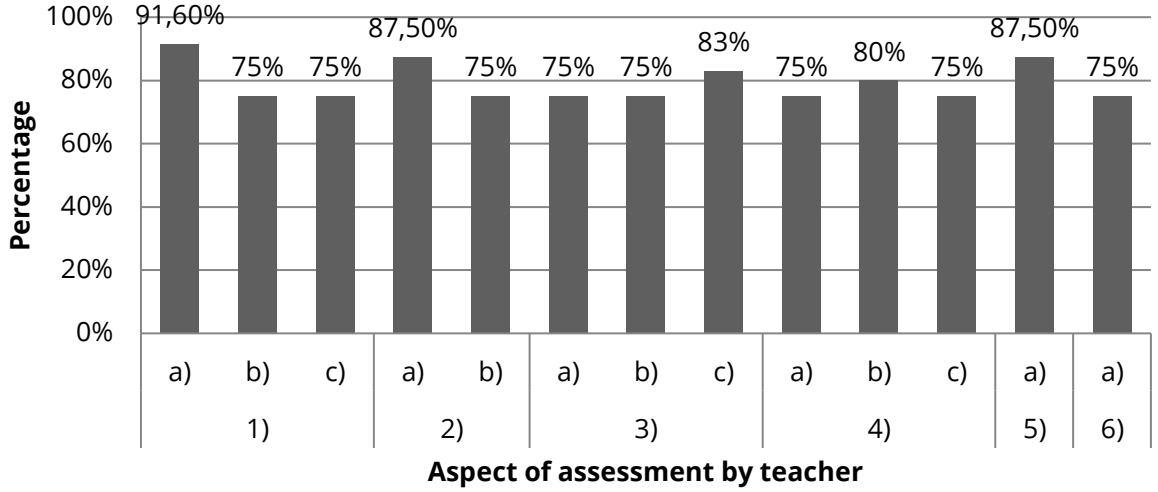

Figure 6. Percentage of e-module assessment scores by teachers. Notes: 1) Content: a) accuracy of the material, b) suitability of the material with KD, c) encourage students' curiosity; 2) Presentation: a) presentation technique, b) presentation support; 3) Language: a) straightforward, b) communicative and interactive, c) compliance with good and correct Indonesian rules; 4) Appearance: a) clear use of letters, b) display of videos, images, animations, and interactive quizzes, c) attractiveness of appearance; 5) Ease of: a) ease of use of interactive e-modules; 6) Use of the STEM approach: a) components of the STEM approach in the PjBL syntax.

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4. E-module assessment scores by students
   The percentage of e-module assessment scores by students is shown in Figure 7. The average score for this percentage is 80% in the "decent" category. Based on the acquisition of student assessment scores, interactive e-modules on ecological material are suitable for use in the field as media and learning resources.

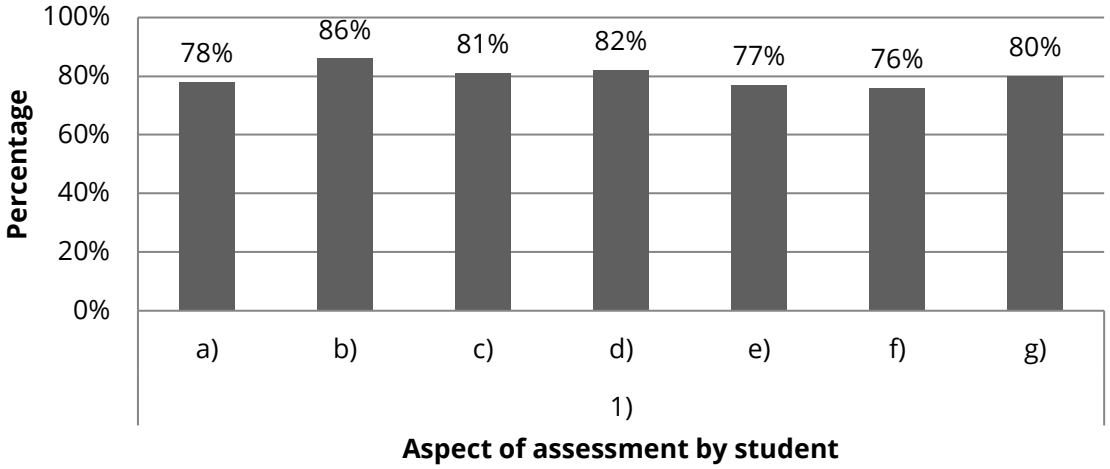

Figure 7. Percentage of e-module assessment scores by students. Information: a) presentation, b) material, c) language, d) pictures, e) benefits, f) ease of use, and g) use of learning approaches.

The results of product validation and assessment in this study are consistent with research by Zukmadini et al. (2022), entitled "Development of the COVID-19 Information Integrated E-Module to Improve Biology Learning Outcomes", this study stated that the e-module has a very valid category and is suitable for use by various expert assessors ranging from material experts, teaching materials experts, and practitioners (teachers) reach more than 85%. Similar research by Syafriah & Bachri (2017), entitled "Development of E-Modules in Biology Subject Subject Animalia Invertebrata for Class X Students at SMA Negeri 1 Dawarblandong Mojokerto Regency", stated that the product validation results obtained a score of 87.5% by material experts, 85.7% by media experts, and 90.3% in large-scale tests on students. In addition, this study also measured student test results which increased, so that all the product has a valid, practical and effective category (Syafriah & Bachri, 2017). Another similar study by Prihatiningtyas et al. (2021) entitled "Interactive Media E-Module Biological Biology Material as a Support for Online Learning at MAN 3 Jombang" explains that, the interactive e-module developed obtained a material validation score of 83.32% with the category feasible, and material validation of 93.76% with a very feasible category. Assessment by students as a response to users gets a score of 78.5% in the "Good" category (Prihatiningtyas et al., 2021). Based on the results of existing research, it can be concluded that the development of STEM-based interactive e-modules on the topic of ecology is feasible for use in the field and gets good responses from students.

CONCLUSION

STEM-based interactive e-modules on ecology materials are compiled using the Canva and Flip PDF Professional applications, then stored in the form of links that students can access and download using gadgets. Ecology materials in interactive e-modules are presented using the PjBL-STEM method, accompanied by clear pictures and videos, animations, quizzes, and assignments. The interactive e-module was validated by material experts and media experts, respectively scoring 98.12% and 93.25% in the "Very Eligible" category. Assessment by teachers and students

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gave a good response with a score of 79.76%, and 80% respectively in the "Decent" category. The results of product validation and assessment show that the product meets the eligibility category on valid and practical aspects, so that the product can be used in the field.

REFERENCES

Amin, M., Ibrahim, M., & Alkusaeri, A. (2022). Meta analisis: Keefektifan STEM terhadap kemampuan berpikir kreatif siswa. *Journal of Authentic Research on Mathematics Education (JARME)*, *4*(2), 248-262.

Ardianti, S., Sulisworo, D., Pramudya, Y., & Raharjo, W. (2020). The impact of the use of STEM education approach on the blended learning to improve student's critical thinking skills. *Universal Journal of Educational Research*, *8*(3), 24-32.

Fausih, M., & Danang, T. (2015). Pengembangan media e-modul mata pelajaran produktif pokok bahasan "instalasi jaringan LAN (Local Area Network)" untuk siswa kelas XI jurusan teknik komputer jaringan di SMK Negeri 1 Labang Bangkalan Madura. *Jurnal Unesa*, *1*(1), 1-9.

Fitriyah, A., & Ramadani, S. D. (2021). Pengaruh pembelajaran STEAM berbasis PjBL (Project-Based Learning) terhadap keterampilan berpikir kreatif dan berpikir kritis. *Jurnal Inspiratif Pendidikan*, *10*(1), 209-226.

Hermansyah, H. (2020). Pembelajaran IPA berbasis STEM berbantuan ICT dalam meningkatkan keterampilan abad 21. *Jurnal Ilmiah Profesi Pendidikan*, *5*(2), 129-132.

Jahidin, J., & Rabani, L. (2018). Miskonsepsi ekologi: sebuah analisis hasil tes kompetisi sains madrasah aliyah. *Jurnal Bioedukatika*, *6*(1), 8-14.

Karnuriman, K., Haryono, H., & Wardani, S. (2019). Development of STEM workers based on STEM to optimize curriculum 2013 implementation. *Innovative Journal of Curriculum and Educational Technology*, *8*(2), 74-77.

Khotimah, R. P., Adnan, M., Ahmad, C. N. C., & Murtiyasa, B. (2021). Science, mathematics, engineering, and mathematics (STEM) education in indonesia: A literature review. *Journal of Physics: Conference Series*, *1776*(1), 012028.

Mater, N. R., Haj Hussein, M. J., Salha, S. H., Draidi, F. R., Shaqour, A. Z., Qatanani, N., & Affouneh, S. (2022). The effect of the integration of STEM on critical thinking and technology acceptance model. *Educational Studies*, *48*(5), 642-658.

Mutmainnah, M., Aunurrahman, A., & Warneri, W. (2021). Efektivitas penggunaan e-modul terhadap hasil belajar kognitif pada materi sistem pencernaan manusia di Madrasah Tsanawiyah. *Jurnal Basicedu*, *5*(3), 1625-1631.

Ozkan, G., & Umdu, T, U. (2021). Investigating the effectiveness of STEAM education on students' conceptual understanding of force and energy topics. *Research in Science & Technological Education*, *39*(4), 441-460.

Prihatiningtyas, S., Tijanuddarori, M. W., Meishanti, O. P. Y., & Anantyarta, P. (2021). Media interaktif e-modul materi virus sebagai penunjang pembelajaran daring di MAN 3 Jombang. *BIO-EDU: Jurnal Pendidikan Biologi*, *6*(2), 133-141.

Purwanti, W. M., & Kuntjoro, S. (2020). Profil miskonsepsi materi ekologi menggunakan four-tier test pada peserta didik kelas X SMA. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, *9*(3), 414-421.

Sartika, D. (2019). Pentingnya pendidikan berbasis STEM dalam kurikulum 2013. *JISIP (Jurnal Ilmu Sosial dan Pendidikan)*, *3*(3), 89-93.

Seruni, R., Munawaroh, S., Kurniadewi, F., & Nurjayadi, M. (2019). Pengembangan modul elektronik (e-module) biokimia pada materi metabolisme lipid menggunakan Flip PDF Professional. *Jurnal Tadris Kimiya*, *4*(1), 48-56.

Syafriah, U., & Bachri, B. S. (2017). Pengembangan e-modul pada mata pelajaran biologi materi pokok animalia invertebrata untuk siswa kelas X di SMA Negeri 1 Dawarblandong Kabupaten Mojokerto. *Jurnal Mahasiswa Teknologi Pendidikan*, *8*(2), 1-5.

DOI: https://doi.org/10.17509/aijbe.v5i2.44785
e-ISSN 2621-7260

Triana, D., Anggraito, Y. U., & Ridlo, S. (2020). Effectiveness of environmental change learning tools based on STEM-PjBL towards 4C skills of students. *Journal of Innovative Science*, *9*(2), 181–187.

Utomo, A. P., Hasanah, L., Hariyadi, S., Narulita, E., & Umamah, N. (2020). The effectiveness of STEAM-Based biotechnology module equipped with flash animation for biology learning in High School. *International Journal of Instruction*, *13*(2), 463-476.

Wahono, B., Lin, P. L., & Chang, C. Y. (2020). Evidence of STEM enactment effectiveness in Asian student learning outcomes. *International Journal of STEM Education*, *7*, 1-18.

Zukmadini, A. Y., Murniati, N., Karyadi, B., Ansori, I., & Rochman, S. (2022). Pengembangan e-modul terintegrasi informasi COVID-19 untuk meningkatkan hasil belajar biologi. *Pedagogi Hayati*, *6*(1), 20-33.

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Authors' Note

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