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Development of SETS e-module on endocrine system material to improve scientific literacy and learning independence of high school students

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Abstract

The level of scientific literacy, learning independence, and student learning outcomes in the endocrine system material are still relatively low. This indicates the need for the development of teaching materials that are able to produce scientific concepts in everyday life and encourage active student participation. This study aims to develop a SETS (Science, Environment, Technology, and Society)-based e-module that is feasible, practical, and effective in improving scientific literacy and learning independence. The study used the Research and Development (R&D) method with the ADDIE development model consisting of five stages: analysis, design, development, implementation, and evaluation. The subjects of the study consisted of 64 grade XI MIPA students at SMA Negeri 1 Mlati. Data collection techniques included interviews, questionnaires, and tests, with descriptive and inferential data analysis using MANOVA. The results showed that the SETS-based e-module was feasible, practical, and effective. The MANOVA test showed a significance value of 0.00 ($p < 0.05$), while the N-gain results showed an increase in scientific literacy of 0.320 and learning independence of 0.460, both of which were in the moderate category. The results of this study provide scientific evidence that the application of the SETS approach through e-modules has a positive impact on students' science literacy and learning independence in biology. This study recommends that SETS e-modules can be used as alternative teaching materials in biology learning and opportunities for further research to develop SETS e-modules for other subjects.

Abstrak. *Tingkat literasi sains, kemandirian belajar, dan hasil belajar siswa pada materi sistem endokrin masih tergolong rendah. Hal ini menunjukkan perlunya pengembangan bahan ajar yang mampu menghasilkan konsep sains dalam kehidupan sehari-hari serta mendorong partisipasi aktif siswa. Penelitian ini bertujuan untuk mengembangkan e-modul berbasis SETS (Science, Environment, Technology, and Society) yang layak, praktis, dan efektif dalam meningkatkan literasi sains dan kemandirian belajar. Penelitian menggunakan metode Research and Development (R&D) dengan model pengembangan ADDIE yang terdiri atas lima tahap: analisis, desain, pengembangan, implementasi, dan evaluasi. Subjek penelitian terdiri dari 64 siswa kelas XI MIPA di SMA Negeri 1 Mlati. Teknik pengumpulan data meliputi wawancara, angket, dan tes, dengan analisis data secara deskriptif dan inferensial menggunakan MANOVA. Hasil penelitian menunjukkan bahwa e-modul berbasis SETS tergolong layak, praktis, dan efektif. Uji MANOVA menunjukkan nilai signifikansi 0,00 ($p < 0,05$), sedangkan hasil N-gain menunjukkan peningkatan literasi sains sebesar 0,320 dan kemandirian belajar sebesar 0,460, keduanya termasuk kategori sedang. Hasil penelitian ini memberikan kontribusi ilmiah berupa bukti bahwa penerapan pendekatan SETS melalui e-modul berdampak positif terhadap literasi sains dan kemandirian belajar siswa pada topik biologi. Penelitian ini merekomendasikan bahwa e-modul SETS dapat dijadikan alternatif bahan ajar pada pembelajaran biologi dan peluang untuk penelitian selanjutnya mengembangkan e-modul SETS pada materi lainnya.*

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A. Introduction

Scientific literacy is one of the important skills that individuals must have in the 21st century, especially amidst the rapid development of science and technology (Nuraini et al., 2023). Scientific literacy not only includes an understanding of scientific concepts, but also the ability to apply them in everyday life (Hariyadi et al., 2023). This ability is important in helping individuals face and solve various problems rationally (Aiman et al., 2020). In practice, someone who has scientific literacy will be able to use scientific concepts and science process skills to disseminate, identify problems, and make the right decisions based on scientific evidence (Hajrah et al., 2021). Thus, scientific literacy plays a major role in forming individuals who are critical, able to draw logical conclusions, and are ready to face current and future challenges scientifically (Yusmar & Fadilah, 2023).

Although scientific literacy is an important skill in facing the challenges of the 21st century, in reality, students' scientific literacy skills in Indonesia are still relatively low. The results of the Programme for International Student Assessment (PISA) 2022 showed that Indonesian students' scientific literacy score was 383, which is at level 1a out of seven levels, where the minimum level considered competent is level 2 (OECD, 2023). This finding is in line with the results of previous studies which showed that many Indonesian students do not yet have optimal scientific literacy skills (Adnan et al., 2021; Suroso et al., 2021; Kamelia et al., 2022; Mayasari & Paidi, 2022; Listiani et al., 2024). Low scientific literacy is influenced by various factors, including non-contextual learning and the use of inappropriate teaching materials (Suparya et al., 2022). Other factors are related to students' learning independence (Kristina et al., 2022).

Learning independence is the ability of students to manage their learning process independently, be responsible for achieving learning goals, and be active in finding and utilizing relevant learning resources (Anggraini, 2023). This ability helps students regulate their thoughts, attitudes, and emotions so that they do not depend on the help of others in achieving learning success (Kasman & Suhartini, 2022). Learning independence has been shown to contribute to improving conceptual understanding, learning motivation, critical thinking skills, and overall learning outcomes (Pratama & Suyanto, 2023). The higher the level of student learning independence, the better the learning outcomes obtained (Rahmah et al., 2024). Therefore, learning independence not only supports students' learning process but also plays a role in helping them achieve optimal learning outcomes.

Despite its important role, in reality the level of student learning independence in the field is still relatively low. Many students show a lack of motivation to learn independently, which is reflected in the habit of not repeating material before learning, not setting learning targets, not making a study schedule, and being passive in completing assignments independently (Aulia et al., 2019; Debitama et al., 2024). Students with low levels of independence tend to depend on teachers, only respond when instructed, and are less prepared before taking part in learning (Aristina & Isnaeni, 2022). This condition is influenced by a learning system that does not encourage active student involvement, one-way methods, and minimal integration of technology and variety of learning media (Alonemarera, 2024). As a result, students have difficulty in identifying learning needs, setting goals, choosing appropriate strategies, and finding the references they need (Renaldy et al., 2023). This condition becomes more complex when students are faced with biological materials that require in-depth conceptual understanding, such as the endocrine system that specifically requires high learning independence is the endocrine system.

Endocrine system material discusses the role of hormones and endocrine glands in regulating various body functions, which requires in-depth understanding (Pantiwati et al., 2022). The characteristics of the endocrine system are abstract, difficult to observe directly, and filled with unfamiliar scientific terms, making this topic quite challenging to learn (Fajriani et al., 2021). In fact, based on the findings of Nugroho et al. (2024), the endocrine system is included in the category of biology material that is most difficult for students to understand, with a difficulty level of 37.5%. In facing these challenges, learning independence plays an important role, because it allows students to actively seek additional learning resources, summarize information, and design learning strategies that suit their needs. The inability to learn independently will have an impact on low mastery of concepts. Therefore, strengthening learning independence is a strategic step to improve students' understanding of the endocrine system material more optimally.

However, the results of a preliminary study conducted in one school showed that learning in the classroom did not fully support the development of student learning independence. In the learning process, as many as 76.9% of students only listened to the teacher's explanation without active involvement, and had minimal initiative to learn independently. In addition, the use of electronic teaching materials, especially e-modules, is still very limited. The e-modules previously used were only in the form of PDF files with textual and monotonous presentation of materials, so they were unable to stimulate student learning activity or independence. In fact, data shows that 76.9% of students prefer electronic media to print media (46.2%), and all students already have Android-based smartphones that are often used for

learning. This condition shows that although technological devices are available and preferred, their use in supporting independent learning has not been optimized. Therefore, innovation is needed in the development of digital teaching materials that are interesting, interactive, and able to facilitate independent learning effectively.

The development of e-modules is a strategic alternative in supporting students' independent learning. As a form of digital teaching material, e-modules have high flexibility and can be designed interactively through the integration of various multimedia elements such as images, audio, video, animation, and digital navigation that allow students to interact actively with learning materials (Awwalina & Indana, 2022; Ayuardini, 2023). E-modules also have characteristics that support independent learning, such as self-instruction, self-contained, stand-alone, adaptive, and user-friendly (Vidianti & Qonita, 2022). These characteristics make e-modules an effective medium in encouraging students' independent learning. Several studies have shown that the implementation of e-modules in the learning process can improve students' ability to organize learning strategies independently and manage time and learning resources optimally (Andriani & Dwiningsih, 2024; Ayunda et al., 2024). In addition, e-modules can be developed in an Android-based application format, making them easier to access through digital devices that are generally owned by students. Therefore, e-modules are not only pedagogically relevant, but also show suitability to the needs and characteristics of students in the digital era.

To provide more contextual and meaningful learning, e-module development can be carried out by integrating the Science, Environment, Technology, and Society (SETS) approach. The SETS approach combines four main aspects—science, environment, technology, and society—in a holistic and interdisciplinary learning framework (Lestari et al., 2020). This integration allows students to not only understand scientific concepts theoretically but also be able to connect them to real problems in society and apply these concepts to find solutions to various problems (Yendrita, 2020; Siagian et al., 2023). This approach effectively develops critical and creative thinking skills and increases awareness of science issues in everyday life (Nasihah et al., 2024). In addition, various studies have shown that the application of the SETS approach contributes positively to increasing students' scientific literacy (Prasasti & Listiani, 2019; Rochim et al., 2022).

Various studies have explored the development of e-modules and the application of the SETS approach in the context of biology learning. Awwalina and Indana (2022) focused on the development of an ecosystem e-module to improve students' scientific literacy. Pantiwati et al. (2022) designed an e-module with the SETS approach on the movement system material to encourage independent learning and Pertiwi et al. (2024) reported the effectiveness of the SETS approach in improving scientific literacy. Although the results of these studies show a positive contribution, to date there has been no SETS-based e-module development that is specifically aimed at the endocrine system material with the aim of simultaneously improving scientific literacy and independent learning. Given the complexity of the endocrine system material and the importance of mastering both competencies, the development of a SETS-based e-module on this topic is very necessary. Therefore, this study aims to produce a valid, practical, and effective SETS e-module in improving scientific literacy and independent learning of grade XI students on the endocrine system material.

B. Material and method

This study aims to develop and evaluate the effectiveness of SETS-based e-modules on endocrine system material. The development process was carried out through a Research and Development (R&D) approach with reference to the ADDIE development model. The ADDIE model was chosen because it has systematic, structured, and integrated stages, allowing for a continuous process of reflection and product revision. These characteristics support targeted product development, in accordance with learning needs, contextual material preparation, and comprehensive evaluation to ensure that the products developed are effective in helping to achieve learning objectives (Fadhila et al., 2022).

The ADDIE model consists of five main stages: analysis, design, development, implementation, and evaluation. Each stage is interconnected and plays an important role in producing valid, practical, and effective products. The first stage, namely analysis, is carried out to identify student needs and learning objectives that are adjusted to the demands of the curriculum. Information from this stage becomes the basis for designing the e-module design in the second stage. At the design stage, the SETS e-module structure is planned and the learning tools and assessment instruments are prepared. The third stage is development, where the e-module product is realized based on the design that has been designed. At this stage, the product is then tested for validity and practicality through expert assessment and implementation tests. After the product is declared feasible, the process continues to the implementation stage. At the implementation stage, the SETS e-module was applied in biology learning in class XI MIPA 1 and MIPA 2 of SMA Negeri 1 Mlati with a sample of 64 students. This study used a quasi-experimental design of the pretest-posttest control group design type and was implemented from March to May 2024. The main objective of this implementation was to test the effectiveness of the e-module in improving science literacy and students'

learning independence. The last stage is evaluation, which consists of formative and summative evaluations. Formative evaluation is carried out continuously at each stage of development to identify deficiencies and make improvements to the product. Meanwhile, summative evaluation is carried out after the product has been developed, to assess the extent to which the e-module has met the learning objectives and user needs.

Data collection was carried out through three main methods, namely interviews, questionnaires, and tests. Each method is used in a targeted manner according to the objectives of each development stage. Interviews and questionnaires are used in the early stages to explore user needs for the product being developed, while tests are used to measure the impact of product use on learning outcomes.

The instruments used in the study were adjusted to the purpose of data collection at each stage. For needs analysis, interview guidelines and need assessment questionnaires were used. Product feasibility was assessed through questionnaires given to material experts and media experts. Product practicality measured by learning implementation sheets and practicality questionnaires for students and teachers. Meanwhile, product effectiveness was tested using learning independence questionnaires and scientific literacy essay questions based on the PISA 2025 framework. The independence questionnaire covers five aspects: not depending on others, initiative, self-discipline, responsibility, and self-confidence. While the essay questions measure the ability to explain scientific phenomena, evaluate investigation designs, and interpret scientific data and evidence.

The data obtained were then analyzed using descriptive and qualitative approaches. Qualitative data came from interviews, needs analysis, and comments and suggestions from respondents. Meanwhile, quantitative data came from questionnaires on feasibility, practicality, and effectiveness. Quantitative data analysis was carried out by calculating the average score or percentage of each indicator, which was then interpreted referring to the feasibility and practicality standards as formulated by Astuti et al. (2023) in Table 1 and Table 2. To analyze the effectiveness of the product, inferential statistical analysis was used with the MANOVA (Multivariate Analysis of Variance) method. This analysis was conducted to determine the significant influence of the product on the effectiveness variables simultaneously, so that a comprehensive picture of the impact of product use on increasing students' independence and scientific literacy was obtained.

Table 1 Validity criteria

No	Percentage (%)	Category
1	81-100	Very valid
2	61-80	Valid
3	41-60	Quite valid
4	21-40	Less valid
5	0-20	Not valid

Table 2 Practicality criteria

No	Percentage (%)	Category
1	81-100	Very practical
2	61-80	Practical
3	41-60	Quite practical
4	21-40	Less practical
5	0-20	Not practical

C. Results and discussion

Product eligibility

The product feasibility is known based on the assessment of material experts and media experts. The results of the material expert's feasibility are presented in Table 3. Based on the results of the validation of material experts, the SETS e-module is declared suitable for use. This shows that the SETS e-module meets the standards to support effective learning. Material experts also provide suggestions and input to improve product quality. These suggestions relate to improving inappropriate content, adding information and recommendations for more effective types of content, such as the use of TDR in making insulin for one of the SETS elements, namely technology.

The SETS e-module was declared feasible because the material was appropriate to the competencies to be achieved, the presentation was orderly, and the use of language was easy for students to understand. This eligibility follows the opinion of Aprilia and Wulandari (2022) who stated that the material in the e-module must be adjusted to basic competencies, presented regularly and coherently (Ainurrahmi et al., 2024) and use clear and easy-to-understand language, not using repeated words and not being long-winded (Jayanti et al., 2024). Using easy-to-understand language will make it easier for students to understand the studied material.

Table 3 Results of validation by material experts

No	Aspect	Value	Category
1	Extent and suitability of material to competency	95	Very valid
2	Presentation of materia	96	Very valid
3	Language	100	Very valid
Average		**97**	**Very valid**

Table 4 Results of media expert validation

No	Aspect	Value	Category
1	Cover	100	Very valid
2	Content	100	Very valid
3	Presentation	100	Very valid
Average		**100**	**Very valid**

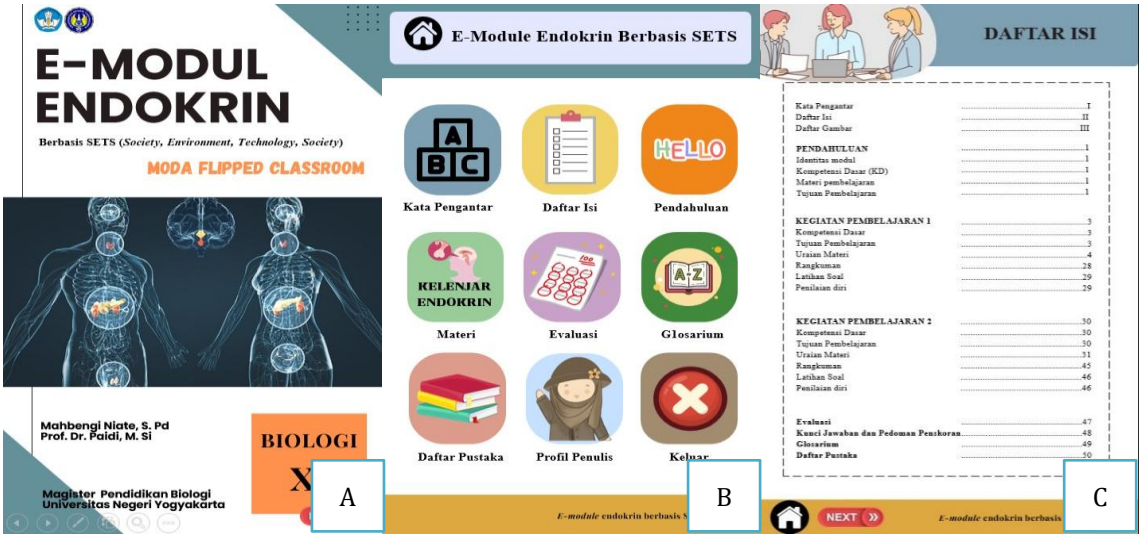

Figure 1
(A) Cover of the SETS e-module, (B) SETS e-module menu list, and (C) SETS e-module table of contents (in Indonesian)

Figure 2
Presentation of the SETS e-module using the SETS approach (invitation, exploration, solution, application, and concept consolidation stages) on material related to endocrine system dysfunction (in Indonesian)

In addition to being based on the assessment of material experts, the e-module's feasibility is also assessed based on the assessment of media experts. The results of the media expert's feasibility are presented in Table 4. Based on the results of media expert validation, the SETS e-module is declared feasibile for use in the learning process. The SETS e-module preview after product feasibility assessment can be seen in Figure 1 and Figure 2. Product feasibility is assessed through cover, content, and presentation aspects. Each aspect is categorized as very valid. From the cover aspect, the SETS e-module cover is attractive because the layout is consistent, the use of the right colors, the appropriate font type and size, and contains an image of the endocrine system that not only beautifies but also provides a clear picture of the contents of the e-module. This is following the opinion of Nurianti et al. (2024) that the cover is an important element of a media that functions as a presenter of information about the contents so it must be made as attractive as possible and relevant to the contents. In terms of content, the e-module is considered feasible because of the good layout, appropriate color choices, and clear writing.

This is by Astuti et al. (2021) opinion that the graphic aspect is very important in feasibility so it must be considered. In terms of presentation, the e-module is considered feasible because of its easy installation process, operation that can be adjusted to the learning speed of students, consistency of navigation buttons, good image quality, and the availability of instructions for use. Based on this, the e-module is declared feasible based on media validation because of its attractive and functional design.

Practicality of the product

The results of practicality are known from the assessment of biology teachers, student responses and the implementation of learning. The results of the biology teacher assessment are presented in Table 5. Based on the teacher's assessment, each aspect received a good score with a very practical category. Thus, it can be concluded that the SETS e-module is practical based on the aspects of learning, material, language and display.

Based on the assessment of students in Table 6, it can be concluded that the SETS e-module is stated as practical based on aspects of media display, ease of use, language and materials. According to students, the SETS e-module is very helpful in learning the material, easy to understand, interesting and in accordance with technological developments. Students provide some input such as refining some elements of the layout and UI and adding some images and animations.

The SETS e-module is stated to be practical for use in the learning process. The SETS e-module was successfully used by students and teachers in biology learning at school, especially on the endocrine system material for 2 meetings and received positive responses from both teachers and students. This positive response was obtained for several reasons, namely: 1) The SETS e-module supports biology learning, especially on the endocrine system material. The material is presented comprehensively in accordance with the curriculum and students' cognitive development. 2) The SETS e-module is easy to operate. The SETS e-module can be accessed via each student's smartphone. In addition, the e-module is also equipped with instructions for use, navigation buttons, easily accessible links, images and videos, summaries, glossaries, practice questions and answer keys that help students' evaluation and understanding. This is in accordance with the statement of Herditiya et al. (2023) an e-module is said to be practical if it can make it easier for students in the learning process, the presentation of videos, instructions for use and evaluation in the e-module can make it easier for students while providing space for students to learn actively without being limited by space and time. 3) The material is delivered in easy-to-understand language. According to Lativa et al. (2024) the use of simple language and the selection of easy-to-read fonts greatly assist students in using e-modules. 4) The SETS e-module has an attractive appearance with the right type and size of the font, as well as visual elements such as images and videos that improve the quality of presentation. An attractive e-module can reduce student boredom (Agusminarti et al., 2024).

Table 5 Biology teacher assessment results

No	Aspect	Value	Category
1	Learning	95	Very practical
2	Material	95	Very practical
3	Language	100	Very practical
4	View	91	Very practical
Average		**95**	**Very practical**

Table 6 Summary of student assessment results

No	Aspect	Value	Category
1	Media view	78	Practical
2	Ease of use	83	Very practical
3	Language	83	Very practical
4	Material	83	Very practical
Average		**82**	**Very practical**

The impact of SETS visualization in e-modules on science literacy and learning independence

Based on the results of the MANOVA analysis, a significance value (Wilks' Lambda) of 0.00 ($p < 0.05$) was obtained, indicating that there was a statistically significant difference between the experimental group and the control group in terms of scientific literacy and learning independence. A p-value of less than 0.05 indicates that the use of SETS-based e-modules has a significant effect on both variables. This finding is supported by the results of the N-gain analysis, which shows an increase in learning outcomes in the experimental group. The N-gain value for scientific literacy is 0.320 and for learning independence is 0.460, both of which are in the moderate category. This shows that the use of e-modules not only has a

statistically significant impact, but also contributes to improving students' abilities.

The SETS e-module can train students' scientific literacy skills. The material in the e-module is presented with stages of invitation, exploration, solution, application, and concept consolidation. At the invitation stage, students are introduced to several issues related to the endocrine system such as thyroid cases and news about the number of diabetes sufferers. At the exploration stage, endocrine system material is presented. At the solution stage, solutions are presented to overcome problems and analyze their impact on the environment and society at the application stage. At the concept consolidation stage, students are given additional material to better understand the endocrine system material. Such presentation of material can train students' scientific literacy. Hardianti et al. (2021) said that SETS can improve scientific literacy through a contextual learning process and help students find the relationship between scientific knowledge, the environment, technology, and society that are interrelated. According to Rikizaputra et al. (2023) the SETS approach can improve scientific literacy because the learning process focuses on science process skills. This is reinforced by Ulfah et al. (2020) who stated that the SETS approach is in line with the definition of scientific literacy. Scientific literacy not only emphasizes memorization of knowledge, but also focuses on the process, development of scientific attitudes, and application of scientific knowledge in everyday life.

In addition to improving scientific literacy, the SETS e-module can also improve learning independence. The e-module is designed in the form of an Android application, which allows students to access materials independently via their respective smartphones. Thus, students can learn independently without relying on teachers or other parties. This encourages students to be responsible for their learning process by planning a study schedule, encouraging learning initiatives and increasing student self-confidence. This is in accordance with research conducted Aminatun et al. (2022) Android-based modules help students to learn more independently because they allow students to learn anywhere and anytime according to their respective learning speeds. Other researchers Nofitasari et al. (2021) said that the use of Android is efficient and effective for students, can be accessed anywhere and allows students to restore materials as needed.

In addition to being an Android application, the SETS e-module is equipped with various components that support student learning independence. These features include instructions for use, navigation buttons that make it easy for students to learn according to their respective abilities, and endocrine system material that is presented comprehensively with images, videos, and additional material links, so that students do not need to access other learning resources. In addition, there are practice questions and assessment rubrics that allow students to evaluate their understanding of the material being studied, as well as LKPD that helps direct the learning process. According to Delita et al. (2022) e-modules are designed to support independent learning with characteristics such as self-instructional, self-contained, adaptive, stand-alone, and user-friendly, all of which contribute to student learning independence. The application of the SETS approach supports student learning independence. Students are required to be able to build their own understanding of the material through contextual learning that involves all SETS elements.

D. Conclusion

This study shows that the SETS e-module on the endocrine system material is feasible, practical, and effective in improving scientific literacy and learning independence. The e-module is considered feasible because it presents structured material and is in accordance with competencies and learning objectives, using easy-to-understand language and an attractive design. This e-module is also stated to be practical because it supports biology learning and can be implemented according to the time and resources available. In addition, the SETS e-module has been proven effective in improving scientific literacy and learning independence because it facilitates both abilities. Based on this study, the SETS e-module can be used as an alternative teaching material in studying the endocrine system material as well as to train scientific literacy and learning independence. Further research is expected to develop the SETS e-module with other biology materials.

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