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Development of Guided Inquiry-Based E-Module on Human Circulatory System Material to Train Scientific Literacy of 11th Grade High School Students

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Abstract: *One of the essential skills needed in the development of the 21st century is scientific literacy. Therefore, the learning process needs to integrate appropriate teaching models and materials to help students develop scientific literacy, one of which is a guided inquiry-based e-module. This study aims to develop a guided inquiry-based e-module on the human circulatory system to train students' scientific literacy. The research methodology used is development research with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The research results were obtained through expert validation tests, readability tests, teacher and student response tests, and scientific literacy ability tests. The overall validation test achieved a percentage of 88.22% (highly feasible). The student readability test achieved a percentage of 97.70% (highly readable). The teacher and student response tests received ratings in the excellent category. Additionally, the scientific literacy test results showed an average score of 61 (moderate) for all students, and an average score of 62.36 (moderate) based on scientific literacy indicators. Overall, this study concludes that the guided inquiry-based e-module on the human circulatory system is suitable for use in the learning process to train students' scientific literacy.*

Keywords: *E-Module, Guided Inquiry, Human Circulatory System, Scientific Literacy, 21st Century*

1. INTRODUCTION

The development of the 21st century is marked as the era of knowledge, with rapid dissemination of information and technological advancements, accelerating synergy within scientific fields. Competencies in the 21st century shape the world of education to be able to integrate knowledge, skills, attitudes, and mastery of Information and Communication Technology (ICT), thus producing students capable of competing at a global level (Ayu, 2019).

One of the essential skills needed in the 21st century is scientific literacy. Scientific literacy refers to students' ability to use knowledge functionally in relation to scientific issues, involving scientific processes and investigations (OECD, 2013). PISA 2022 results show that the level of scientific literacy in Indonesia remains low, with Indonesia scoring 383 compared to the overall average score of 485 (OECD, 2023). In the science category, Indonesia ranked 65th out of 81 countries (Susanto *et al*., 2024).

Despite the importance of scientific literacy in the 21st century, Indonesia's relatively low ranking in scientific literacy reveals a gap in students' readiness for global challenges. Previous studies point out that factors such as teacher-centered learning, conventional teaching methods, and lack of focus on scientific literacy training contribute to this deficiency (Yusmar & Fadilah, 2023).

The lack of interest and motivation in learning reduces the active role of students in the learning process. Interviews revealed that students

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are not fully engaged in the learning process. Students tend to be less interested, quickly bored, and find it difficult to concentrate. Contributing factors include teaching materials that do not meet the needs of the students, as well as inappropriate teaching models and methods. Engaging and appropriate teaching materials can be an effective strategy to increase student interest in learning (Setyaningtyas *et al*., 2023). Research by Permana (2020) showed that low learning outcomes are caused by students' lack of active participation in the learning process and the use of less appropriate teaching models.

One of the teaching models that has an impact on scientific literacy is guided inquiry (Jofi Kuswanto *et al*., 2021). The guided inquiry model is investigative, where students, under the guidance of the teacher, are encouraged to discover knowledge on their own, thus gaining more meaningful learning experiences (Muliani & Wibawa, 2019). The guided inquiry model actively involves students in exploring topics and solving problems (Akbar *et al*., 2023).

Based on the results of the needs analysis conducted through interviews with teachers and students, it was found that the teaching materials used by teachers are textbooks and modules. However, the modules used are still general in nature, consisting only of material summaries and exercises, without a more targeted approach toward the skills to be achieved. The design of the modules presented is still simple and lacks interactivity. To create an enjoyable and engaging learning environment, the learning process must utilize teaching materials that can attract students' interest in learning (Khasanah & Nurmawati, 2021).

One effective strategy to increase student engagement and interactive learning is the use of appropriate and relevant teaching materials (Haryadi & Nurmala, 2021). Putra's research (2016) reported that the effectiveness of providing inquiry-based learning devices for prospective MI science teachers impacted mastery of scientific literacy skills. Teaching materials integrated with a teaching model make learning activities more structured and effective, one of which is guided inquiry, which can help train students in scientific literacy (Jofi Kuswanto *et al*., 2021). Guided inquiry-based teaching materials also help students become more active in the learning process (Kusumaningsih & Trimulyono, 2020). Implementation Inquiry Learning Model with Science Literacy in the teaching and learning activities has proven to be able to improve students' critical thinking skills (Sutiani, 2021).

The appropriate teaching material to be integrated with the guided inquiry model is the e-module. E-Modules are teaching materials that can encourage students to learn independently, enabling them to construct their knowledge, while the teacher acts as a facilitator. E-Modules are designed with several components that allow students to learn independently anytime and anywhere (Self-Instructional). Moreover, e-modules can be adapted to suit developments (Adaptive) and their users (User-Friendly) (Kosasih, 2021).

Research by Agung *et al*. (2020) states that e-modules presented in electronic form make learning more engaging and interactive because historical messages can be conveyed through animations, videos, and images, which can influence students' enthusiasm and motivation to learn.

Based on interviews, it was found that biology material, especially the human circulatory system, is still considered difficult by most students. Research by Jauharti *et al*. (2022) emphasizes that the human circulatory system requires a high level of understanding, making it challenging if delivered only verbally, as the processes involved are difficult to observe directly. Therefore, varied teaching materials are needed to help students understand this material.

This research introduces a novel approach by developing a guided inquiry-based e-module specifically designed to improve scientific literacy in high school students, with a focus on the human circulatory system, a challenging topic in biology. By integrating multimedia elements and adaptive features, this e-module aims to create a more engaging and interactive learning experience that fosters deeper understanding and active participation among students. This study is innovative in its approach to combining digital learning tools with the guided inquiry model, targeting a crucial gap in current teaching practices and materials in high school biology.

Based on the background described, to what extent does the use of an e-module integrated with

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the guided inquiry model train scientific literacy of the human circulatory system?

2. RESEARCH METHOD

This research uses a development research method with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) based on the perspective of Cennamo, Abell & Chung (1996); (Rayanto and Sugianti, 2020). The study was conducted at SMA Negeri 3 Toboali, Bangka Belitung, with the research subjects being students from Class XI IPA 1. Data collection was carried out using instruments such as needs analysis interviews, validation test questionnaires, readability tests, teacher and student response tests, and scientific literacy ability tests.

The analysis stage is the initial stage that aims to collect information related to conditions in the field, identify problems and find appropriate solutions to the problems found. The analysis carried out in this study is performance analysis, needs analysis and curriculum analysis which is carried out through interviews and questionnaires through *google* forms for biology teachers and students of grade XI Science 1. The Design Stage is a stage used to design concepts and content that will be compiled in the e-module, selecting appropriate media and formats. The design at this stage is made based on the results of analysis from the previous stage, is still conceptual and serves as a guide for the next stage of development. The resulting at this stage is the initial design of the e-module that is developed including the preliminary design, activities/content and conclusion.

The Development Stage is the process of realizing the initial design of the e-module that has been prepared previously into a finished product. Through this stage, the e-module is tested for feasibility through the validation of several experts as well as a readability test. The expert validation test is carried out by each validator expert on different aspects, namely media, materials, learning and practitioners, including lecturers and biology teachers. The total validators are four expert validators who conduct validation tests representing different fields of expertise and aspects. This is intended to obtain more objective and accurate research and avoid bias in the assessment of the developed products. Furthermore, a readability test was carried out to determine the response of students' readability level to the e-module. The number of respondents at this stage of the readability test was 12 people taken from different students' cognitive levels (high, medium, and low). This is intended so that the readability test gets responses from various student perspectives.

The implementation stage is the application of an e-module that was developed to obtain feedback from teachers and students. This stage is directly tested through the learning process (*Laksana et al*., 2023). The process in this stage is a test of teacher and student response as well as a science literacy ability test which is a form of student learning outcomes. This stage was tested on 1 biology teacher and 1 class XI of science totaling 20 students. The evaluation stage is a stage that is carried out to assess and provide feedback on the e-modules that have been developed and have been implemented in the learning process (Laksana *et al*, 2023). The evaluation stages in this study include summative evaluation and formative evaluation. Summative evaluation is carried out to find out the extent of success obtained from the developed product or the level of efficiency and effectiveness of the developed product, while formative evaluation is an evaluation process during the development stage that serves as a reference for improving the media so that it can be used effectively and efficiently (Kaniawati *et al*, 2023). The summative evaluation includes the results of teacher and student response tests and student learning outcomes, namely science literacy ability tests, while formative evaluation includes data on product validation test results from several experts.

Data processing techniques in the study use the Guttman scale and the Likert scale. The Guttman scale is used for the readability test instrument, while the Likert scale is used for the expert validation test, teacher response test, and student response test.

Table 1. Guttman Scale Assessment Criteria

No	Criteria	Score
1.	Yes	1
2.	No	0

(Djaali & Muljono, 2008)

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Table 2. Likert Scale Assessment Criteria

Alternative Answers	Assessment Score
Very good	5
Good	4
Quite good	3
Not good	2
Very Not Good	1

(Lubis *et al*, 2021)

This research uses descriptive qualitative and quantitative analysis techniques. Qualitative data were obtained from interviews with teachers and questionnaires from students, while quantitative data were obtained from the e-module feasibility tests, including expert validation tests, readability tests, teacher and student response tests, as well as scientific literacy tests. The formula used for the e-module feasibility test according to Leonardy (2023) is as follows:

$$P = \frac{f}{N} \times 100\ \%$$

Description:
P = percentage of assessment
f = score obtained
N = Maximum number of scores

The following table shows the interpretation of data from the calculation results obtained:

Table 3. E-Module Content Validity Assessment Criteria

Percentage Interval (%)	Criteria
81 – 100	Very Eligible
61 – 80	Eligible
41 – 60	Quite Eligible
21 – 40	Less Eligible
0 – 20	Very Less Eligible

(Ayuardini, 2023)

Table 4. E-Module Readability Test Assessment Criteria

Percentage Interval (%)	Criteria
81 – 100	Very Readable
61 – 80	Readable
41 – 60	Quite Readable
21 – 40	Less Readable
0 – 20	Unreadable

(Handayani *et al*, 2022)

Table 5. Assessment Criteria for Teacher and Student Response Scores

Percentage Interval (%)	Criteria
81 – 100	Very Good
61 – 80	Good
41 – 60	Quite Good
21 – 40	Not Good
0 – 20	Very Not Good

(Ayuardini, 2023)

The science literacy ability test consists of 10 multiple-choice questions using indicators of science literacy competency aspects. Before use, the science literacy ability test is carried out to test the instrument through validity and feasibility tests. The results after testing were obtained 10 valid questions with a reliability test result of 0.658 which showed that the test instrument had high and qualified criteria. The science literacy test is tested at the implementation stage. The analysis of test results was carried out with each correct answer given a score of 1 and a false answer given a score of 0. Then, the total score is calculated from the answers given which are then converted into values using the formula according to Arikunto in Sutrisna (2021) as follows :

$$Score = \frac{Score\ obtained}{Maximum\ score} \times 100$$

Table 6. Criteria for Achieving Scientific Literacy

No	Value Range	Criteria
1.	67-100	High
2.	33-66	Medium
3.	<33	Low

(Sutrisna, 2021)

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3. RESULTS AND DISCUSSION

The entire development process of the research, which used the ADDIE model, has been completed, resulting in a product in the form of a guided inquiry-based e-module on the human circulatory system for 11th grade SMA/MA students. The data obtained from this research are as follows:

Analysis Phase

Interviews were conducted on teachers and students of different cognitive levels (high, medium and low). This can help describe the learning conditions in the classroom. The results of the research through the interviews revealed several issues, including that the learning process does not focus on developing students' scientific literacy; learning outcomes in circulatory system materials have not fully met the minimum competency standards (KKM), while the KKM score in schools is 75; teaching materials are still in the form of general textbooks and printed modules; learning is not yet fully student-centered; Most students consider biology, especially the circulatory system, to be a difficult subject; and students prefer electronic teaching materials with interactive and attractive designs.

Additionally, a curriculum analysis was conducted to determine and review core competencies and basic competencies. This resulted in the formulation of competency achievement indicators (IPK) and learning objectives, which served as references for the scope and limits of the material used, as well as learning activities in the e-module. The e-module was developed based on the 2013 curriculum under KD 3.6 and 4.6, focusing on the human circulatory system material.

Design Phase

This phase resulted in an initial design of the e-module, consisting of two learning activities based on the stages of the guided inquiry model. The design also included other components such as e-module identity, a preface, a table of contents, a general description of the e-module, core competencies (KI), basic competencies (KD), learning objectives, concept maps, usage instructions, material deepening, final exercises, self-assessment, a glossary, and a bibliography.

The learning activities were structured according to the guided inquiry syntax adapted from Zulfiani (2022), which includes the stages of presenting problems, formulating hypotheses, designing and conducting experiments, collecting and analyzing data, and drawing conclusions.

Additionally, the media used for designing and visualizing the e-module included the Canva and Heyzine applications. The design format of the e-module featured images and animations themed around the human circulatory system, predominantly using red, green, and brown colors, with fonts such as Sansita, PAALALABAS WIDE, Poppins, and GAGALIN.

Below is the layout and design of several components of the developed e-module:

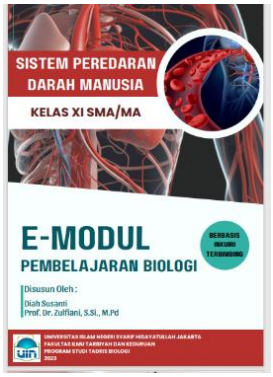

Figure 1. Front Cover

Figure 2. General Description of the E-Module

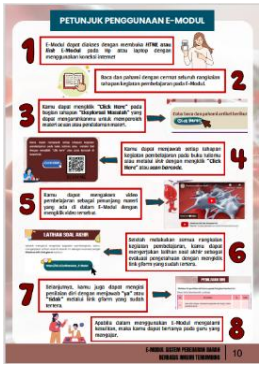

Figure 3. Instructions for Use

Figure 4. Learning Objectives

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Figure 5. Learning Activities

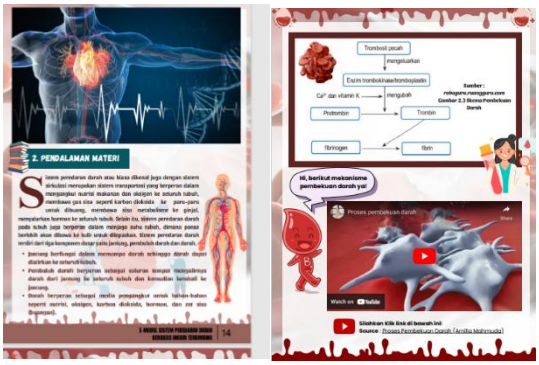

Figure 6. In-depth Study of the Material

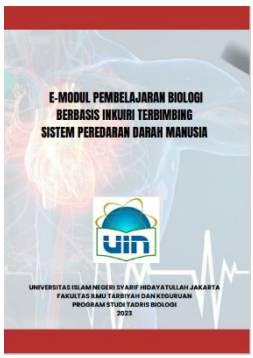

Figure 7. Back Cover

Development Phase

This phase involved testing the feasibility of the previously created e-module through expert validation and readability tests. The expert validation was conducted by four experts: a media expert, a learning expert, a content expert, and a practitioner. The validators for the expert validation consisted of university lecturers and high school biology teachers.

Table 7. Results of the Overall E-Module Validity Test Analysis

Expert Validation	Percentage (%)	Criteria
Material	87,40	Very Eligible
Media	85,5	Very Eligible
Learning	80	Eligible
Practitioner	100	Very Eligible
Total Percentage (%) and Conclusion Criteria Total E-Module	**88,22**	**Very Eligible**

Table 7 shows the overall validation results by the four validators, yielding a total percentage of 88.22% (very feasible). This result indicates that the e-module developed by the researcher has met the feasibility criteria. Therefore, after comprehensive revisions and improvements, the e-module can be used appropriately by both teachers and students in the learning process.

Based on the validation by the media expert, a total percentage of 85.5% was achieved, with the e-module being categorized as highly feasible. The evaluation was based on three components: graphical presentation, content delivery, and language use. These results indicate that the e-module is appropriate and ready for use, with improvements made based on the suggestions and comments from the validator. Some of the improvements made based on the results of the assessment of media expert validators include changes in font size, changes in the cover of the e-module and the addition of some section information on the e module.

The validation analysis by the content expert resulted in a percentage of 87.40%, also categorized as highly feasible. The results for each component—content feasibility, presentation, and language—were deemed very feasible. According to the content expert, the material included in the e-module was appropriate, although it was recommended to add more instructional videos to support the material .

The validation analysis by the learning expert resulted in a percentage of 80%, categorized as feasible. The components assessed were the guided inquiry learning activities, content delivery, and language use. The learning expert's

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evaluation indicated that the learning activities aligned with the guided inquiry syntax. The expert concluded that the e-module was feasible for use, with some improvements based on the suggestions and feedback from the validator. Some of the improvements include the improvement of word writing errors, the replacement or change of sentences, the improvement of the use of punctuation, the change in color, the improvement of time allocation, the improvement of the writing of the bibliography, and the improvement of the observation table at the stage of designing and conducting experiments.

The validation analysis by the practitioner resulted in a percentage of 100%, categorized as highly feasible. This result shows that every component of the e-module—content feasibility, presentation, and language—was highly feasible and appropriate.

Furthermore, after the e-module product was validated by several experts, then the e-module was tested on a small scale with a total of 12 students with the categories of low, medium and high mastery levels. The readability test was carried out to see the response of the readers' level to the e-module. According to Nissa *et al*. (2023), readability testing is done to reduce errors that can lead to misunderstandings between the author's intent and the reader's understanding. The results of the readability test for students showed a score of 97.70% (very easy to read). These results were obtained from showing that students gave very positive feedback on the readability of the e-module. Dewi & Arini (2018) explained that good readability in a text can increase learning interest and memory retention, improve reading efficiency, and help maintain students' reading habits.

Implementation Stage

This stage involves testing the e-module product with students and teachers during the learning process. The test of student response to the e-module was carried out in 1 class XI of science which amounted to 20 people, while the teacher response test amounted to 1 biology teacher.

Based on the results of the teacher response test, a percentage of 100% (very good) was obtained. The results of the analysis are detailed in Table 8.

Table 8. Results of Teacher Response Test Analysis

Components	Percentage (%)	Criteria
Practicality	100	Very Good
Feasibility of Material Content	100	Very Good
Language	100	Very Good
Graphic Display	100	Very Good
Total Average Percentage (%) and Conclusion Assessment Criteria	**100**	**Very Good**

Furthermore, the results of the student response test showed a percentage of 93.18% (very good). The analysis of the student response test can be seen in Table 9.

Table 9. Results of Students Response Test Analysis

Components	Percentage (%)	Criteria
Practicality	92	Very Good
Feasibility of Material Content	92,67	Very Good
Language	94	Very Good
Graphic Display	94,40	Very Good
Total Average Percentage (%) and Conclusion Assessment Criteria	**93,18**	**Very Good**

Based on the two tables above, it was found that the results for the linguistic component indicate that the language used in the e-module is easily understood. The results for the graphic display component show that the developed e-module has an attractive design. The results for the practicality component indicate that the e-module is practical and can be accessed anywhere, with instructions and learning activities in the e-module being easy to understand. The results from the content feasibility component demonstrate that the material and activities for the guided inquiry learning stages in the e-module are appropriate. Overall, this shows that each component of the e-module is feasible and suitable.

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Next, a science literacy ability test was administered to students to assess their science literacy skills after using the guided inquiry-based e-module. The results of the science literacy ability test are as follows:

Table 10. Summary of Results of Science Literacy Ability Achievement Test Based on Students as a Whole

No	Value Range	Number of Students	Percentage
1.	67-100 (High)	9 people	45 %
2.	33-66 (Medium)	10 people	50 %
3.	<33 (Low)	1 person	5 %
	Total	**20 people**	**100%**

Table 11. Recapitulation of Science Literacy Ability Achievement Test Results Based on Science Literacy Indicators

No	Science Literacy Indicators	Average value	Criteria
1.	Explaining Phenomena Scientifically	48,75	Medium
2.	Evaluating and Designing Scientific Investigations	76,67	High
3.	Interpreting data and evidence scientifically	61,66	Medium
Overall Average Score of Science Literacy Indicator Achievement		62,36	Medium

Table 10 shows that of those 20 students, 45% achieved high criteria, 50% achieved medium criteria, and 5% achieved low criteria. This shows that more than 50% of students achieve science literacy test results in the medium to high category. These results show that the use of guided inquiry-based e-modules effectively stimulates and trains students' science literacy skills. Students are actively habituated and trained to understand the material through learning that encourages the nature of "discovery", thereby assisting students in understanding the material and phenomena related to the material.

Furthermore, Table 11 shows that the average score based on science literacy indicators is 62.36, also categorized as moderate. The first indicator has an average score of 48.75 (moderate), the second indicator has an average score of 76.67 (high), and the third indicator has an average score of 61.66 (moderate). Among these, the second indicator achieved the highest average score, indicating that students are more capable of designing and conducting scientific investigations. The use of guided inquiry-based e-modules encourages students to be more active and skilled in discovering or solving problems through experiments. The stages in guided inquiry activities motivate students to take responsibility for investigations, seek evidence, analyze knowledge, and critically respond to questions (Sani, 2019). The first indicator has the lowest average score, although it is still categorized as moderate. This indicates that this skill needs further training, as students tend to memorize rather than understand concepts. According to Faridah *et al*. (2022), students who better understand concepts are more capable of relating them to complex and abstract phenomena. Overall, the average scores based on science literacy indicators demonstrate that guided inquiry-based e-modules can train and stimulate students' science literacy abilities.

Science literacy skills can be fostered and developed through learning that utilizes guided inquiry-based e-modules. Guided inquiry learning focuses on investigation, where students play a more active role through their creativity to discover or seek out knowledge concepts, making their learning experience more meaningful (Marto *et al*., 2023). According to Fitri and Fatisa (2019), inquiry-based learning encourages students to think optimally and aligns with constructivist learning, promoting the skills necessary for science literacy. This is supported by the average scores of the science literacy tests, indicating that the guided inquiry-based e-modules in this study can help train students in science literacy, particularly regarding the human circulatory system.

Evaluation Stage

The evaluation stage is conducted through two types: formative and summative evaluation. Formative evaluation is carried out during the development of the e-module by testing its feasibility. The results of the formative evaluation are obtained by considering revisions and

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improvement notes; the e-module has met the feasibility requirements for use in classroom learning.

Additionally, summative evaluation is conducted by measuring the achievement of science literacy after using the guided inquiry-based e-module. The results indicate that the guided inquiry-based e-module can effectively help train science literacy skills, based on the average science literacy scores of the students.

4. CONCLUSION

Based on the research conducted, it can be concluded that the final product produced is a guided inquiry-based e-module on the topic of the human circulatory system to train science literacy for XI grade students in senior high schools (SMA/MA). The results of expert validation tests, readability tests, and responses from both teachers and students indicate that the e-module is highly suitable for use in teaching. Furthermore, the results of the science literacy tests for students also show that the developed e-module is appropriate and can be used to train students' science literacy.

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