RESEARCH ARTICLE

The effectiveness of AR e-module of flower structure material on biology students' science literacy

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Abstract: The electronic-module (e-module) is one of the teaching materials needed so that the learning process can take place optimally. E-module owned by UM biology students generally do not use the latest technology. Augmented Reality (AR) is a form of technology where there is a process of integrating the virtual world with the real world. Not a few students experience difficulties in understanding the flower structure material. Student scientific literacy is still far from what is expected. The research conducted is Research and Development with the Lee and Owens Development Model. Data collection was carried out during October-December 2022. The technique of analyzing quantitative descriptive data. The subjects in this study were 37 biology students class of 2021 without any differences in gender, age and study program. The results of the effectiveness of the AR electronic-module based on n-gain calculations obtained a score of 0.7 where on that score the AR e-module was categorized as quite effective in increasing scientific literacy. It is hoped that in the future there will be teaching materials and media that can improve some of the competencies needed by the latest generation.

Keywords: Augmented reality; biology students; e-module; science literacy

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Article history:
Received: 6 April 2023
Revised: 11 July 2023
Accepted: 13 July 2023
Published: 30 July 2023

10.22219/jpbi.v9i2.25747

p-ISSN: 2442-3750
e-ISSN: 2537-6204

How to cite:
Sulisetijono, S., Sunarmi, S., & Rochmah, A. N. (2023). The effectiveness of AR e-module of flower structure material on biology students' science literacy. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(2), 217-224. https://doi.org/10.22219/jpbi.v9i2.25747

Introduction

Flower structure is one of the topics in lectures on plant structure and development at the Biology Department, Universitas Negeri Malang (UM). All biology students must take the Structure and Development of Plants course. The material contained in these lectures is concrete concept material where students can use all of the senses directly in the learning process (Soedjito & Saryono, 2011). In this lecture discusses all plant organs from roots, stems, leaves, flowers, fruits, seeds and their development. The topic of flower structure is the main key in lectures on plant structure and development. In the topic of flower structure, it contains material for flower parts and their development. However, not a few students have difficulty understanding flower structure material because of the many flowers observed and their lack of understanding of the important parts of a species. Biology as a science must aim to give experience it is about mind, practice and heart. Therefore, the ideal study of biology does not consist only of: it incorporates not only the transfer of knowledge, but also the active role of the student in deepening concepts (Hunaepi et al., 2021).

Furthermore, the development of scientific literacy is still a task that is never completed. Even though scientific literacy is an urgency in the 21st century, the development of these skills is still low. A learning can be said to be successful if student learning outcomes have increased. However, in reality the learning outcomes of UM biology students are still far from what was expected. This is evidenced by the initial analysis of the scientific literacy value of UM biology students of 39 in the low category. The low value of scientific literacy is caused by students not being used to processing knowledge at the level of cognitive analysis and associating existing knowledge with new knowledge. In fact, scientific literacy can be trained in students' learning activities. It can be incorporated into learning activities, especially biology (Yuniar et al., 2020).

Overcoming the problems that have been described, teaching materials are needed that are able to increase student understanding and scientific literacy related to the topic of flower structures. Teaching materials are one of the important components in the world of education where teaching materials have an important role that can be specific or general in nature (Magdalena et al., 2020). One of these teaching materials is the electronic-module (e-module). The e-module is one of the innovations in teaching materials with the integration of technology and information that has developed rapidly. This innovation is in line with the characteristics of e-module, namely adaptive, where the module must have high adaptive power to the development of science and technology. Learning innovations are expected to be applied at all levels of education as a form of developing scientific literacy (Irawan et al., 2020). Development of e-module can make students more comfortable compared to conventional learning and make learning much more effective. With the development of interactive e-module, it can increase student motivation in learning where students will involve sensory activities, provide opportunities for students to determine accelerated learning and be able to carry out self-evaluations. (Yolanda, 2021). Materials can be used in the form of e-module, as e-module also help teachers to make students more active and independent (Herawati & Muhtadi, 2018).

Based on observations made in September 2022, the e-module owned by UM biology students are generally very simple and do not contain the latest technology. This resulted in students being less motivated and less understanding in studying the topic of flower structures, e-module which were monotonous to study and had not included learning stages.

The most common form of technology that enables real-world integration with virtual worlds is Augmented Reality (AR). AR can be used as a teaching tool that conveys information in a clear and interactive, real-time, and educational way (Carolina, 2022). Utilization of augmented reality in educational media is possible on Android and iOS-based smartphones which can display 3D objects virtually, just like in real life, by scanning barcodes that contain object-specific information (Haryani & Triyono, 2017). The existence of AR technology can assist students in learning abstract material and assist students in observing objects that are difficult to observe with the naked eye. According to AlNajdi et al., (2020) AR offers an opportunity to observe and learn from real-world behavior, allowing students to imagine how theories might be applied, and thus could be extended to general education. The use of AR can also help make e-learning learning more exciting, interactive and fun. Where it has been applied, this approach has improved learner outcomes, increased motivation, and facilitated collaborative learning. AR provides learning opportunities to observe and test theories, and integrates virtual reality into real life to foster creative thinking and effective decision-making. AR is gaining traction in education because it has the potential to enhance learning and teaching (Annetta & Shapiro, 2019). Student reactions to AR prominence focus on three things:Engaging, explorable, and motivating. This is consistent with previous studies that AR media are fun and interesting media for young people (Al-Azawi et al., 2019). The learning outcomes achieved through the use of AR media are the ability of students to acquire lower cognitive skills (memory, comprehension, application) and higher cognitive skills in the form of analyzing (Yamtinah et al., 2023). Furthermore, using AR can improve student learning outcomes in multiple subjects (Ling et al., 2021) and Interest in and Understanding of Specific Material Concepts (Kuit & Osman, 2021).

In accordance with the previous presentation, AR technology has given a very positive response to the world of education. At the same time the e-module with the help of AR which will be developed more specifically discusses the flower parts of various species that have never been developed before so that it becomes one of the breakthrough innovations in the development of material e-module in the UM biology department lectures.

Broadly speaking, the problem being faced is that biology students' scientific literacy is not yet optimal, especially in the material of floral structures. Writing articles wants to show the effectiveness of the development of AR e-module for biology students' scientific literacy in the flower structures material.

Method

This Research and Development used Lee and Owens Development Model. The Lee and Owens Development Model has several stages, namely (1) Assessment or analysis, (2) Design, (3) Development, (4) Implementation, (5) Evaluation. The first stage (Assessment or analysis) is the stage where all the analysis needed is collected as a basis for developing technological materials in teaching materials, the analysis starts from material analysis, audience analysis, technology analysis to cost-benefit analysis. The analysis phase was carried out by observing and interviewing lecturers in the plant structure and development course. The next stage is the design stage. This stage is the multimedia design that will be developed. The third stage in Lee and Owens is the development stage. In the development stage, there is a description of the AR technology development process in the e-module and a product trial process is carried out. The product trial process must be carried out in order to produce a valid and practical technological product before moving on to the implementation stage. Validity and practicality were obtained from questionnaire calculations carried out by several experts, test subjects

and educational practitioners. The implementation stage was carried out on research subject students and also measured the acquisition of scientific literacy scores from calculating the value of product effectiveness on the development of scientific literacy values. The final stage is evaluation. The evaluation phase aims to collect data as a basis for determining whether the AR e-module that has been developed is effective against existing problems in the learning process so that it can achieve the stated goals.

Data collection was carried out during October-December 2022. The data was analyzed using quantitative descriptive technique. The subjects in this study were 37 UM biology education students class of 2021 without differentiating gender and age. Scientific literacy measurement is carried out using sub-indicators from the (OECD, 2019). OECD scientific literacy sub-indicators include: (1) Describing scientific knowledge, designing predictions and hypotheses based on phenomena, designing investigations, (2) Evaluating scientific investigation designs, Interpreting and communicating scientific information in writing or orally, and (3) Describing and analyzing one or more relationships between science, technology and society to understand the application of science in everyday life.

Instruments for measuring scientific literacy are in the form of pre-test and post-test questions with indicators of OECD 2019 scientific literacy. Furthermore, the calculation of scientific literacy scores is carried out using the OECD 2019 scientific literacy rubric. Following is a table of guidelines for assessing scientific literacy, guidelines for calculating scientific literacy scores and criteria for literacy scores science. The scientific literacy scores of biology students were obtained from pre-test and post-test calculations using the OECD scientific literacy scoring guidelines in Table 1.

Table 1. Scoring Scientific Literacy

Criteria	Score
If the answer is correct, sequence using clear grammar	4
If the answer is correct, it is less coherent by using unclear grammar	3
If the answer is not correct with clear grammar	2
If the answer is wrong, the grammar is not clear	1
If not answered	0

Student scientific literacy scores = Question1+Question 2+Question 3+Question 4+Question 5+Question 6. Measuring the effectiveness of the AR e-module uses the gain score calculation with the following Formula 1. Criteria for the level of effectiveness of the AR e-module can be seen in the Table 2.

$$\text{n} - \text{gain} = \frac{(post\ test\ score - pre\ test\ score)}{(maximum\ score - minimum\ score)} \quad (1)$$

Table 2. Criteria for the level of effectiveness of the AR E-Module

n-gain score	Effectiveness level
≥ 0.7	Effective
0.3 – 0.7	Effective enough
≤ 0.3	Less effective

Results and Discussion

Development of AR electronic-module

The development of AR e-module uses the Lee and Owens (2004) development model with five stages, namely analysis, design, development, implementation and evaluation. The following is a further explanation of the stages of Lee and Owens (2004). Analysis phase, based on the analysis that has been carried out through interviews and observations, there are several gaps between the real world and future expectations. These gaps include learning modules owned by students that are still old-fashioned and there is no the latest technology, student understanding of interest structure material is far from expectations, low student motivation in learning which has an impact on students' scientific literacy levels.

Design stage, the specifications for the media developed: (a) software: unity, Google drive, Google form; (b) hardware: computer, keyboard, mouse; (c) interface design: consists of cover, preface, table of contents, material 1 material 2, concept map, learning activities, reference list, QR-code augmented reality image, and developer biodata page; (d) theme: development of AR e-module using a theme appropriate to the material to be presented; (e) ext: the type and size of the font will be adjusted to the needs and attractiveness of the AR e-module; (f) image: the type of image used is adjusted to the needs in development; (g) video: the type of video used is adjusted to the needs in development.

Development stage, the third stage is the development stage. The AR e-module was developed using the Unity program which students can use independently and assist lecturers in the learning process. The developed AR e-module contains several components, namely cover, preface, table of contents, material concept map, learning activities, reference list, QR Code AR images, developer page (Figure 1).

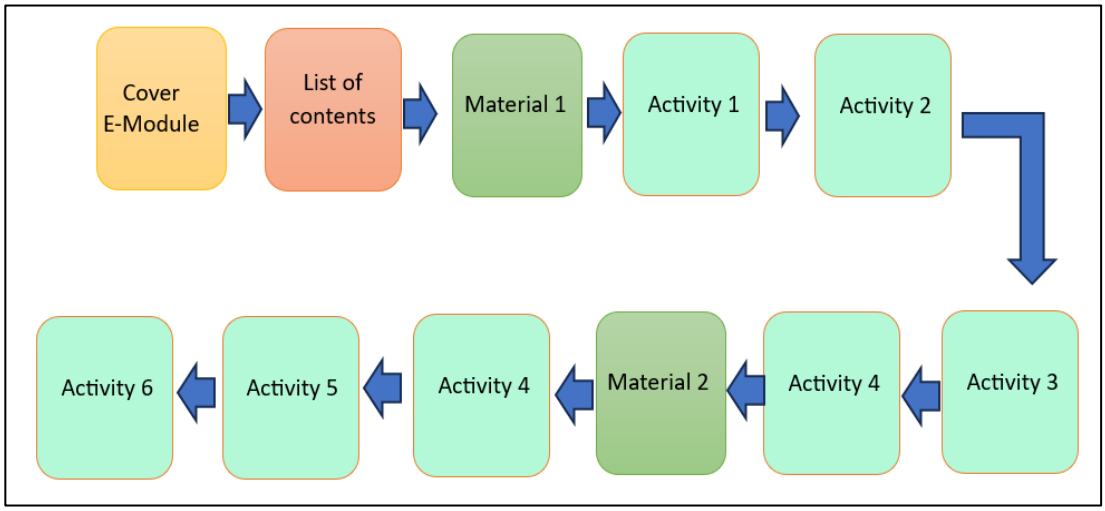

Figure 1. Learning flow in the AR e-module

After making the learning flow and developing electronic-module, the next activity is to carry out product validation, trials on trial students and education practitioners. The product validation results can see in Table 3. The results on students can see in Table 4. The results of trials of educational practitioners can see in Table 5. Based on the calculation of the validation and the percentage of trials that have been carried out, the AR e-module product has very valid and sufficient criteria and is very practical.

Table 3. Average media validation results on products

No	Media validation	Average	Percentage (%)	Criteria
1	Flower Morphology Structure Material	4.8	96	Very Valid
2	Material Relating the Morphological Structure of Flowers to the Structure of Stems and Leaves	4.8	96	Very Valid

Table 4. Average percentage of student trials

No	Media validation	Percentage (%)	Criteria
1	Flower Morphology Structure Material	80	Practical enough
2	Material Relating the Morphological Structure of Flowers to the Structure of Stems and Leaves	80	Practical enough

Table 5. Average percentage of educational practitioners trials

No	Media validation	Percentage (%)	Criteria
1	Flower Morphology Structure Material	96	Very practical
2	Material Relating the Morphological Structure of Flowers to the Structure of Stems and Leaves	96	Very practical

Biology students' scientific literacy scores

The next step is to look at AR electronic-module products on students' acquisition of scientific literacy in Table 6.

Table 6. Science literacy score for biology students

Information	Score	Max Score
Pretest	391	1176
Posttest	906	1176

Science literacy scores of biology students were obtained from pre-test and post-test calculations using the OECD scientific literacy scoring guidelines.

AR e-module effectiveness

The effectiveness of the AR e-module based on n-gain calculations obtained a score of 0.7 where on this score the AR e-module is categorized as effective enough. The learning process is inseparable from the process of imparting knowledge from educators, namely lecturers to students. The learning process requires learning strategies, teaching materials and learning media so that the process of imparting knowledge can run well and effectively. Good and effective teaching materials able to improve student learning outcomes and improve their life skills in the 21st century.

Developm 21st-century skills using these resources and competencies-matched learning techniques. In fact, many lecturers are still not leveraging technology in their learning process due to lack of preparation, training and instruction. Therefore, the learning process still focuses on lecturers using lecture methods and taking notes (Santosa et al., 2022). Thus, the lecturers needs to transform her 21st century skills like passive learning into active learning (Respati & Atun, 2023).

To produce teaching materials that are effective in achieving learning objectives needs to be designed and developed optimally. In essence, teaching materials are arranged according to the field of study with the curriculum used. Revealed several criteria in the preparation of teaching materials including: a) instructions for use, b) competencies to be achieved in the meeting, c) materials, d) worksheets and evaluation. Good teaching materials are teaching materials that are arranged systematically where the teaching materials fully display the competencies that will be mastered by students and used in the learning process to achieve learning goals. Teaching materials must be unique and specific wherein the development of teaching materials must be in accordance with certain goals and aimed at certain targets in based on the competencies that must be mastered.

The preparation of teaching materials must follow several principles. These principles include relevance, consistency, and adequacy. The principle of relevance is that educational material must be relevant to a person's level of expertise and related expertise. Principle of Consistency means that if there are five competencies that must be developed by a student, then the relevant teaching materials must be included in the teaching materials. The Principle of Adequacy is that subjects are taught in a way that prepares students for the skills being taught. The teaching materials may not be too broad or too narrow. In addition to containing learning materials that are appropriate to the field of study, teaching materials also have several functions, including directing all student activities in the learning process according to competence and as an evaluation tool in achieving learning goals (Magdalena et al., 2020).

Instructional materials designed must always pay attention to technological and information developments so that the resulting teaching materials can be sustainable in accordance with the times. If the teaching materials do not keep up with technological and information developments, the substance that will be given to students will decrease and will not be able to encourage students to master the skills of the XXI century. E-module are educational tools that contain materials, procedures, and questions that are presented in an engaging and methodical way to acquire competence (Handayani et al., 2021). Teaching materials that meet these challenges are those that utilize IT, such as e-module with videos and learning animations. Educators can use electronic-module as learning resources for students inside and outside the classroom (Asrial et al., 2022). Modules developed in digital forms, such as e-module, are aided by technology and are equipped with videos and animations to facilitate students' comprehension of the material, thereby creating positive learning outcomes for students (Nurhayati et al., 2022).

Augmented Reality technology is quite widely present in society, but its use is still only for commercial use and has not yet entered the world of education. Augmented Reality (AR) is the visualization of digital information superimposed on a real-life environment, providing users with additional information while helping them solve tasks (Hurst et al., 2021). The developed e-module already has AR technology where this technology can help students in the learning process. This is evidenced by the value of the effectiveness of teaching materials with n-gain calculations, a value of 0.7 is obtained, where this value has criteria that are quite effective in increasing the scientific literacy score of UM biology students.

Hurrahman et al. (2022) revealed that the E-Module based on Augmented Reality technology is easy to use, attractive to students and able to assist in visualizing abstract concepts. Pratiwi et al., (2021) said that the E-Module on the immune system material with Augmented Reality technology is able to help high school class XI students to understand the concept of the immune system well, students can learn independently, active and having fun. Masdi & Pratama, (2022) said that Augmented Reality-assisted E-Modules are able to provide students with an understanding and construct their own thoughts on real problems. AR technology can provide interactive and immersive learning environments that engage and motivate students. By integrating AR into learning, educators can create more dynamic and engaging learning experiences that allow students to visualize and explore concepts in new and exciting ways (Savale et al., 2023).

The development of the AR e-module was also able to increase students' scientific literacy scores. The increase was 2.3%. Measurement of scientific literacy uses scientific literacy sub-indicators from the (OECD, 2019) which are carried out at the end of each lesson. By increasing students' scientific literacy, it is expected that students will become more skilled in solving real problems and get original and rational thinking about solutions to daily life problems (Indrawan et al., 2022). Revealed that the experimental group experienced an increase in scientific literacy compared to the control group. The development of AR e-module enables students to develop abstract thinking skills and scientific literacy (Rizti Yovan & Kholiq, 2021). Additionally, the use of augmented reality media may help students visualize what is happening. Augmented reality media has made it easier for students to understand complex concepts and visualize abstract concepts to understand the structure of object models. This means that these learning media can be supporting student learning and improve scientific competence (Setiawan et al., 2022). According Ayu et al., (2021) AR will help interest in Madura's scientific literacy, improve the quality of learning with innovative media, and prepare generations of the country's children for the challenges of this growing millennial age.

Conclusion

Learning is inseparable from the preparation of strategies and teaching materials in order to achieve learning objectives and master competence. The developed AR e-module proved to be quite effective in increasing scientific literacy with a value of 0.7. Furthermore, there is an increase in scientific literacy of 2.3%. Effective teaching materials must be able to improve life skills in the 21st century and be able to encourage students to learn effectively and independently.

Author Contributions

S. Sulisetijono: methodology, review, and editing; **S. Sunarmi:** question validation, review, and editing; and **A. N. Rochmah:** writing original draft preparation.

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