Development of Ecosystem E-Module Based on Socio-scientific Problems Assisted by Quick Response Code (Qr Code) to Enhance Scientific Literacy of Class X Students in SMAN 1 Kepanjen

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Abstract. Through the mastery of scientific literacy, students are expected to be able to participate in solving real problems through understanding science and technology based on a scientific approach. This study aims to develop an electronic module (e-module) based on socio-scientific problems with the help of a Quick Response Code (QR Code) on Ecosystem material that has been tested for validity, practicality, and effectiveness to improve scientific literacy for class X students of SMAN 1 Kepanjen. This study uses the ADDIE development model, which main activities are analyze, design, develop, implement, dan evaluate. The results of the validity test were obtained through expert validation of learning devices, materials, assessments, teaching materials, and teachers sequentially, namely: 98.75%; 100%; 100%; 99.5%; and 95% which as a whole belong to the very valid category. The practicality test results show an average of 93% which belongs to the very practical category. Data on the effectiveness of the e-module obtained from the implementation stage is 0.66 which indicates that the e-module has a moderate level of effectiveness. The use of e-module is able to improve students' scientific literacy skills by 85% which is in the high category. The results of observing the implementation of the Socio-scientific Problem Based Learning (SSI) model show an average score of 98% which is included in the very well implemented category. Based on the research data, the e-module based on socio-scientific problems assisted by the QR Code is classified as valid, practical, and effective for enhancing scientific literacy for class X students of SMAN 1 Kepanjen, so that it can be applied in learning activities.

Keywords: Ecosystem E-Module, Socio-scientific Problem, Scientific Literacy

1 Introduction

Science education aims to prepare students who are able to adapt to the progress of life in the 21st century, namely by mastering several life skills needed in the 21st century. In relation to the characteristics of the 21st t century, there are several key skills that are

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important for students to master, one of which is scientific literacy [1]. Scientific literacy is defined as the skill of using scientific knowledge to explain scientific phenomena, understand and provide scientific evidence, and conclude based on scientific evidence [2]. The need to master scientific literacy for the world community arises because each individual is expected to participate in solving real problems through understanding science and technology based on mastery of biology, physics, chemistry, mathematics, and the environment [3]. According to Nofiana [4], scientific literacy is multidimensional, meaning that individuals who have scientific literacy are characterized by their ability to utilize science concepts, science process skills, and science values in solving everyday problems and understand the interactions between science, technology, and society including the development of social and economic aspects.

Based on the assessment of science learning outcomes in the aspect of science literacy conducted by The Organization for Economic Co-operation and Development (OECD) in the Programme for International Student Assessment (PISA) shows that the scientific literacy of Indonesian students is still relatively low when compared to the average international score [5]. As quoted from the OECD, the results of the last PISA test in 2018 showed an average student literacy, science and mathematics score of 396 which made Indonesia rank 70th out of 78 countries. The scientific literacy of students in Indonesia is at level 1 where students can only use basic knowledge to recognize or identify simple scientific explanations. The low PISA score also shows the initial picture of students' scientific literacy and the quality of learning at the previous level [6].

The data on the low scientific literacy of students by the OECD shows compatibility with the results of the preliminary study of measuring scientific literacy using the Environmental Change material adapted from Suwono, et al's [7] research to 32 students of grade XI SMAN 1 Kepanjen on December 12, 2022. The Environmental Change test questions were used because these questions have been validated and are in accordance with the scientific literacy indicators. The test results showed that the average score of all scientific literacy indicators, which include: explaining phenomena scientifically, designing and evaluating scientific investigations, and interpreting data and evidence scientifically was 49%. According to Purwanto [8], the average score obtained by students shows that students' scientific literacy is still very low. Low scientific literacy scores indicate that the learning process does not lead to a scientific literacy context, so it has not provided opportunities for students to develop problem-solving skills through a science approach [9].

The observation of learning activities in class X-2 SMAN 1 Kepanjen on August 22, 2022 showed that learning activities did not reflect student centered learning, so students were classified as passive individuals. Learning is dominated by verbal information delivery activities about a biological concept and students are less involved in field investigation activities. Learning activities have not implemented the syntax of a particular learning model and there is no integration of scientific literacy indicators. Learning is carried out with discussion activities using Student Worksheets (LKS) developed by the teacher, but has not applied special problems based on contextual problems and has not been based on digital technology innovation. The results of an interview with one of the biology teachers of SMAN 1 Kepanjen on December 12, 2022 showed that the teacher had developed special problems that presented several contextual problems, but students did not have the skills to reason critically and analytically, as evidenced by students giving answers referring to the textbooks provided by the

school. Based on the results of the interview, information was obtained regarding the curriculum applied at SMAN 1 Kepanjen in learning activities, especially in class X, namely implementing the Merdeka Curriculum. One of the urgencies of implementing the Merdeka Curriculum is to improve aspects of student learning outcomes in the most essential aspects, among numeracy and literacy in reading, mathematics, and science so that it is indirectly related to the development of scientific literacy [10]. The implementation of the Merdeka Curriculum has a distinctive feature, namely learning only focuses on essential material and there is a development of soft skills and character based on Pancasila values [11].

Learning problems are supported by the results of a questionnaire on December 12, 2022 regarding the needs analysis of 32 students of class XI SMAN 1 Kepanjen on the implementation of the learning process and teaching materials used. According to students' opinions, the teaching materials used are less able to facilitate learning activities, because they only contain practice questions and a little summary of the material without presenting other supporting information in the form of websites or learning videos that can be an alternative learning resource for students. Students have difficulty understanding a concept by relying on teacher explanations, discussions, and presentations carried out during the learning process, so 97% of students think it is necessary to develop teaching materials to visualize and support in mastering a biological concept that leads to scientific literacy activities.

Several ways can be done to improve scientific literacy, including: developing strategies, teaching materials, and teaching media based on a multidisciplinary approach that is integrated with science problems [12]. The selection of appropriate strategies, teaching materials, and teaching media in accordance with the development of science and technology is expected to facilitate student learning activities, so as to create ideal learning and develop students' scientific literacy in accordance with the 21st century learning criteria. Ideal learning places students as objects in learning activities according to their respective characteristics, so it is expected that learning uses innovative teaching materials in accordance with the development of the 21st century [13].

Teaching materials in the form of electronic modules (e-modules) can be used as an alternative solution to overcome problems that occur in learning. E-Module has several characteristics, including: adaptive, self contained, stand alone, self instruction, and user friendly [14]. In accordance with research by Inanna, et al. [15], the use of e-modules has advantages over other teaching materials, namely e-modules are economical and practical, so that they can facilitate students to learn independently because they can access e-modules flexibly, not bound by space and time. The use of e-modules that are structured, interactive, and equipped with animations, video shows, and various learning resources can enrich students' learning experiences and effectively improve students' scientific literacy [16].

The E-Module was developed with a Quick Response Code (QR Code) and presented in the form of a flipbook online. Based on research conducted by Lee [17], the use of QR codes in learning can be a means for teachers to create more interesting biology learning, so as to increase student learning motivation. QR Code is able to convey information in the form of images, videos, and learning materials easily and quickly, so that it can be a means of information distribution and instant access to information [18]. The flipbook presentation form is a form of presenting a document in the form of a set of pages that can be moved like the pages of a book, and can be added

to various other supporting media [19]. The integration of technology in the developed e-module product is expected to improve students' scientific literacy and train other 21st century skills, namely students' skills in mastering technology.

The development of e-modules should be relevant to the material included and adapted to a particular learning model to meet the established Competency Outcomes (CP) [20]. The e-module teaching materials to be developed contain the syntax of the Problem-Based Learning model that uses Socio-scientific issues as the basis for problem solving (SSI). The combination of problem-based learning with socio-scientific issues can provide real and more meaningful learning to students, so it is expected to improve scientific literacy. Socio-scientific issues provide contextual learning situations that have opportunities for the development of argumentative scientific skills, exploration of moral issues, development of moral reasoning, and reflective judgment skills, so that students are able to make decisions on issues that are presented scientifically and have social value and indirectly help train scientific literacy [21]. SSI in biology subjects can be applied to Ecosystem material [22]. The application of SSI in learning Ecosystem material can be done by presenting local and global issues related to ecosystems that are complex, controversial, and are real-world problems involving social, economic, ecological, and ethical approaches, so that they can become the basis for scientific literacy education [23]. Ecosystem material is contextual material related to the surrounding environment, so there are many phenomena related to socio-scientific issues that can be raised as a basis for problem solving in learning using the SSI model [24]

Considering previous research related to the development of biology e-modules to improve scientific literacy, there is no research that develops e-modules based on socio-scientific problems specifically on Ecosystem material [25]. Based on the above background, research and development was conducted to develop an e-module based on socio-scientific problems assisted by QR Code on Ecosystem material that was tested for validity, practicality, and effectiveness to improve the scientific literacy of class X students of SMAN 1 Kepanjen.

2 Research Methods

This research uses the research and development method with the aim of producing a teaching material product in the form of an Ecosystem e-module based on socio-scientific problems assisted by QR Code to improve students' scientific literacy. The development model used by the research is the ADDIE development model [26]. The ADDIE development model consists of several stages, namely: analyze, design, develop, and implement Fig.1. The ADDIE development model contains comprehensive instructions and there is a revision stage that is used as a consideration to improve the quality of the product developed [27].

The research conducted based on the problems that arise, namely related to low scientific literacy. The subjects involved in the research and development were validation experts of teaching materials, learning devices, materials, assessments, field practitioners (teachers) and students of class XI MIPA 1, X-1, and X-2 SMAN 1 Kepanjen. Expert validators of teaching materials, learning devices, materials, and assessments have met the criteria of research subjects, namely having expertise in teaching materials,

learning devices, materials, and assessments, and have taken a minimum education level of Master of Biology Education or Biology. Field practitioner validators (teachers) are Biology teachers of SMAN 1 Kepanjen with a minimum education of S1, have teaching experience of five years or more and have been certified.

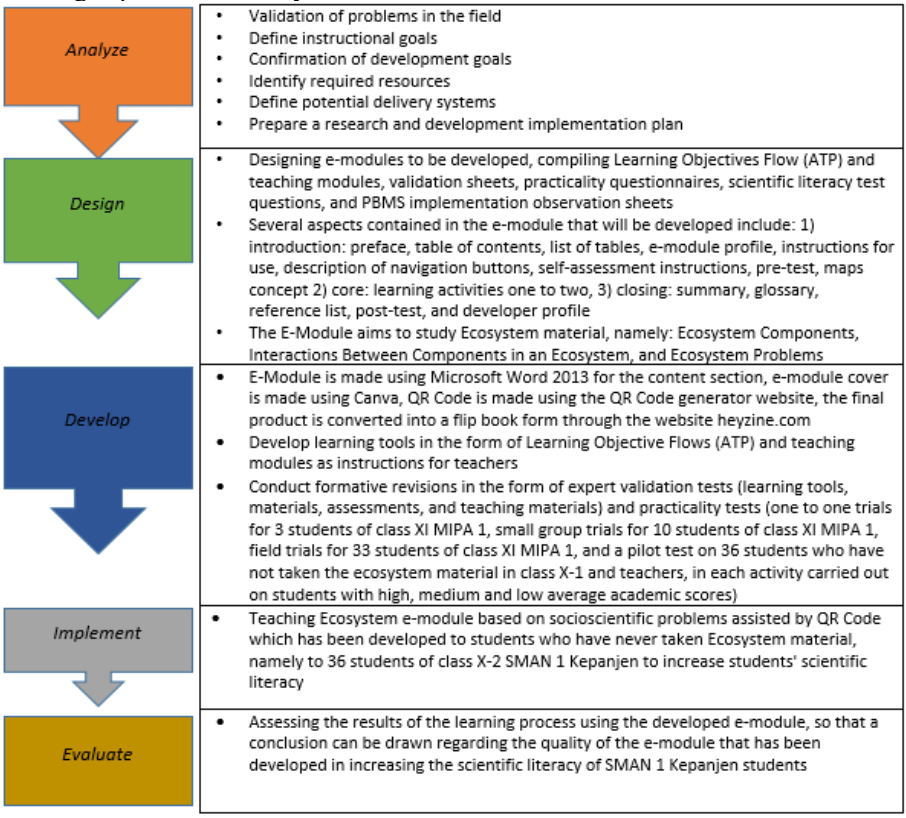

Fig 1. Modification of ADDIE development stages

The research and development was conducted from December 2022 to May 2023. The data collection instruments used in research and development are described in Table 1.

Table 1. Data Collection Instruments

Data Type	Data Source	Data Collection Instrument
Needs Analysis	Teacher	Interview guideline sheet Learning activity observation sheet
	Students	Needs analysis questionnaire Scientific literacy pre-test
Validity Test	Experts on teaching materials, learning tools, materials, assessments, and field practitioners (teachers)	Validation sheet (teaching materials, learning tools, materials, assessments, and field practitioners (teachers))
Practicality Test	Students	Student response questionnaire sheet
	Field practitioners (teachers)	Field practitioner (teacher) response questionnaire sheet
Effectiveness Test	Students	Scientific literacy pre-test and post-test question sheets

The data analysis technique of this research is qualitative-quantitative data analysis. Qualitative descriptive data analysis obtained from the review results in the form of comments and suggestions for improvement obtained from the questionnaire validation results of teaching materials, learning devices, materials, assessments, field practitioners (teachers) and students after using the developed e-module. The qualitative data obtained was used as a reference for revising the developed e-module. Quantitative data comes from the results of the needs analysis questionnaire, validity test, practicality test, and effectiveness test with the following description.

2.1 Validity Test

The results of the validity test data analysis were obtained through a data collection instrument processing questionnaire scores from experts on learning devices, materials, assessments, and teaching materials on the e-module developed. The percentage of validity of the teaching materials developed is calculated using the following formula.

$$V = \frac{\Sigma X}{\Sigma Xi} \text{ x } 100\% \quad (1)$$

Description:
V = Validity
ΣX = Total validator answer score
ΣXi = Total ideal score

2.2 Practicality Test

The practicality of the developed e-module was obtained through the results of teacher and student questionnaires after using the e-module. The percentage of data from the practicality test was analyzed using the practicality analysis formula as follows.

$$K = \frac{\Sigma X}{\Sigma Xi} \text{ x } 100\% \quad (2)$$

Description:
K = Practicality
ΣX = Total score of respondents' answers
ΣXi = Total ideal score

The results of the calculation of the validity and practicality of the e-module developed, then concluded with criteria for validity and practicality, the standard used by researchers related to validity and practicality that the PMBS-based e-module aided by QR Code is declared theoretically feasible if the average assessment is ≥ 70, 01%.

2.3 Effectiveness Test

Measurement of the effectiveness of the developed e-module is calculated through an increase in the results of the pre-test and post-test of students' scientific literacy. The effectiveness of the e-module was analyzed using the N-Gain formula.

$$N\text{-}Gain = \frac{02-01}{Maximum\ score-01} \quad (3)$$

Description:
O1 = Pre-test measurement results
O2 = Post-test measurement results

Data analysis of the effectiveness of using e-modules to improve students' scientific literacy is concluded by referring to N-Gain Criteri, the standard used by researchers related to the effectiveness that the PMBS-based e-module assisted by QR Code is declared theoretically feasible on average assessment $0.30 \leq g \leq 0.70$.

3 Result And Discussion

This research and development produces a final product in the form of a QR Code-assisted socio-scientific problem-based e-module aimed at improving the scientific literacy of class X students of SMAN 1 Kepanjen, especially on Ecosystem material. The developed e-Module can be accessed by scanning the QR Code that is disseminated to students through the Google Lens feature or pressing the link provided with the QR Code. The E-Module developed in this study follows the ADDIE model stage developed with the following procedures.

3.1 Analyze

The analysis stage aims to identify problems that arise and find solutions to overcome existing problems [27]. Problems in the field were identified through observation of learning activities, interviews with biology teachers, namely Mrs. Umu Halimah, M.Pd., analysis of student needs and student scientific literacy.

The results of the needs analysis stage show that students have a very low level of scientific literacy, which shows the average of each scientific literacy indicator of 49%. The problems found are due to the lack of innovative teaching materials and learning

activities that have not integrated the syntax of a particular learning model. Based on the results of the analysis found gaps regarding learning activities, it is necessary to develop an e-module based on socio-scientific problems assisted by QR Code to improve the scientific literacy of students of SMAN 1 Kepanjen.

The required resources include human resources and learning facilities. The human resources needed are validators to validate the developed e-module, namely: expert validators of teaching materials, learning devices, materials, and assessments namely Drs. H. Triastono Imam Prasetyo. M.Pd. and field practitioner validator (teacher) namely Umu Halimah, M.Pd. The facilities needed in this research and development include: gadget (laptop or smartphone), Microsoft Office, Canva, QR Code generator, heyzine.com website, classroom, LCD and projector, and whiteboard.

3.2 Design

The design stage is carried out after knowing the problems in learning activities based on the results of the analysis which is used as a reference in determining research solutions, so that the specifications of the e-module product functions developed are obtained. The design stage includes various stages, namely: compiling a list of tasks, compiling performance objectives, and creating an assessment strategy. The results of the design stage are described as follows.

The preparation of the task list aims to determine the performance plan needed in developing the e-module, which includes: e-module design draft, validation sheet, student response questionnaire, scientific literacy test sheet, learning tools in the form of learning objectives flow (ATP) and teaching modules, and learning implementation observation sheet.

The E-Module developed is adjusted to the learning model, competencies to be achieved, and other teaching media used in learning activities on Ecosystem material. The learning model chosen is a socio-scientific problem-based learning model, the competencies to be achieved are scientific literacy, and the teaching media applied are QR codes. The addition of QR Code facilities embedded in the e-module can help students access contextual information and make learning more practical and is one of the means of technological innovation in learning. QR Code can be used as a container for information in the form of websites, articles, images, videos, materials, competency tests, and feedback. Cahyadi [28] stated that e-modules equipped with audio, visuals, links, and QR codes can improve student understanding and create learning situations that are not boring, so that they can increase student learning motivation. The Ecosystem material presented in the e-module is adjusted to the material indicators that students must master based on the Learning Outcomes (CP) including discussing: Ecosystem Components and Interactions between Components and Ecosystem Problems.

3.3 Development

The development stage in the ADDIE model contains product design realization activities, in this study what is meant is teaching materials. The develop step in this study includes: generating content, selecting or developing supporting media, developing learning instructions for students and teachers, and conducting formative revisions. The

e-module developed in this research refers to the guidelines for writing e-modules from Kemendikbud [29]. The e-module is made using Microsoft Word 2013 for the contents, the e-module cover is made using Canva, and the QR Code is made using the QR Code Generator Website, after all parts are put together it will be converted into pdf format and then converted into a flip book form through the hyzine.com Website. The E-Module contains content and several learning activities on Ecosystem material which also contains the latest and relevant socio-scientific issues to find solutions by students, so that it is expected to have an impact on increasing students' scientific literacy.According to Faridah [30], the content and learning activities contained in the e-module are based on up-to-date and relevant sources. Up-to-date and relevant teaching materials play an important role in learning activities, so as to realize a quality learning process and be able to improve students' understanding of a concept [31]. The results of e-module development can be seen in.

The e-module that has been developed is tested for validity and practicality by several experts so that data is obtained in the form of validity and practicality results which are used as a reference in carrying out formative revisions to improve the quality of the e-module and ready to proceed to the next stage. The level of validity and practicality of the e-module was measured using a Likert scale (score 1-5), then converted based on the percentage score formula in (%), and concluded to know the category based on the instrument developed by Akbar [32]. The results of the validity and practicality tests are described as follows.

Validity Test Results. The validation data was obtained through a data collection instrument processing questionnaire scores from experts in learning devices, materials, assessments, teaching materials, and field practitioners (teachers) on e-modules. The following is a description of the data from the e-module validation results.

Validation of Learning Device Experts. Validation by learning device experts was carried out on March 13, 2023. The results of the validation of learning devices in Fig 2 show an average percentage of 98.75%, including a very valid category. Based on the results of the validation of learning device experts, it is recommended to improve the Flow of Learning Objectives (ATP) on several Learning Objectives (TP) because there are several Operational Verbs (KKO) that are not suitable so they need to be revised. TP contains the competencies that students achieve while carrying out learning activities, including attitudes, knowledge, and skills, so that to make it easier to achieve a TP, an appropriate KKO is needed [33].

The tools are prepared referring to the SSI model that integrates scientific literacy indicators in it. Learning tools act as a reference for implementing learning activities using e-modules to empower scientific literacy. According to Ardianto & Rubini [34], learning tools that use a particular learning model syntax can overcome problems that occur in learning activities, for example: low mastery of material, learning skills, learning experience problems, and problems related to interactions between students and teachers in learning.

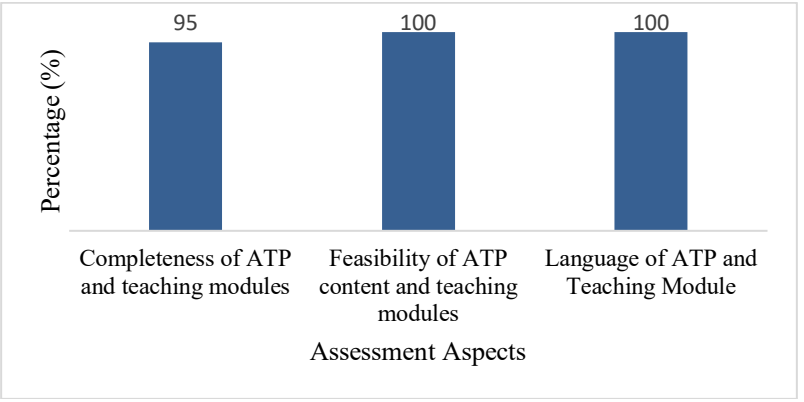

Fig 2. Recapitulation of Validation Results by Learning Device Experts

Material Expert Validation. Validation by material experts was carried out on March 13, 2023. The material validation results in Fig 3 show an average percentage of 100% and are included in the very valid category, meaning that all the material presented in the e-module is correct, complete, and in accordance with the level of high school students. Based on the results of the material expert validation, no comments or suggestions were found for the material included in the developed e-module. According to Kosasih [35], the content in the form of material in a teaching material must be in accordance with the learning objectives so that learning can be meaningful. This is in accordance with one of the characteristics of the e-module, namely self contained, meaning that students can learn as a whole a basic competency in a teaching material [36].

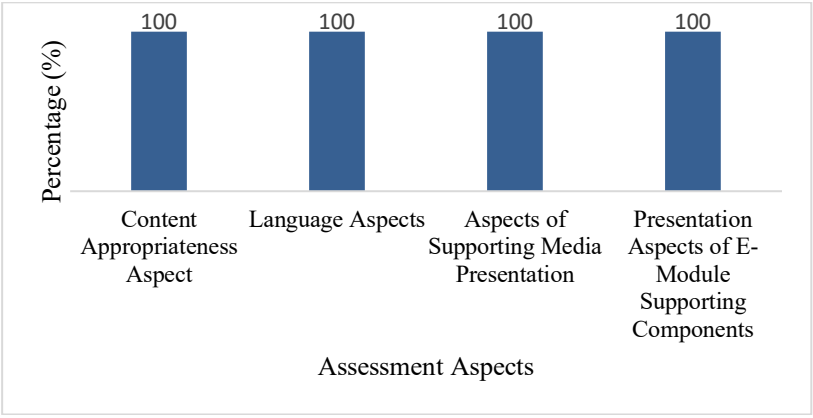

Fig 3. Recapitulation of Validation Results by Material Experts

Assessment Expert Validation. Validation by assessment experts was carried out on March 13, 2023. The results of assessment validation carried out on scientific literacy pre-test and post-test questions, LKS questions for Learning Activities 1 and Learning Activities 2, and competency tests for Learning Activities 1 and Learning Activities 2 in Fig 4 show an average percentage of 100% and are in the very valid category. Based

on the results of the assessment expert validation, no comments or suggestions were found for the assessment included in the e-module. The questions in the e-module are arranged based on the question indicators developed from the TP. The preparation of question indicators that are adjusted to the TP aims to measure the achievement of a CP [37]. CP achievement shows that students have completely mastered a material and can proceed to the next CP.

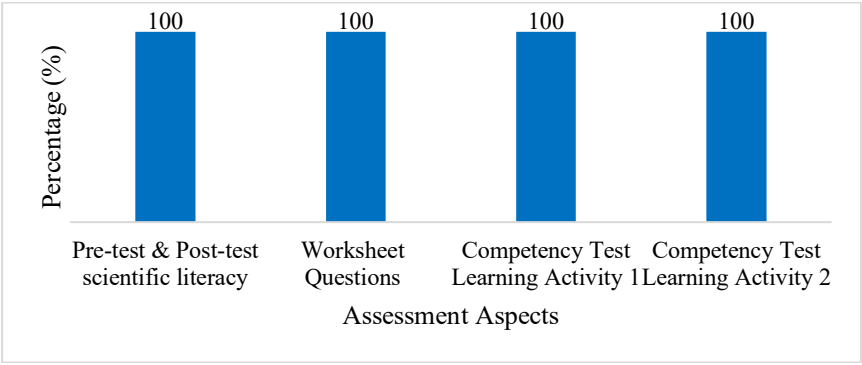

Fig 4. Recapitulation of Validation Results by Assessment Experts

Expert Validation of Teaching Materials. Validation by teaching material experts was carried out on March 13, 2023. The results of teaching material validation in Fig 5 show an average percentage of 99.5% and are in the very valid category. The developed E-Module is in accordance with several characteristics, namely: adaptive, self contained, stand alone, self instruction, and user friendly [38]. The adaptive aspect has been fulfilled because the e-module is in accordance with the development of science and technology that is all digital, especially through the QR Code contained in the e-module and in accordance with the habits of students in using gadgets during learning activities. The self contained aspect is fulfilled because the learning material has been packaged in a complete and complete unit to achieve a CP by paying attention to a clear and correct systematic according to the scientific hierarchy. The stand alone aspect is fulfilled because the developed e-module is equipped with various learning resources in the form of websites, videos, and images to support students in learning Ecosystem material. The self-instruction aspect is fulfilled because the e-module has been arranged systematically and in detail because it contains several essential components in learning activities, which include: concept maps, learning objectives, complete, and relevant material descriptions, worksheets, competency tests, assessment instruments that allow students to carry out self-assessment, and there is feedback on self-assessment carried out by students, so that e-modules help students learn independently. The user friendly aspect is fulfilled because the e-module has been adapted to the interests and needs of students in learning activities, namely not dominated by reading text, provided learning video features, interesting animations and illustrations to clarify concepts, use simple and easy-to-understand language, and navigation features that are easy to operate and understand by students.

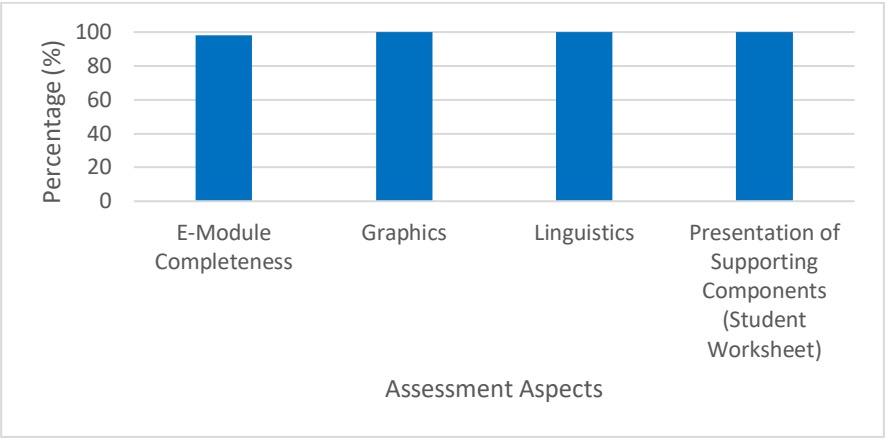

Fig 5. Recapitulation of Validation Results by Teaching Material Experts

Field Practitioner Validation (Teacher). Validation by field practitioners was carried out on March 15, 2023. The results of the validation of field practitioners (teachers) in Fig 6 show an average percentage of 96% with a very valid category. Suggestions for improvement given by field practitioners are the addition of character education aspects in the e-module. Character education originating from Pancasila values is an important part of the implementation of the Merdeka Curriculum [39]. Character education for the Pancasila Student Profile in school students must be considered in order to form a noble moral foundation for students. The integration of Pancasila Student Profile character education aims to make students have an awareness of the importance of Pancasila values and have a commitment to do good in everyday life and at the next level of education [40].

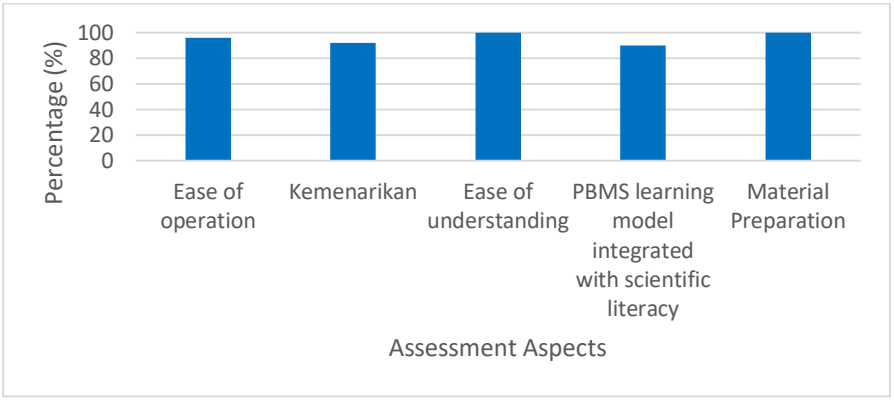

Fig 6. Recapitulation of Validation Results by Field Practitioners (Teachers)

Practicality Test Results. The practicality test was conducted on March 17 to April 4, 2023 to determine the level of ease of operation, attractiveness, graphics, and ease of understanding of the developed e-module. The practicality test was carried out on stu-

dents who had studied Ecosystem material and on students who had never taken Ecosystem material and teachers through filling out a practicality questionnaire after using the e-module. At the practicality test stage, no learning activities were carried out, only explaining the contents of the e-module and filling out the practicality response questionnaire. Referring to Branch [41], the practicality test stage consists of several activities, namely: one to one trial, small group trial, field trial, and pilot test. Data from the practicality test results at each stage are used as a reference in carrying out formative revisions, so that they can be continued at each stage of the practicality test.

Based on several stages of the practicality test in Fig 7, the average practicality test results were 93% and indicated that the e-module developed was in the very practical category. The level of practicality of the e-module in the very practical category correlates with an increase in the percentage of practicality test results at each stage. The increase in practicality test results is partly due to formative revision activities at each stage based on comments and suggestions for improvement from respondents, so as to obtain results in the form of improving the quality of the e-module developed [42].

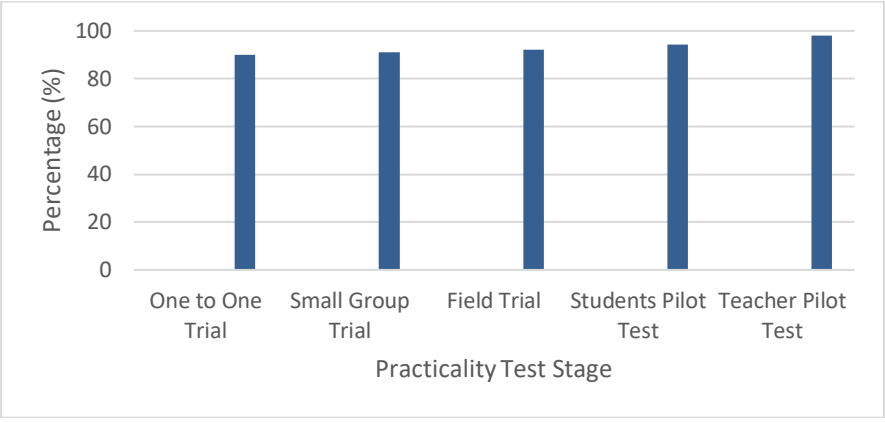

Fig 7. Recapitulation of Practicality Test Results

There are comments and suggestions for improvement obtained from the results of the practicality test, one of which is related to the discovery of typos in several parts of the e-module. Referring to Lathifah & Susilo [43], a good teaching material is indicated based on linguistic aspects. The writing aspect is related to the language aspect, both of which determine the ease of users in understanding the e-module. Errors in spelling or writing can interfere with the learning communication process conveyed through the content contained in teaching materials, therefore there needs to be a checking stage so that the teaching materials developed minimize spelling or writing errors [44].

Students provided suggestions or improvements to several e-module components, such as: adding hyperlinks to the table of contents, adding a list of images, and summaries in each learning activity. The table of contents is an important part of a document that is located at the beginning of the page. The table of contents is organized systematically and presents an overview of the content or material contained in a teaching material [45]. According to Imaningtyas [46], the purpose of adding hyperlinks to each point in the table of contents aims to make it easier for students to navigate and access the material. In addition to the table of contents, at the beginning of the e-module there

is also a list of images that function to provide a sequence of images contained on a page, making it easier for e-module users to find the position of the image they want to go to [47]. The summary is located at the end after the presentation of the material. According to Agustine, et al [48], a summary given at the end of a book can provide opportunities for students to review important ideas or concepts about the material that has been learned.

3.4 Implement

The implementation stage is carried out by teaching the SSI e-module that has been developed to students who have never taken Ecosystem material, namely to 36 students in class X-2. The implementation stage was held on April 5 to May 3, 2023. This stage aims to determine the effectiveness of the e-module based on the increase in students' scientific literacy after learning by using the e-module. According to Branch [49], there are two main activities in the implementation stage, namely: preparing teachers and preparing students which are described as follows.

Researchers act as teachers who teach e-modules based on the components that have been prepared in the form of ATP, teaching modules, and e-modules. Scientific literacy is empowered through learning activities using the SSI model carried out four times a meeting (two SSI model learning cycles). The first and second meetings students learned about Ecosystem Components and Interactions between Components with two socio-scientific issues. The issue of "The Massive Stocking of Catfish in the Mataram Sewer can Disrupt the Ecosystem" was done by odd group students, while the issue of "Rice Fields Threatened with Harvest Failure Due to Rat Pest Attack" was done by even groups. Issues The third and fourth meeting students learned about Problems in Ecosystems with a socio-scientific issue in the form of "The Impact of IKN Development on the Coastal Pesut Population of the Mahakam River".

The SSI model used in the e-module can facilitate and familiarize students in taking real-life experiences or simulations and applying their knowledge to take appropriate action on problems in their environment, thus helping to develop their scientific literacy [50]. Through socio-scientific problem-based learning, during field investigation activities students are directed to conduct investigations and collect data through interviews with catfish farmers or farmers. Direct field investigation activities can increase students' learning motivation and curiosity in solving social problems through consideration of science concepts, with attention to positive impacts on social, environmental, economic and science. SSI allows students to take real-life experiences or simulations and become independent learners, thus improving students' skills to solve problems in accordance with learning objectives and familiarizing students in applying their knowledge to take appropriate action on problems in their environment [51]. SSI also facilitates students to learn and develop scientific literacy indicators such as: explaining phenomena scientifically, designing and evaluating scientific investigations, and interpreting data and evidence scientifically [52].

During learning activities, students look enthusiastic and motivated in learning ecosystem material using e-modules based on socio-scientific problems assisted by QR Code that has been developed, in this case students feel facilitated and easy to understand the material through learning resources contained in the QR Code. The use of e-

modules in learning activities can help students learn independently [53]. Student independence can be seen when learning activities take place, students' dependence on the teacher begins to decrease, because each student is able to access the material that is the subject of discussion independently and is free to repeat the explanation if they feel they have not understood a concept. The QR Code contained in the developed e-module is intended as an information container to facilitate students in accessing learning videos, materials, character education content, biological facts, learning evaluations, collecting worksheets, pre-test and post-test, and carrying out self-assessment.

3.5 Evaluate

The evaluation stage is carried out to assess the results of the learning process using the developed e-module, so that a conclusion can be made about the quality of the e-module that has been developed. The results of the evaluation stage included in the form of data from the test results of the effect of using the e-module developed on scientific literacy and the implementation of the learning process using the SSI model.

The effectiveness of using e-modules to improve students' scientific literacy is known based on the results of the N-Gain analysis. Based on the N-Gain calculation, the result is 0.66, meaning that the effectiveness of the e-module to improve students' scientific literacy is included in the moderate category. According to Sudjana [54], the effectiveness of the teaching materials developed is declared theoretically feasible if the average assessment is $0.30 \leq g \leq 0.70$.

Test data were used to determine the effect of using e-modules on students' scientific literacy obtained based on the results of the pre-test and post-test. The test results show that after the use of the e-module, there was an increase in students' scientific literacy in each indicator with the indicator that experienced the highest increase, namely interpreting data and scientific evidence by 91% while the indicator that experienced the lowest increase was designing and evaluating scientific investigations by 77% Fig 8. The overall average of students' scientific literacy increased by 31% Fig 9. After using the e-module, the average scientific literacy was 85% which indicates that students' scientific literacy is in the high category. The results of research conducted by Irwansyah, et al., [55], show that the use of e-modules by adopting problem-based learning is able to facilitate the development of critical thinking skills and student motivation including scientific literacy, when compared to conventional learning, so it is feasible to use in learning.

Indicators of explaining scientific phenomena are developed in the orient students to problems and hypotheses phase through activities to identify phenomena, formulate questions and hypotheses about the problems presented. During learning activities, students are directed to find and understand in detail the phenomena regarding the socioscientific issues presented, so that students can define problems and organize the investigation process. Furthermore, students are directed to offer appropriate hypotheses to be examined later in the field investigation stage. Based on the research results, the indicator of explaining the phenomenon scientifically shows a percentage of 87% which is classified as a very high category. According to Rahrdjo, et al [56], problem-based learning can place problems as the starting point of learning, so that students learn and try to explore to explain the problems or phenomena presented and develop scientific thinking skills.

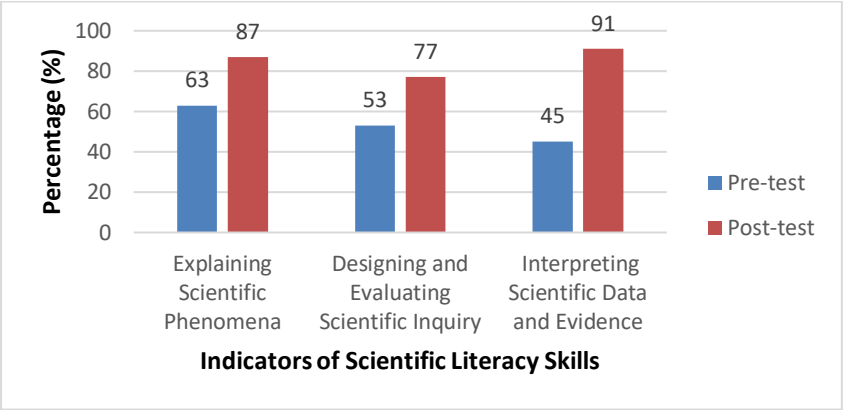

Fig 8. Summary of Scientific Literacy Score on Each Indicator

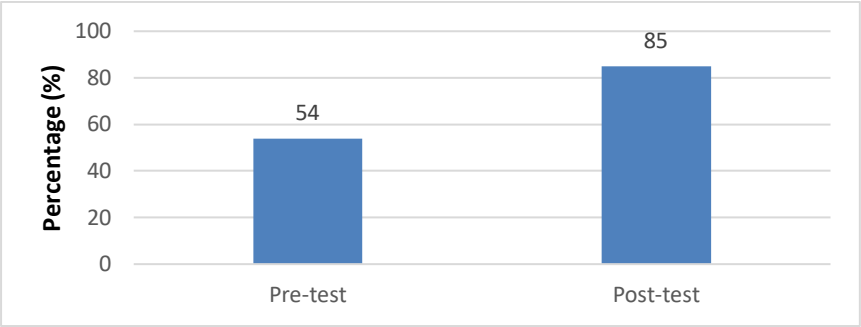

Fig 9. Summary of Comparison of Pre-test and Post-test Results of Students' Scientific Literacy

The QR Code listed in the organize students to study phase is intended to help students improve scientific literacy. The QR Code plays a role in providing references and helping students to get learning resources to support their understanding of concepts before being ready to carry out investigative activities in the field. The QR Code available on the e-module is connected to a learning resource link which is expected to facilitate learning activities to understand a science concept on Ecosystem material. Based on research conducted by Savitri, et al., [57], the use of QR Code as a learning media makes students motivated to develop their scientific literacy because QR Code is able to collect various teaching materials and resources in one container so that students have a clear picture of the problem and have the desire to solve the problem.

Indicators of designing and evaluating scientific inquiry are developed through the doing investigation phase. Students are directed to design an investigation framework in the form of a mind map that contains: the main problem, the possible causes of the problem, the possible consequences if it is not resolved or found a solution, and alternative solutions in terms of science, social, economic, and environmental. In the next stage, students are directed to conduct interviews in accordance with the instructions presented in the e-module to test several alternative solutions that they have offered.

After obtaining data in the field, students are directed to conduct discussions to analyze and evaluate problem solving data to conclude the most efficient solution. Based on the research results, the indicator of designing and evaluating scientific investigations shows a percentage of 77% which is classified as a high category. The learning process based on socio-scientific issues is suitable for training scientific literacy skills because it can be used as a link to real problems in society and stimulate students to think at a higher level. Students are ultimately able to design scientific investigations, assess their impact, and make decisions regarding appropriate actions to address existing problems [58]. Scientific literacy empowered through socio-scientific issues effectively improves students' understanding of science in various contexts, argumentation skills, empathy, and moral reasoning [59].

Indicators of interpreting data and scientific evidence are developed in the develop and present the work phase. Indicators of scientific literacy are measured through students' ability to formulate explanations about the data from interviews in the field and find conclusions in the form of scientific concepts based on evidence from the results of the investigation. Students are directed to communicate the results of the investigation carried out through presentations in front of the class by exchanging ideas or feedback between groups and teachers. This also shows students' mastery of the topic of investigation that they have carried out. Based on the research results, the indicator of interpreting data and scientific evidence shows a percentage of 91% which is classified as a very high category. According to Imaningtyas, et al. [60], socio-scientific problem-based learning connects phenomena and knowledge possessed by students, so that students are trained to have the ability to analyze the information collected and establish causal relationships to determine various possible solutions to problems.

The e-module product developed contains learning activities using the SSI model. The e-module is designed to create student-centered learning activities. The implementation of Socio-scientific Problem-Based Learning is obtained based on the results of observations of learning implementation by observers. Observation of learning implementation shows a result of 98% and indicates that SSI learning activities are very well implemented, so it can be concluded that learning activities are carried out in accordance with the teaching module that has been prepared in Table 2. When learning activities take place, the teacher acts as a facilitator who assists in checking the results of the formulation of problems and hypotheses made by students, monitoring student investigation activities, and facilitating students if they have problems in operating the e-module.

Table 2. Summary of Learning Implementation Observation Results

Meeting	Score Each Activity					Score		Score Percentage (%)	Description
	Phase I	Phase II	PhaseIII	Phase IV	Phase V	ΣX	ΣXi		
I-II	14	34	19	5	10	83	85	98	Very good
III-IV	14	34	20	5	9	83	85	98	Very good
Overall average								98	Very good

Description:
ΣX = Total score obtained
ΣXi = Total ideal score

Suggestions for Product Utilization and Development. The developed E-Module aims to facilitate student learning activities, so it is expected to be able to facilitate students in learning the material presented. Presented a variety of interesting illustrations to add aesthetics and attract students' interest in learning Ecosystem material. The benefits of the e-module developed in this study, namely: training students to learn and find concepts of Ecosystem material independently, helping students achieve CP and TP on Ecosystem material, alternative teaching materials to overcome library shortages, a place to increase students' scientific literacy.

The advantages of the developed e-module are: e-module has gone through the validation stage so that it is suitable for learning in schools, e-module is arranged according to SSI syntax so that it is suitable for learning using the Merdeka Curriculum, the existence of socio-scientific issues regarding Ecosystem problems spurs students' interest in learning because students are directed to carry out problem solving by direct investigation through interview activities in the field, e-modules are packaged in electronic form accompanied by QR codes and links that can be shared and accessed flexibly and independently by students, e-modules contain illustrations and interesting features such as biological facts (Fabi) and character education Pancasila Student Profile (Peka), and e-modules are equipped with links presented in the form of QR codes aimed at making it easier for students to access information, learning videos, materials, pre-test and post-test, learning evaluation, collection of worksheets, and implementation of self-assessment.

The shortcomings of the developed e-module are: the material is limited to Ecosystems, only implemented in one class, need to adjust the characteristics of the e-module if it will be developed in different schools because the e-module developed is only tailored to the needs and characteristics of SMAN 1 Kepanjen students, and a stable network is needed in order to access the e-module without constraints.

4 Conclusion

Based on the results of research and development of e-modules based on socio-scientific problems assisted by QR Code can improve the scientific literacy of class X students of SMAN 1 Kepanjen which is indicated based on the increase in the percentage of students' pre-test and post-test scores by 31%. The results of the validation test obtained through data collection instruments in the form of processing questionnaire scores from learning device experts, materials, assessments, teaching materials, and field practitioners (teachers) on the e-module that has been developed sequentially, namely: 98.75%, 100%, 100%, 99.5%, 95% which are classified as very valid. The practicality test results showed an average of 93% which was classified as very practical. The e-module effectiveness data obtained from the implementation stage is 0.66 which indicates that the e-module has a moderate level of effectiveness. The use of e-modules is able to improve students' scientific literacy with an average of 85% which is in the high category. The results of the observation of the implementation of the PBMS model showed an average score of 98% which included a very well implemented category. Based on the research data, the Ecosystem E-Module based on Socio-scientific Problems assisted by QR Code is valid, practical, and effective to enhancing the

scientific literacy of class X students of SMAN 1 Kepanjen, so it can be applied in learning activities.

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