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The Validity of IPAS Module based on STEM to Improve Students' Scientific Literacy Skills

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ABSTRACT

Objective: This study describes the validity of based inquiry change textbooks used to train students' scientific literacy skills. The validity of the developed inquiry-based textbooks is viewed from the aspects of content feasibility, presentation feasibility, linguistic feasibility, inquiry suitability, and scientific literacy. **Method:** This study used the development of the 4D model (define, design, and develop), which was modified and implemented in the Science Education Postgraduate Program at Surabaya State University. The data collection technique was carried out using the textbook validation method. The assessment instrument used was a textbook validation sheet that two chemistry lecturers validated as validators. Data analysis was carried out quantitatively and descriptively. **Results:** The research results are in the form of validation of STEM-based textbooks, with an average score of 91.20% in the very valid category. **Novelty:** The novelty of this research is that there are STEM-based features in textbooks about change that can improve students' scientific literacy skills. Based on the data analysis, the developed inquiry-based textbooks are valid and suitable for learning.

INTRODUCTION

The government is shifting from teacher-centered education to student-centered through the Independent Curriculum. The independent curriculum provides flexibility for educators to create quality learning that suits the needs and learning environment of students. Currently, the Merdeka Curriculum teaching module is considered a tool crucial for the smooth implementation of learning with a new mode or paradigm, mainly when it is associated with the transformation of the industrial and digital revolutions. The Independent Curriculum teaching module refers to several media tools or facilities, methods, instructions, and guidelines designed in a systematic, engaging, and specific way according to the needs of students. The teaching module implements the Learning Objective Flow (LOF) developed from Learning Outcomes (LO) with the Pancasila Student Profile as the target. Teaching modules are arranged according to the phases or stages of student development. The teaching module also considers what will be learned with clear learning objectives. Of course, its development base is also long-term oriented. Teachers also need to know and understand the concept of teaching modules to make the learning process more exciting and meaningful. Related to this, I developed the independent curriculum teaching module. The Natural and Social Sciences Teaching Module (TNSSTM) is one of the new subjects included in group C at the vocational education level and is only given in phase E in class X. The TNSSTM Project subjects integrate social sciences and natural sciences. The TNSSTM Project subjects function to equip students to be able to solve real-life problems in the 21st century that are related to natural and social phenomena around them scientifically by

applying scientific concepts (Lytra & Drigas, 2021; Prahani et al., 2020; Saphira et al., 2023; Suprapto & Ku, 2019; Zayyinah et al., 2022).

Scientific literacy can be defined as a person's ability to solve problems in everyday life so that various problems that develop can be solved scientifically and based on data and scientific evidence. The level of scientific literacy of students can be seen from several indicators, including the ability to explain scientific phenomena, evaluate and design scientific discoveries, and be able to interpret data and scientific evidence (OECD, 2017). Scientific literacy skills are one of the skills that can answer the demands of education in the 21st century, which include life and career skills, information technology and media skills, as well as learning and innovation skills, which are divided into critical thinking, problem-solving, communication, collaboration and creative. Emphasis on the skills above needs to be done to lead students to be trained and have thinking and learning skills to compete in the global era. Several skills must be possessed by students in 21st-century education, namely critical thinking, communication, collaboration, and creativity, or what is known as the 4C (Sugiharto, 2020). These skills are essential so that students are ready and able to keep up with the demands of the times and achieve one of the goals of 21st-century education, which is to increase students' scientific literacy skills (Saraswati, 2021), in line with Simmamora (2020), which states that scientific literacy skills are one of the skills needed by students to deal with every aspect of global life in the 21st century (Susetyadi et al., 2018).

Students with scientific literacy skills can use scientific knowledge, identify questions, and draw conclusions based on facts about issues related to nature and technology through their activities. Students can solve problems using scientific concepts obtained in the educational aspect to be creative in creating technology so that students can make the right decisions in solving problems (Saraswati, 2021)—mastery score. One way to train scientific literacy can be done through inquiry-based textbooks, in line with Hanum's (2021) statement that using the guided inquiry learning model can improve the science literacy skills of tenth-grade high school students. In addition, guided inquiry applications can also improve long-term memory, critical and creative thinking skills, motivation to learn science, and cognitive learning outcomes in science (Oktaviani et al., 2018). Students require problem-solving abilities in order to solve problems that arise in their lives (Mulyani, 2021). Presentation of contextual problems through the learning process can also be one way to train students' scientific literacy (Afriana, 2022).

STEM learning involves interdisciplinary, authentic, and contextual knowledge, that is, science, technology, engineering, and mathematics (Holmlund et al. 2018). One of the teaching modules that can be developed is the STEM-based science teaching module to increase scientific literacy, which can be applied in learning through material that can relate to real life and is linked to information so that students are encouraged to dig deeper into information (Amahoroe et al., 2020; Asih et al., 2020; Bashooir & Supahar, 2018). One of the materials in science learning that is suitable to be developed in this STEM-based Module is Substance and Change material. Based on this description, researchers are trying to develop STEM-based Teaching Modules to improve students' scientific literacy.

RESEARCH METHOD

The STEM module on STEM-based substance and change materials increases scientific literacy developed using the Borg & Gall (2007) model (Analysis, Design, Development,

Implementation, and Evaluation). Based on the results of the evaluation, the Module was revised in such a way as to meet the needs that needed to be optimally achieved after the implementation process. Presentation of modules that integrate STEM and focus on one object related to matter, substance, and change. The selection of the Borg & Gall model in this development is based on clear steps from start to finish. The learning was applied in a limited way with a purposive sampling technique to obtain heterogeneous students. The study's trial design was a pre-experiment (one group pretest-posttest design). This study aimed to produce a Module-based STEM to train high school students to improve science literacy skills that are valid and theoretically feasible. This Module can be used as a substance change of TNSSTM for class X Vocational High School. Textbook development will be done in December 2022 at the Surabaya State University Postgraduate Program.

The Modules developed are STEM-based textbooks that are validated based on content feasibility, presentation feasibility, linguistic feasibility, and suitability with skills literacy science with learning inquiry. The Module was then reviewed and validated by two validators (Choiria et al., 2019). The research objective of developing STEM-based teaching modules was to increase the scientific literacy of class X students of Vocational High School ITABA Sidoarjo. As many as 36 students were randomly selected. The data obtained are test results (pre and post-test), and student responses after using the teaching modules used for trials have been reviewed, revised based on the validator's suggestions, and declared valid to be used based on the validator's assessment.

Instrument and Procedures

The types of instruments used in this study were STEM-based teaching module validation instruments, scientific literacy skill test instruments, and student response questionnaires after using the developed teaching modules. The scientific literacy skills test is prepared based on indicators of scientific literacy consisting of (a) explaining scientific phenomena, (b) evaluating and designing scientific investigations, and (c) interpreting data and evidence. The form of the test is an essay with nine questions. In comparison, the student response questionnaire consists of 20 questions consisting of aspects of content, appearance, and language of the teaching modules. The theoretical feasibility data collection technique uses the review and validation method. The research instrument used in this study was a module validation sheet. The eligibility of the Module will be measured based on the assessment by two (two) validators on validation sheets consisting of media expert lecturers and subject matter expert lecturers. The validation assessment sheet starts from 1 to 4. A module is declared valid with a minimum average value of 2.6. The module validation procedure starts with problem analysis, gathering information, preparation, and module validation by the validator.

Data Analysis

The data analysis technique used in this study is descriptive quantitative, presenting research results based on the data obtained. Feasibility analysis on interactive e-books, namely validation analysis and analysis of student response results. The validity assessment by experts was obtained by calculating the average score for each eligibility criterion and the overall average score in percentage form. It is said to be valid if the percentage is ≥ 70.00% with the correct interpretation and is very feasible according to

the Likert scale. Data analysis of module validation results was carried out by calculating the average value obtained from validators one and 2 to determine the quality of the teaching modules developed, as shown in Table 1.

Table 1. Criteria for data validation.

Average Score	Category
1.00 – 1.75	Less Valid
1.76 – 2.50	Quite Valid
2.60 – 3.25	Valid
3.26 – 4.00	Verry Valid

(Adapted from Ridwan, 2013)

The reliability of learning devices is valid if the reliability value is 0.60 or 60.00% (Prahani et al., 2020). After obtaining the results of the textbook validity value, its reliability will be calculated. The percentage of textbook reliability is calculated using the formula:

$$R= (1- (A-B)/(A+B)) \times 100\%$$

Information:
R: Reliability of the instrument (Percentage of Agreement)
A: A higher score than the validator
B: Lower score than the validator

RESULTS AND DISCUSSION

Results

The research results are in the form of validation of STEM-based Modules that the Unesa Chemistry lecturer has reviewed as a validator. The components of the validation assessment are validating aspects of content eligibility, presentation eligibility aspects, language feasibility aspects, conformity aspects with inquiry, and suitability aspects with scientific literacy. The recap of the results of the module validation on the material substance and the changes developed are presented in Table 2.

Table 2. Validation results of STEM-based teaching modules to increase students' scientific literacy.

No	Aspects	Rating Score			Average	Category
		Validator 1	Validator 2	Validator 3		
1.	Organization of Module/Content	3.42	3.21	3.78	3.47	Very Valid
2.	Concept elaboration	3.80	3.60	3.80	3.73	Very Valid
3.	Appearance	3.75	3.25	3.75	3.58	Very Valid
Validation Average Score					3.60	Very Valid
Percentage of agreement					91.20%	Reliable

Based on the recapitulation of interactive e-book validation results (shown in Table 3), it can be seen that the average value on the eligibility aspect of the content is 3.47; on the aspect of elaborating the concept of material is 3.73, and on the display aspect is 3.58. Scores on each aspect indicate very valid criteria. The average results of the three

aspects are also in the very valid category with an average score of 3.60; besides that, the percentage of approval from the validation results shows a value of 91.20%, which means that the developed teaching modules can be tested. Based on the results of the validation, what has been developed is valid and reliable for use in learning based on the results of the validator.

The results of validating the student's scientific literacy tests include aspects of the material, construction, and language domains. This product trial uses a one-group pretest-posttest design, namely research conducted by looking at differences in pretest and posttest. The test is used to collect data through scientific literacy tests in the form of essay questions. Before the test was used, the scientific literacy skills test items were first validated by two expert lecturers and one teacher. The validation results of the scientific literacy skills test can be seen in Table 3.

Table 3. Validation results of scientific literacy test questions by the validator.

Aspects	Validator
Theory	3.43
Construct	3.51
Language	3.43
Average	3.45
Category	Valid

The results of the validation of the scientific literacy tests, both pretest and posttest, get a score of 3.45 so that the scientific literacy skills test can be declared valid and can be used to measure increases in scientific literacy in learning. Practicality of teaching modules: All learning activities using STEM-based Teaching Modules can be applied when teachers introduce new knowledge and skills. Two observers carried out observations on the implementation of lesson plans in learning. Observations were made at two meetings, meeting I on the effects of greenhouse gases and meeting II studying the impact of global warming and its solutions. The average observer assessment at meeting I was 3.20, with a percentage of agreement between observers of 94%. The average assessment of the two observations at meeting II was 3.40, with a percentage of agreement between observers of 88.70%. The implementation of all activities is also accompanied by time management and a well-conditioned class atmosphere. High student activity during learning shows that learning is student-centered. Students can find their concepts, as in Ausubel's meaningful learning theory, which emphasizes the importance of students associating new experiences, phenomena, and facts into the system of understanding that students have. Teaching that supports students discovers essential concepts in learning and can be retained in students' minds for longer. This is to the information processing theory that active student involvement in learning causes information to be stored in long-term memory.

Discussion

Identification is done by providing an online questionnaire to relevant student respondents regarding the teaching modules used. There 89.00% of respondents who stated that they did not know about STEM-based teaching modules, and 78.00% had inferior literacy skills. In this research, there are learning outcomes that must be met, namely, student's ability to face problems in their surroundings and future life, the ability to relate learning concepts to everyday life, and the ability to increase students' scientific literacy.

The module developed is a STEM-based learning module on substance and change material to increase scientific literacy. Scientific literacy indicators, Module Features, mini projects, Substance and Change Chapter Material, Summary, Concept Map, Bibliography, and Glossary. The material contained in this textbook consists of 4 sub-chapters, namely material classification, material properties, chemical changes and physical changes, and mixture separation applications. Figure 1 displays the cover section of the developed Science Module.

Figure 1. Teaching module display.

STEM-based science teaching module developed based on scientific literacy, this Module is aimed at increasing students' scientific literacy. Therefore, the teaching modules developed have various features in module presentation activities that can stimulate the achievement of scientific literacy indicators in *STEM*-based student worksheet display in Figure 2. STEM-based student worksheet displays improve students' ability to work on and obtain information and work with their groups to find problems in the student worksheet. The student worksheet provides information and phenomena in life so students can provide simple solutions related to everyday life. One example that illustrates that learning is information processing is a STEM-based science inquiry design (Rusyati et al., 2019; Sugianto et al., 2018).

The initial stage begins with selecting a topic, namely whether there are natural events around where the student lives that are appropriate to the topic the student will study (Erman et al., 2020). These events should be taken that can confuse students at the beginning of learning. Learning begins with symptoms that allow conflicts in students' reasoning to emerge; students will analyze and critically solve problems by looking for various sources and applications in this student worksheet. According to UNESCO, educational trends in the 21st century contain four main pillars, namely: (1). Learning to

know, (2) Learning to do, (3). Learning to live together, (4). They are learning to be. This is in line with the demands of the curriculum, which must be developed based on the principles: (1) centered on the potential, development, needs, and interests of students and their environment, (2) diverse and integrated, (3) responsive to developments in science, technology, and art (4) relevant to life's needs (5) comprehensive and sustainable (6) lifelong learning (7) balanced between national interests and regional interests. Piaget found that Cognitive development largely depends on how far the child will actively interact with the environment. Presentation of knowledge will encourage students to discover their knowledge. This is done through inquiry interaction guided in class.

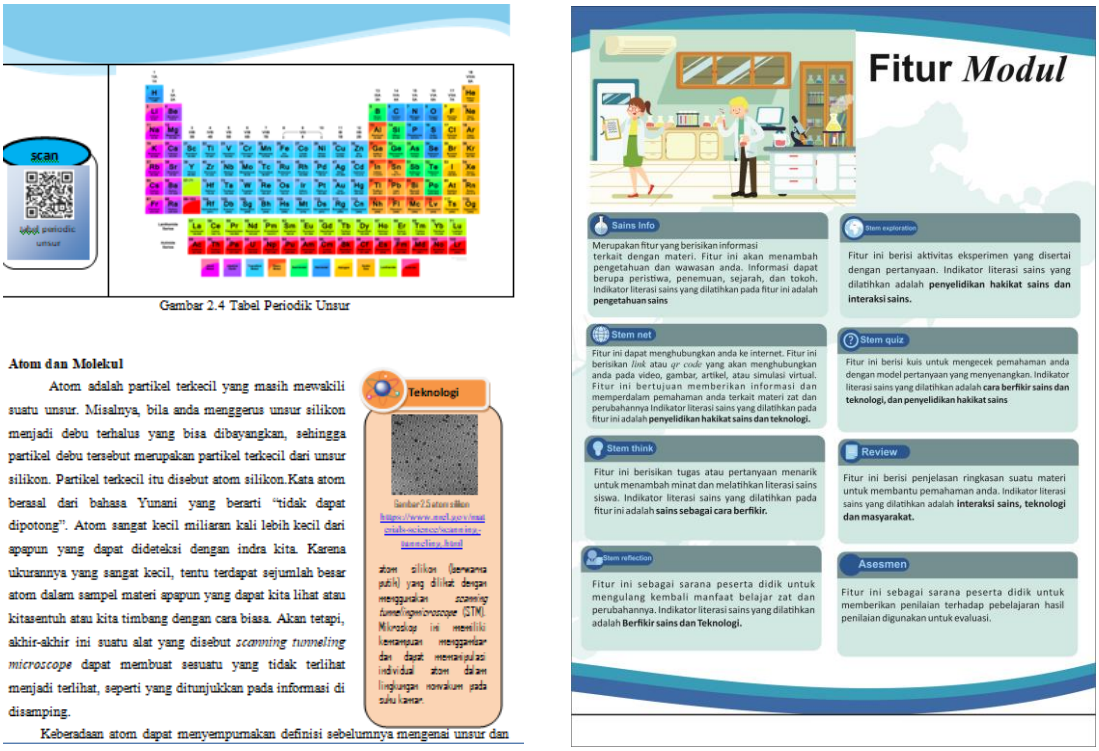

Figure 2. STEM-based modules and scientific literacy indicator features.

Some of the features contained in this Module are science info, stem net, STEM think, STEM reflection, STEM explore, stem quiz, review, assessment, and mind map. The following is presented in Table 4, which shows the relationship between each feature and aspect of students' creative thinking skills.

Table 4. STEM Module features to train scientific literacy skills.

Modul STEM	Description	Scientific Literacy
Sains Info	Features that contain material and phenomena in life	Science Knowledge
STEM net	This feature contains a link or QR code that links to images, videos, and articles in learning.	Scientific inquiry and evidence
Mini Projects	This feature contains simple STEM experiments to hone students' scientific literacy skills.	Evaluate and design experiments
Sains Mind Map	It contains student activities to make a mind	Science Knowledge

Modul STEM	Description	Scientific Literacy
	map as a summary of all the material that has been studied and develop conceptual understanding.	

In addition to the features in Table 2, some quizzes contain questions or problems that require relevant solutions or answers and are done by students within the time limit. A quiz is a form of students' understanding of each sub-chapter and is proof that students have read and carried out activities in the teaching modules that have been developed. During the development and validation stages, several changes and improvements were made to produce STEM-based science teaching modules to improve students' scientific literacy, which is better and feasible to use based on the results of reviews and suggestions from expert lecturer validators (Fitriansyah, 2021; Flores, 2017). Based on the review conducted by the validator, there are several suggestions and input for improving this teaching module, including reading content from adding a module cover, the answer key to the problem formulation is still not quite right, making a STEM concept map containing teaching material so that it is clear that STEM is used, and improve language in sentences that are not quite right. Based on the results of the validator's review, in addition to suggestions and input for module improvement, the results of the module validation include content feasibility, concept elaboration, and display feasibility (Gardner et al., 2019; Lestari et al., 2018).

As teachers, we must complete the targets revealed by the curriculum, society, and stakeholders to manage learning. Learning management includes four stages, namely: 1) learning program planning; 2) implementation of learning programs; 3) monitoring and evaluating the learning process; and 4) analysis of monitoring and evaluation results to be used as input in revising the learning program. Assessment of students' scientific literacy abilities is based on scientific competencies, which include identifying scientific issues, explaining scientific phenomena, and using scientific evidence. According to scientific literacy, it is the primary goal of science education. Scientific literacy refers not only to understanding the structure of science and technology but also to understanding the nature of science and technology and their relationship to society (Pratama et al., 2020; Rahayu et al., 2018; Rahmatina, 2020). It is stated that STEM learning has several benefits, namely fostering scientific literacy in students to apply evidence-based scientific knowledge in everyday life (Lutfi et al., 2018; Pangesto et al., 2017). STEM-based guided inquiry learning has the potential to improve students' scientific literacy.

CONCLUSION

Fundamental Finding: In this research, the feasibility of open STEM modules to improve students' scientific literacy skills was developed and declared suitable for use in learning—validation assessment of 91.20%. From the research conducted, it can be concluded that 1) the teaching module developed has a validity score of 3.60 in the very valid category; 2) The student scientific literacy test has a validity score of 3.45, which can be declared valid and can be used to measure scientific literacy abilities. **Implication**: The low increase in students' scientific literacy is caused by several factors, such as limited textbooks that are relevant to STEM, and students are only able to explain STEM macroscopically, not in detail. **Limitation**: This research was only developed based on STEM-based teaching modules to increase scientific literacy in substance change material. **Future Research**: STEM-based open modules will likely be

developed to improve scientific literacy skills in other materials. We hope these findings can be helpful for further research to improve students' scientific literacy.

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