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Designing a STEM Project-Based Learning Module for Scientific Literacy and Critical Thinking Elementary School Students

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Abstract. STEM education is useful for facing 21st century competition. However, the availability of STEM project-based learning (STEM-PjBL) modules for enhancing scientific literacy and critical thinking Indonesian students is still rare, especially at the elementary school level. The objective of this study is to design a STEM-PjBL module that enhances students' 21st-century skills, specifically focusing on improving their scientific literacy and critical thinking capabilities by organizing the constructs and items within the module. This study is qualitative research at the stage of designing the content of STEM-PjBL module using literature reviews and expert interviews. The acquired data underwent thematic analysis for examination. The resulting module construct includes module objectives; module structure; module content that includes STEM components; scientific literacy components, and critical thinking components; learning aids or media; and assessment in modules with accompanying items for each construct. The resulting module construct and item are used as the basis for the next stage, namely the module development stage. This study holds significance for advancing STEM education in Indonesia and serves as a valuable asset, particularly for initiatives highlighting STEM-PjBL learning activities aimed at enhancing 21st-century skills.
Keywords: STEM-PjBL module, scientific literacy, critical thinking, 21st-century skills

Introduction

In recent decades, there has been an increasing emphasis on scientific literacy as a fundamental goal of science education that is universally recognized and has been incorporated into the educational framework of many countries to drive global progress in science education (Almeida et al., 2022; Wei et al., 2021). Meanwhile, the Indonesian Ministry of Education has identified the enhancement of learning quality across all educational tiers as a strategic priority, including the endeavor to elevate the average scientific literacy score in PISA assessments. However, in Indonesia, the cultivation of this skill has not been fully realized within the science learning process (Dewi et al., 2021). Notably, the primary school science curriculum in Indonesia does not explicitly delineate the components of scientific literacy as integral elements encompassing both knowledge and procedural skills (BSKAP Kemendikbudristek, 2022).

Nevertheless, according to findings from international evaluations such as PISA and TIMSS, the outcomes remain below anticipated levels. The OECD's 2022 PISA survey results indicate that Indonesian students achieve lower scores in science compared to the OECD average, where the average OECD science score is 485 and Indonesia only achieved a score of 383 (OECD, 2023). Besides that, since the last 20 years released by PISA, the scientific literacy achievement of Indonesian students has not experienced a significant improvement, and the findings of the PISA 2022 assessment study state in Indonesia's best performing students and low performing in science is the lowest compared to reading and mathematics. For the primary school level, Indonesia was the first and last to participate in TIMSS in 2015 (Mullis et al., 2016), with the average science achievement results for students in year 4 of primary school being in the bottom 4 with a score of 397 (Nizam, 2016).

Low scientific literacy achievement can reflect a deficiency in critical thinking abilities. In the learning process, teachers do not develop high-level thinking skills and tend to memorize facts and present material in lectures. Teachers also do not provide positive stimulation to students in learning. A student's with high-level thinking skills profile can be seen through the student's ability to question something and relate it to the information received to find answers (Adriyawati et al., 2020) In PISA assessments, questions that employ higher-order thinking skills (HOTS) are utilized to gauge students' reading proficiency, mathematics, and science (Setyowati et al., 2021). HOTS include problem-solving, critical and creative thinking, and decision-making (Alkhatib, 2019).

Today, critical thinking is a non-negotiable need to face the complexity of real life problems, but some people still have a low level of ability for this ability (Suardana et al., 2018). Research conducted in Indonesia shows that Indonesian students' abilities in this regard are still lacking (Purwanto et al., 2019), compounded with the observation that the learning methods used do not effectively encourage the development of critical thinking skills (CTS). Meanwhile, analysis of textbooks in Indonesia revealed that only a number of assignments in the material promised to improve students' CTS (Solihati & Hikmat, 2018).

At the primary school level science, technology, engineering, and mathematics (STEM) should start being taught. Integrated STEM education is important for elementary schools because disinterest in science among students begins at this stage (Toma & Greca, 2018). Various research results show through STEM with PjBL strategies, students are given the opportunity to be more active in building knowledge because this learning approach has student-centered characteristics, where students make decisions and frameworks to solve problem, and collaborating to produce a product (Khurma et al., 2023; Markula & Aksela, 2022; Ummah et al., 2019). Through this approach, learning activities that were initially teacher-centered become student-centered.

Moreover, the advantages of STEM education in preparing for the challenges in the 21st century encompass fostering and nurturing critical thinking in students from a young age, alongside promoting scientific literacy as a foundational skill for the modern era (Chambers et al., 2019; Ijirana et al., 2022). The integration of STEM into project based learning (PjBL) has been associated with positive outcomes, including enhanced academic achievement, a greater sense of autonomy, and improved emotional awareness among students (Rizki & Suprapto, 2024). Previous studies have aimed to develop science curricula centered on the engineering process and scientific inquiry (Pekbay, 2023; Yata et al., 2020). These components can form the basis of STEM education frameworks, and research has explored different instructional approaches.

Presently, Indonesia has introduced a novel curriculum named the merdeka curriculum and promoting independent thinking among students and urging teachers to transition from conventional to modern educational approach. Significantly, the merdeka curriculum deviates from its precursor by prioritizing PjBL (Purnomo et al., 2023). These projects are designed to instill in students 21st-century skills aligned with the nation's unique characteristics. As a result, teachers must improve their teaching and professional skills necessary to successfully execute the curriculum (Umar et al., 2023). In the curriculum, teachers are also given the freedom to develop their own learning plans or learning modules. In this case, the government also provides guidelines for the minimum components that must be included in the learning plan or module being developed.

At present, there is a scarcity of STEM-PjBL module aimed at bolstering 21st-century skills among Indonesian students, particularly at the elementary school level. Therefore, the objective of this study is to create the construct and item of a STEM-PjBL module aimed at enhancing students' scientific literacy and critical thinking capabilities by structuring the construct and item within the module. Therefore, the question in this research is what are the main constructs and items of the STEM-PjBL module for elementary school teachers?

Methods

This study adheres to the design and developmental research (DDR) methodology as delineated by Richey and Klein (2007) in developing the STEM-PjBL module. This methodology involves three key phases: needs analysis, design and development, and assessment. For this particular research, qualitative methods were used using literature reviews and expert interviews for the data collection to design content of the STEM-PjBL module in second phase. Before developing a module, a design process is needed to determine the constructs and items that need to be insert in the module.

The selection of informants for interview in this research was carried out using purposive sampling. A total of 7 informants were involved in this research with the criteria of 1 science education lecturer, 1 elementary school education lecturer, 1 ministry of education curriculum expert, and 4 expert teachers. The informants were selected based on the criteria of coming from the field of elementary school education and also science education, having experience in their field for more than 10 years, and coming from the Cirebon district area according to the research location in the need analysis phase for expert teachers. For literature review used indexed journals, books, and government or agency documents. The literature employed in the analysis pertains to the requisites for creating module content, including STEM, PjBL, scientific literacy, and critical thinking. Through the findings of the literature analysis, the essential components for developing the STEM-PjBL module in Indonesia were identified.

Data from the results of literature analysis were analyzed through thematic analysis. Thematic analysis is a technique used to identify, analyze, and report patterns or themes within data and It provides a detailed and organized description of dataset (Braun & Clarke, 2006). After the module constructs and items are arranged, the next process is an expert interview to obtain approval and input on the components that have been prepared through the previous literature review process.

Results and Discussion

The main constructs that will be designed in the STEM-PjBL module are the focus of this research which include (1) module objective components, (2) module structure, (3) module content which includes STEM components, scientific literacy components, and critical thinking components, (4) teaching aids, and (5) assessment in the module.

The first item to look for constructs is the module objectives. By evaluating the research articles used in this research, it appears that there is still limited research developing STEM-PjBL module for scientific literacy and critical thinking for elementary school students. The findings of the article analysis for module objective items are shown in Table 1.

Table 1. Summary of article for module objective.

Authors (Year)	Objective module components
Galadima et al. (2019)	Provide meaningful experiences or skills to integrate STEM into teaching.
Samat et al. (2019)	To implement the STEM approach within the Chemical Bond topic and to tackle the challenges students face in comprehending this subject matter.
Siew & Ambo (2018)	Enhancing educators' understanding of integrating PjBL into STEM instruction. Assisting teachers in cultivating scientific creativity through the integration of suitable instructional methods.
Vossen et al. (2020)	Teachers' comprehension of the module's goals and objectives, as well as understanding the learning objectives of incorporating research within a project design.

Upon analyzing the literature, the researcher devised three objective items for developing a STEM-PjBL module: 1) enhancing teachers' knowledge of implementing STEM-PjBL in the teaching and learning process, 2) improving teachers' skills in implementing STEM-PjBL in the teaching and learning process, and 3) strengthening student competencies (scientific literacy and critical thinking) through the use of the STEM-PjBL module.

Following the presentation of these objectives to experts, adjustments were made to the component indicators of implementing STEM education due to their lack of measurability. Experts recommended changing "implementing" to "designing and implementing." Consequently, the module's objectives were refined to: 1) augmenting teacher knowledge to design and implement STEM education through PjBL in the teaching and learning process; 2) enhancing teachers' skills to design and implement STEM education through PjBL in the teaching and learning process, and 3) reinforcing student competencies (scientific literacy and critical thinking) through the utilization of STEM-PjBL module in the teaching and learning process.

Meanwhile, the Ministry of Education of the Republic of Indonesia identified the challenges faced in advancing education related to the educational ecosystem, teachers, pedagogy, and curriculum, among others freeing learning as a burden to learning as a pleasant experience; liberating the teacher as a transmitter of knowledge to become a teacher as a facilitator of learning; and liberating manual or face-to-face learning into technology-facilitated learning (Kementerian Pendidikan dan Kebudayaan, 2020).

In addition, in the learning process, teachers do not connect the content of science in learning with the context in the real world. Teachers mainly focus on explaining theoretical knowledge and the lack of class interaction, resulting in a boring class atmosphere (Qian, 2022). Although many efforts made by science teachers and standard documents usually focus on providing explanations of science content through affirming facts about nature and how it works, it is equally important to promote contextual explanations of how those explanations are produced and received (Herman et al., 2019). This is of course closely related to the teacher's knowledge and skills in facilitating learning in the classroom, the fact is that science teachers still need to improve their ability to manage activities in the classroom in order to improve the competence of their students. By applying a STEM-based learning approach in the world of education, it can be one of the alternatives to overcome the educational challenges that occur in Indonesia.

The second construct within the module is its structure. This pertains to all the essential elements incorporated in the module for elementary school teachers' teaching and learning processes. The content within this module encompasses general information, core components, and supplementary materials aligned with the basic module components outlined by the government (Anggraena et al., 2022). Module structure items include modules containing: Pancasila student profile; module identity which includes subjects, topics, project titles, phases and project implementation time; students' initial competencies (prerequisites); infrastructure and learning media; learning objectives; STEM component; topic and project introduction; issue/scenario/problem; student assignments; meaningful understanding; trigger question; diagnostic, formative, and summative assessments; learning activities/steps; reading material; test questions; assessment rubric; project solution suggestions for teachers; and learning media. After bringing the structural items of this module to an expert interview, all experts agreed to the items that had been prepared by the researcher, there were no changes to the content, meaning only the spelling or a few terms were corrected.

The availability of modules can help teachers and students in obtaining information about materials and steps in learning. In addition, the development of STEM modules has not been widely applied, so it is an opportunity for researchers to develop STEM modules related to the situation in Indonesia (SEAMEO Regional Centre, 2021). Integrating STEM concepts into the module structure developed by the government will enrich the learning structure in Indonesia.

The third construct to look for is the module module content. By evaluating the research articles used in this research, There are 10 literatures that are relevant to STEM content, 8 scientific literacy literatures, and 7 critical thinking literatures that are required in the module. The results of the article analysis for module content items are summarized in Table 2, Table 3, and Table 4.

Table 2. Summary of article for module content (STEM)

Authors (Year)	STEM components
The Ontario Public Service, (2022)	- **Engineering** • Research and understand a problem • Ideate and generate potential solutions • Select an option and develop a prototype • Test the prototype • Evaluate and revise the prototype • Communicate the solution - **Technology** • Select and use appropriate digital tools to collaborate, communicate, create, innovate, and solve problems • Understand how to manage and regulate their use of technology • Use digital tools to define and plan data searches, collect data, and identify relevant data sets • Demonstrate a willingness and confidence to explore and use new or unfamiliar digital tools and emerging technologies • Manage their digital footprint by engaging in social media and online communities • Analyse and understand the impact of technological advancements on society, and society’s role in the evolution of technology

Wan et al., (2022)	- **Science** • Formulate questions about natural phenomena • Set up a hypothesis and conduct an experiment to test it • Identify variables and invariables in the fair test and/or controlled experiment • Analyse the results from the data collection/experiment • Draw conclusions related to the scientific phenomena • Suggest improvements and recommendations for further study - **Technology** • Use IT instruments to gather data • Analyse data on a computer • Run software to produce figures and tables • Select and use technical tools/products to solve a problem • Using online tools to generate ideas - **Engineering** • Design a product/model for solving a problem • Identify the constraints or flaws of the model or design • Test the design to evaluate its performance • Modify the model or design - **Mathematics** • Collect and record the data • Calculate averages • Calculate percentages • Generate table and figures to present the data • Find the patterns or rules in the data
Toma & Greca (2018)	- **Science** Application of scientific methodologies in order to address the scientific concepts needed to solve the problem - **Mathematics** Data analysis and interpretation - **Technology** Handling of devices and instruments for the design of experiments, data gathering and analysis - **Engineering** • Students design or implement the technological device that solves the initial problem, using the scientific concepts developed previously • Students propose possible technological applications in real world situations of the scientific concepts addressed throughout the inquiry • Students communicate their results and offer a possible resolution of the initial problem
Han et al. (2016)	- **Science** • Explain concept • Inner workings - **Technology** • Learn how technology has advanced • Learn about the concept help - **Engineering** • Apply design concepts to problems in physical and mechanical systems. • Use consistent units for all measurements and computations. • Engage in design and prototype development. • Use teamwork to solve problems. • Complete work according to established criteria. • Develop a plan for implementation of an individual product.

	- **Mathematics** • Add, subtract, multiply and divide decimals. • Analyze ratio, proportions, and measurement scales. • Calculate volume of solids. • Calculate area of common shapes (e.g., squares, rectangles, circles, and triangles). Measure objects with precision. • Use special reasoning to devise a sprinkler plan.
Australian Curriculum Assessment and Reporting Authority (2016)	- **Technology** • innovation, enterprise and production skills • the design process, including • investigating and defining (design briefs, design thinking) • generating and designing (communicating possible solutions including drawings, models, prototypes) • producing and implementing evaluating collaborating and managing (developing project plans and project managemen). - **Mathematics** • Collecting, representing and interpreting data • Linear measurement, scale ratios and similarity • Measurement of area and volume • Pythagoras' theorem and trigonometry • The Cartesian plane • Financial mathematics. - **Science** • motion and aerodynamics • energy transfer and renewable energy • global systems and their interactions • abiotic factors and biotic interactions with plants • body systems and interconnectedness • atoms, chemical reactions, acids and bases • data trends • ethics and human impacts on ecosystems.
Lou et al., (2017)	- **Science** • The concept • The principle • Methods - **Technology** • Selection of materials • Use of tools • Ways of processing • Testing, adjustment and correction - **Engineering** • Problem resolution • Creative thinking • Design of modelling • Structural design drawing and graphing - **Mathematics** - Calculation
White, (2014)	- **Science** The systematic study of the nature and behavior of the material and physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms - **Technology** The branch of knowledge that deals with the creation and use of technical means and their interrelation with life, society, and the

	environment, drawing upon such subjects as industrial arts, engineering, applied science, and pure science - **Engineering** The art or science of making practical application of the knowledge of pure sciences, as physics or chemistry, as in the construction of engines, bridges, buildings, mines, ships, and chemical plants - **Mathematics** A group of related sciences, including algebra, geometry, and calculus, concerned with the study of number, quantity, shape, and space and their interrelationships by using a specialized notation
State Superintendent of Public Instruction (2014)	- **Science** • The laws of nature associated with physics, chemistry, and biology • The treatment or application of facts, principles, concepts, and conventions associated with these disciplines - **Technology** • Comprises the entire system of people and organizations, knowledge, processes, and devices that go into creating and operating technological artifacts, as well as the artifacts themselves • Throughout history, humans have created technology to satisfy their wants and needs - **Engineering** • The design and creation of human-made products • A process for solving problems - **Mathematics** • Patterns and relationships among quantities, numbers, and space
Honey et al., (2014)	- Science: commonly addressing biology, chemistry, physics, and Earth and space sciences - Mathematics education: commonly addressing arithmetic, geometry, algebra, trigonometry, and calculus - Technology: educational, or instructional, technology (filmstrips, movies, television, videos, and learning aids such as calculators and electronic white boards); personal computer and the Internet, - Engineering: engineering design process and of concepts such as constraints, criteria, optimization, and trade-offs
Quinn et al., (2012)	- Asking questions (for science) - Defining problems (for engineering) - Developing and using models - Planning and carrying out investigations - Analyzing and interpreting data - Using mathematics and computational thinking - Constructing explanations (for science) - Designing solutions (for engineering) - Engaging in argument from evidence - Obtaining, evaluating, and communicating information

Based on literature analysis, researcher uses simple STEM concepts because they will be used at the elementary school level. For science, items include explaining science concepts according to level and carrying out scientific investigations. For technology includes the use of tools to collect and analyze data and selecting materials. The engineering component includes identifying problems, designing and developing prototypes/products, presenting to receive input, analyzing and interpreting data to find optimal design solutions, providing prototype/product design solutions, identifying design constraints or weaknesses, and producing prototypes/products. And the last one for mathematics includes collecting and recording data, making graphs to present/present data, looking for patterns or rules in data, paying attention to precision, and calculations.

When implementing STEM learning in schools, it's crucial to adjust it to students' developmental stages. At the elementary level, students merely require an introduction to a basic STEM. This allows them to engage in solving fundamental engineering-related problems that are significant yet often overlooked in the early grades. (Cunningham, 2018; English & King, 2015).

Currently, there is still a gap between the Ministry of Education's strategic goal of realizing 21st century learning at all levels and the current implementation of learning in Indonesia. There are several compelling reasons why it is important to engage students in STEM, including STEM learning helps students deepen their understanding of important concepts in science and math; students become innovative critical thinkers and are able to make thoughtful decisions; students learn how to approach and solve problems, develop a sense of ethics and social awareness, and good cooperation skills; moreover, students become more technologically literate and understand how their STEM courses can open doors to future careers (Jolly, 2017).

Table 3. Summary of article for module content (Scientific literacy)

Authors (Year)	Scientific literacy components
Firdaus & Asmali (2021)	- Concept knowledge - Use of scientific knowledge in analyzing texts/articles - Use concepts or knowledge meaningfully - Analyze and evaluate data or events - Solve the problem
Costa et al (2021)	- Ability to differentiate between scientific and non-scientific realms - Comprehension of Science and its practical implementations - Understanding the nature of Science and its connection to Culture - Valuing and feeling at ease with science, including exhibiting admiration and curiosity. - Proficiency in utilizing scientific knowledge for problem solving - Understanding and valuing of science and technology and their interrelationship with society
Hasanah & Silitonga 2020)	- Competence in posing questions - Acquisition of new knowledge - Explain scientific phenomena and formulation conclusions based on evidence - Recognition of the characteristics of science - Consciousness of how science and technology influence the natural, intellectual and cultural landscape - Enhancment of compliance to engage and care about science-related issues .
Ministry of Education (2019)	- Collecting and interpreting data - Utilizing evidence - Critically evaluating evidence - Engaging with scientific principles
Wang et al. (2019)	- Describing phenomena through scientific explanation - Evaluating and designing scientific investigations - Interpreting data and evidence scientifically - Applying scientific knowledge in practical context
OECD (2017)	- Provide scientific explanations for phenomena - Assess and develop scientific enquiry - Interpret data and evidence scientifically Interest in science - Valuing scientific approaches to enquiry - Develop environmental awareness
Australian Curriculum Assessment and	- Identify questions - Gain new knowledge

Reporting Authority (2016)	- Address challenges and develop conclusions grounded in evidence to comprehend the world - Acknowledge how perceptions of the nature, evolution, and practical applications of science - Influence our ability to make informed decisions and shape our interpretations of information responsibly.
Gormally et al. (2012)	- Recognize a valid scientific argument - Assess the credibility of sources - Assess appropriate and inappropriate utilization of scientific data - Comprehend elements of research design and their influence on scientific results/conclusions - Create visual depictions of data - Analyze visual representations of data - Utilize quantitative skills to solve problems, including those involving probability and statistics - Comprehend and interpret fundamental statistical principles - Provide rationale for inferences, predictions, and conclusions drawn from quantitative data

Scientific literacy indicators are used as indicators for compiling practice questions in modules, such as practice questions for formative and summative assessments. Based on the results of literature analysis, scientific literacy indicators used to prepare questions in the module include 1) explaining phenomena scientifically, 2) interpreting data and evidence scientifically, 3) evaluating and 4) designing scientific investigations, and 4) applying scientific knowledge. The scientific literacy criteria are adjusted to match the proficiency level of elementary school students. Understanding the scientific literacy of young learners is crucial as these skills strongly impact their performance across different subjects. Among these subjects, natural science holds a crucial position during elementary education, serving as a foundational pillar for students to confront the challenges of the global era (Winarni et al., 2020). The experts unanimously approved all the scientific literacy components proposed by the researchers as they aligned with the characteristics of science learning at the elementary school level.

There is a correlation between STEM skills and students' scientific literacy, students will develop a better understanding of STEM based on understanding basic science concepts drawn from sources related to the learning process, textbooks, print media, electronic media, and social media (Rochman et al., 2019). Gertner et al., (2021) developed students' science literacy through a portfolio project that, overall, achieved its goal of addressing the unique challenges community college students face when taking introductory STEM courses. Science literacy development at the elementary school level can be developed through the introduction of STEM-PjBL learning.

Table 4. Summary of article for module content (Critical thinking)

Authors (Year)	Critical thinking components
BSKAP Kemendikbudristek (2022)	- Process qualitative and quantitative information objectively - Establish connections differentiate among various pieces of information - Analyze information systematically - Evaluate information critically - Draw conclusion based on evidence
(Ariyana et al., 2018)	- Identify problems effectively - Evaluate the logical coherence of provided reasons and their relevance to the problem - Determine if the developed reasons are sufficient to support the true conclusion

	- Compare finding with the real-world situation - Ensure clarity in treminology and explanations to avoid errors in drawing conclusion - Verify something that has been discovered, decided, observed, studied and concluded
Australian Curriculum Assessment and Reporting Authority (2021)	- Analysing and evaluating possibilities based on predefined criteria - Formulating and assessing arguments - Utilizing information, evidence and logical reasoning to draw reasoned conclusions and to solve problems
Ennis (2018)	- Focusing on specific question - Assess arguments - Pose and respond to clarifying questions - Comprehend and apply fundamental graphs and mathematical concepts - Assesing the credibility of a source - Observing and evaluating observation reports - Applying existing knowledge - Drawing deductions and judging deductions - Making and evaluating inductive inferences and arguments - Making and assessing value judgments - Define terms and assess definitions - Manage equivocation effectivelyIdentifying and evaluating unstated assumptions - Engaging in suppostional thinking - Recognizing and addressing fallacies - Recognize and assess the quality of their own thinking (metacognition) - Organizing thoughts and actions in a systematic manner - Employ rhetorical strategies
Kivunja (2018)	- Employ higher-order cognitive processing skills outlined in Bloom's taxonomy to evaluate and develop ideas as well as to generate novel concepts - Participate in a disciplined intellectual the process of actively and adeptly conceptualizing, applying, analyzing, synthesizing, and/or evaluating information. - Demonstrate the capacity to think deeply and to solve unfamiliar problems using various approaches - Effectively manage and respond well to unfamiliar challange - Exhibit an open-minded attitude - Approach issues with rationality and logical reasoning - Handle issues responsibly with sensitivity and concern for others, society, the environment, and the global community
Facione (2015)	- Interpretation - Analysis - Inference - Assessment - Explanation - Self-Regulation
Richard Paul & Elder (2006)	- Purpose - Questions - Perspective - Information - Inferences

	- Ideas - Implications - Assumptions

The goal of incorporating natural sciences into elementary school curricula is to empower students to become effective learners, take ownership of their education, and utilize their knowledge in real-world scenarios. Moreover, science instruction at this level can bolster elementary students' critical thinking skills by nurturing an environment that promotes analytical thinking throughout their educational journey (Susanto et al., 2022). The experts also agreed with the researchers regarding all the critical thinking components prepared by the researchers because they were suitable for elementary school level.

Critical thinking is among the competencies that are utilized as an outcome or will be assessed during learning activities using the STEM-PjBL module. According to the findings of the literature analysis and experts interview, CTS can be measured through observation activities or group interviews, where the teacher makes observations and asks questions according to the indicators of CTS to be measured, apart from that, it can also be done through test questions. The CTS items used in the module are initiative, generating practical ideas, being sharp in identifying problems, making conclusions, making judgments, explaining effectively, and being sharp in seeing shortcomings.

Through STEM-PjBL education, it has the potential to improve students' CTS, because research conducted in several countries has proven successful. Mutakinati et al., (2018) conducted a study to analyze the CTS of Japanese high school students through a worksheet instrument consisting of designing solutions and understanding concepts to identify critical thinking. The results showed that they had sufficient thinking skills to criticize their own plans in solving contextual problems. Meanwhile in China PjBL can be used as an effective approach to develop students' CTS (Wang, 2022).

The fourth construct that needs to be included in the module is the learning aid items component, There are 7 articles related to STEM-PjBL module learning aid requirements which is summarized in Table 5.

Table 5. Summary of article for module teaching aids.

Authors (Year)	Teaching aid components
Wieselmann et al. (2022)	- Tools and materials for the project
Komada et al. (2022)	- Power point slide
Shu & Huang (2021)	- Power point slide
(Wahyu et al., 2020)	- Internet access
Tomblin & Mogul (2020)	- Video
Zainal et al. (2018)	- STEM modules from various countries - Video
Ellison & Allen (2018)	- Internet access

Learning aids or learning media are things that can help teachers improve the quality of learning, it holds significance in the educational journey as it serves to inspire and encourage elementary school students to engage with the learning materials effectively (Zuliana et al., 2020). Aside from cognitive style, students' proficiency in science is also impacted by factors such as the choice of learning resources and the incorporation of straightforward and accessible media. For instance, employing tangible materials readily available in the environment is anticipated to generate engaging and enjoyable learning scenarios. This approach aims to address challenges students may encounter and ultimately boost their motivation to learn (Setiawan et al., 2023).

Experts provide input on the items of teaching aids or media that have been prepared by researchers based on various literature. Experts suggest adding learning aids such as pictures, virtual lab simulations/animations on the internet, simple tools or materials for projects (such as: ice cream sticks, used cardboard, plastic, used bottles, styrofoam, rubber, thread, etc.), and also game tools such as cards or puzzles to increase students' learning motivation, especially elementary school students who still enjoy playing activities. Based on suggestions from experts, the items of learning aids or media that will be included in the module include STEM modules from various countries, images, learning videos, PowerPoint slides, animations from internet, web page, simple materials for projects, and game tools such as puzzles. Constructive learning or constructivism provides opportunities for students to explore and build experiences using all available resources such as media, teaching materials, etc. to explore the information contained therein (Schunk, 2012).

The fifth and final construct that needs to be included in the module is the learning assessment component. There are 11 related articles used for the STEM-PjBL learning assessment items component which are summarized in Table 6.

Table 6. Summary of article for assessment in module.

Authors (Year)	Learning assessment components
Coronado et al. (2021)	- Written test
Duke et al. (2021)	- Written test
Aránguiz et al. (2020)	- Oral presentation - Self evaluation
Guo et al. (2020)	- Oral presentation
Khandakar et al. (2020)	- Poster presentation - Demonstration
DeMink-Carthew & Olofson (2020)	- Self assessment
Belwal et al. 2020)	- Observation
Magnus et al. (2020)	- Observation
Nagarajan & Overton, (2019)	- Poster presentation
Kızkapan & Bektaş (2017)	- Self asessment
Bell (2010)	- Self assessment

Elementary students typically have limited attentions spans for long assessments, and teachers are hesitant to sacrifice valuable instructional time for assessments that do not directly contribute to students' grades. These constraints are genuine and reasonable (Gane et al., 2021). In the module, practice questions and test questions will be provided, teachers can use them directly or copy the practice questions or rubrics in the module. Based on expert views, assessing students' scientific literacy can be done through test questions, while assessing CTS can be done through group interviews while students complete group projects. Therefore, based on literature review and experts interviews, the assessments items that will be used in the module are adjusted to project assessment needs and also student competency assessments such as scientific literacy and CTS, internal assessments such as self-assessment, group interviews, oral presentation assessments, observation, product assessment, portfolio, and also written tests. Specifically, the low achievement of science and science literacy of Indonesian students on national and international assessments can reflect low thinking skills. The profile of a student's HOTS can be seen through the student's ability to question something and connect it with the information received to find the answer (Adriyawati et al., 2020) on PISA questions that use questions based on HOTS to determine students' abilities in reading, math, and science (Setyowati et al., 2021). Therefore, the instrument and assessment system should also lead to the achievement of student competencies.

Conclusion

This research focuses on designing the constructs and items of a STEM-PjBL module for scientific literacy and critical thinking elementary school students. Module constructs produced through literature reviews and expert interviews include module objective; module structure; module content which includes STEM components, scientific literacy components, and critical thinking components; teaching aids; and assessment in the module. The module objective construct includes 3 items consisting of enhancing teachers' knowledge of implementing STEM-PjBL in the teaching and learning process, improving teachers' skills in implementing STEM-PjBL in the teaching and learning process; and strengthening student competencies (scientific literacy and critical thinking) using STEM-PjBL module. The module structure follows the general guidelines in the merdeka curriculum which includes 18 items such as pancasila student profile; module identity which includes subjects, topics, project titles, phases and project implementation time; students' initial competencies (prerequisites); infrastructure and learning media; learning objectives; STEM component; topic and project introduction; issue/scenario/problem; student assignments; meaningful understanding; trigger question; diagnostic, formative, and summative assessments; learning activities/steps; reading material; test questions; assessment rubric; project solution suggestions for teachers; and learning media. Meanwhile, the module content is divided into three parts, namely STEM content, scientific literacy, and critical thinking. For STEM, the components for Science items include include explaining science concepts according to level and carrying out scientific investigations. For Technology includes the use of tools to collect and analyze data and selecting materials. Engineering includes identifying problems, designing and developing prototypes/products, presenting to receive input, analyzing and interpreting data to find optimal design solutions, providing prototype/product design solutions, identifying design constraints or weaknesses, and producing prototypes/products. And the last one for mathematics includes collecting and recording data, making graphs to present/present data, looking for patterns or rules in data, paying attention to precision, and calculations. For scientific literacy items include explaining phenomena scientifically, interpreting data and evidence scientifically, evaluating and designing scientific investigations, and applying scientific knowledge. For critical thinking items consists of initiative, generating practical ideas, being sharp in identifying problems, making conclusions, making judgments, explaining effectively, and being sharp in seeing shortcomings. Meanwhile, items in teaching aids include STEM modules from various countries, images, learning videos, PowerPoint slides, animations from internet, web page, simple materials for projects, and game tools such as puzzles. Finally, the items for assessment consist of student competency assessments, self-assessment, group interviews, oral presentation assessments, observation, product assessment, portfolio, and also written tests. The existing module items will be used as a basis for the next stage, namely the module development stage.

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