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Development of a science, environment, technology, and society-based learning module to foster critical thinking in elementary students

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ABSTRACT

This study aims to develop a science, environment, technology, and society (SETS)-based learning module to enhance critical thinking skills among elementary school students. Employing a research and development (R&D) approach adapting the Borg and Gall model, this module is designed to enrich the learning process of natural and social sciences (IPAS). The research sample involved elementary school students from selected schools, utilizing quantitative methods to measure the module's effectiveness. Validation results showed high scores in content, media, language, and pedagogy, indicating a highly valid module. Practicality tests revealed high practicality from both learners' and educators' perspectives, with average scores above 90. The findings indicate a significant increase in students' critical thinking abilities post-module learning, as measured by pre-test and post-test instruments. Implications of these findings suggest that integrating SETS concepts into IPAS learning can be an effective strategy in enhancing elementary students' critical thinking skills. These findings also offer insights for educational practitioners in designing more interactive and environmentally relevant learning materials.

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1. INTRODUCTION

In an era marked by rapid connectivity and change, the importance of critical thinking skills in education has increasingly become a primary focus. Defined as the ability to analyze, evaluate, and synthesize information [1] critical thinking is recognized as an essential foundation for students to interact effectively with the world around them. Facione [2] asserts that critical thinking is not only crucial in an academic context but also in daily life, enabling individuals to make reasoned and critical decisions. Research by Paul and Elderfurther [3] highlights how critical thinking skills can be enhanced through structured reflective and analytical practices, a vital component in education.

Critical thinking encompasses high-level thinking skills, one of the components of 21st-century literacy issues [4]. Incorporating critical thinking skills into the curriculum helps maintain an educated citizenry; preparing students for college, future careers, and life situations [5]. Critical thinking is essential in building students' knowledge to question, argue, and refute obtained information, stimulating students'

cognitive reasoning in knowledge acquisition [6]. Students require critical thinking as they develop ideas to contemplate issues present in learning [7]. The role of information and communication technology (ICT) in education has undergone significant transformation, particularly with the emergence of e-learning, augmented reality (AR), and virtual reality (VR), offering more interactive and engaging learning approaches [8]. These technologies, as described by Prensky [9] not only change how students learn but also challenge educators to integrate teaching methods that facilitate critical thinking skills.

However, the emerging challenge is how to implement these technologies effectively in primary education to enhance critical thinking skills. According to Voogt and Roblin [10] 21st-century education requires the integration of skills such as critical thinking, creativity, and collaboration, which must be combined with the use of ICT. Especially at the elementary level, where the foundation for learning and critical thinking skills is laid, the role of technology becomes crucial [11]. As we recognize the pivotal role of technology in fostering critical thinking at the elementary level, it becomes increasingly apparent that an integrative approach is necessary-one that incorporates the interconnected realms of science, environment, technology, and society (SETS). The importance of integrating SETS education in developing critical thinking has also been explored in the literature. Astuti *et al*. [12] demonstrated that SETS approaches could enhance student understanding and critical thinking skills. This aligns with Bybee [13] emphasizes the significance of science, technology, engineering, and mathematics (STEM) education in preparing students to face 21st-century challenges, it's important to recognize that SETS education, although distinct, complements STEM by integrating environmental and societal perspectives with scientific and technological learning.

The use of technology and problem-oriented teaching methods proposed in SETS approaches provides a rich learning context and supports the development of critical thinking skills [14]. In this context, a SETS-based learning model emerges as a holistic approach that combines aspects of science, environment, technology, and social in education [15]. The rationale for using this approach is for students to perceive these elements integratively, gaining deeper understanding beyond mere knowledge acquisition [16]. The SETS learning model develops concepts of green chemistry and environmental care; its nurturant effect is enhancing critical thinking and higher-level thinking abilities [17]. The instructional effect aimed at is the cognitive, affective, and psychomotor aspects [18], [19]. Astuti *et al*. [12] showed that employing SETS approaches could improve student comprehension as well as critical thinking skills. This approach allows students to view problems integratively and develop deeper understanding not just as knowledge but also as part of practical problem-solving in daily life.

Education research has highlighted the importance of critical thinking skills within school curricula [1], [2]. Despite this recognition, there is a gap in practical application and development of effective curriculum materials to hone these skills at the elementary level [10]. Previous studies tend to focus on enhancing critical thinking through traditional teaching methods or using technology, often without a comprehensive integration of SETS aspects that could provide a richer learning context for students [8]. Furthermore, although the literature supports the use of SETS approaches in education [12], research specifically targeting the development of SETS-based modules at the elementary level remains limited. There is a gap in research examining the direct influence of SETS modules on enhancing students' critical thinking skills at the basic level, particularly in grade four, where the foundation for these skills is being constructed.

This research aims to fill that gap by developing and implementing a SETS-based learning module specifically for fourth-grade elementary students. The primary goal is to evaluate the extent to which this SETS-based module can enhance students' critical thinking skills, given the importance of these skills in 21st-century education [11]. By integrating SETS concepts into the learning module, this research aims to provide new insights into effective ways of integrating various learning aspects to facilitate the development of critical thinking in elementary-age children.

Within this research framework, the primary research question focuses on the effectiveness of SETS-based learning modules in enhancing critical thinking skills of fourth-grade elementary students. This question seeks to explore the extent to which the developed learning module based on SETS principles can contribute to improving students' critical thinking abilities. This research is conducted within the context of primary education, taking into account cognitive, affective, and psychomotor aspects relevant to the learning age in grade four. Critical thinking, as defined by Ennis [1], is a complex intellectual process that necessitates the ability not only to comprehend information but also to analyze, evaluate, and synthesize it. This process involves deep and reflective thinking, enabling individuals to make reasoned judgments and construct logical arguments [2]. In this approach, critical thinking is viewed not just as a skill but also as an intellectual attitude involving constructive skepticism and a quest for truth. Bloom *et al*. [20] educational taxonomy classifies critical thinking as one of the highest forms of cognitive processes. This taxonomy categorizes critical thinking within the realms of analysis, evaluation, and creation, indicating that this thought process goes beyond basic recall and understanding, urging students to delve deeper into ideas, make connections, and generate new insights.

Paul and Elder [3] further developed this framework by emphasizing the importance of intellectual discipline in critical thinking. They propose that critical thinking involves the ability to question assumptions, analyze concepts, and critically evaluate contexts. This approach underscores the importance of developing critical thinking skills to foster independent and reflective thought. Collectively, these theories underscore the importance of critical thinking as a vital skill in education, providing students with tools to navigate a complex and often ambiguous world. Learning modules are systematically organized and engaging teaching materials that contain content, methods, and evaluations which students can use independently to achieve desired competencies [21]. A module, as a standalone and self-contained unit of planned learning activities, is designed to assist students in achieving well-defined objectives [8]. Critical thinking and learning autonomy may be enhanced if educators pay greater attention to how learning models are applied and are able to develop engaging and innovative devices [22].

SETS learning is an innovative approach that integrates various disciplinary aspects to provide students with a more holistic understanding. As explained by Astuti *et al.* [12] the SETS approach blends scientific concepts with their applications in society and the environment, allowing students to understand the interrelationships among disciplines in a broader context. This approach facilitates a deeper and contextual understanding of the subject matter, not just as theoretical knowledge but also as practical understanding applicable in daily life. Freeman *et al*. [23] demonstrate that active teaching methods, such as those used in SETS modules, significantly improve student performance in science, technology, and mathematics. This research found that interactive and contextual approaches in learning enhance students' comprehension and retention of material.

Bybee [13] emphasizes that the SETS approach allows students to see how science interacts with various aspects of society and the environment. This broadens their understanding of science from merely an academic subject to an important tool for addressing global and local issues. In this way, students can develop the critical thinking skills necessary to evaluate information and make environmentally and socially informed decisions. Paechter [24] underscores the importance of scientific literacy in education, aligning with the goals of SETS learning. This research highlights how broader scientific literacy, encompassing understanding of technology and environmental issues, is essential for 21st-century learning.

Bell [25] adds that the SETS approach enriches STEM learning by providing a rich context for understanding scientific concepts. Through this approach, students learn not only scientific principles but also understand their applications and impacts on the environment and society [26]. Zeidler and Nichols [27] explore how contextual science education, similar to the SETS approach, affects students' moral and ethical development. They found that integrating environmental and social issues into science learning enriches students' understanding of scientific implications in real life and encourages the development of ethical thinking [28]. This approach aids students in developing a deeper and applied understanding of scientific concepts while honing their critical thinking skills [13]. The SETS approach provides a framework for integrating interdisciplinary learning and offers opportunities for students to explore, discover, and understand the world around them in a more comprehensive and meaningful way [29].

The SETS-based modules created by researchers aim to innovate in the development of SETS-based modules that did not exist in previous learning. The content contained within these modules is based on topics such as the water cycle. The stages involved in module development include identifying potential issues, data collection, product design, design validation, design revision, product testing, and product revision.

2. METHOD

2.1. Research design

The research and development (R&D) design used in this study follows the model developed by Borg and Gall [30]. The process starts with "research and information gathering" and moves to "Planning," which then leads to "product development." From there, the process goes through "initial field testing," followed by "revision of initial field test results." After the initial revision, "main field testing" takes place. This is followed by an "operational product revision," which then leads to "operational field testing." The product goes through "final product refinement" before the "dissemination and implementation" stage. There is also a feedback loop from "dissemination and implementation" back to "final product refinement," suggesting that further refinements may be made after the product is disseminated based on additional feedback or testing. The Borg and Gall model is a widely recognized framework for developing educational products and interventions. This model emphasizes a systematic and methodical approach, starting from the identification and analysis of initial needs to the evaluation of the final product. This approach aids researchers in designing and developing learning modules that are not only theoretically robust but also practical and relevant to student needs.

In the context of this study, the Borg and Gall model allows researchers to systematically develop, test, and evaluate the SETS learning module. The process begins with an in-depth needs analysis to understand the critical aspects that must be integrated into the module, such as scientific concepts, environmental issues, technology, and social aspects. This is followed by the design and development of the module, involving the creation of learning materials that align with the needs and characteristics of elementary school students. The evaluation of the final product, the developed module, is a crucial stage in this model. Evaluation is conducted to ensure that the module is effective in enhancing students' critical thinking skills. This evaluation method involves testing the module in a real classroom environment and collecting feedback from students and teachers. This process allows for the refinement and adjustment of the module based on feedback and test results [31]. The use of the Borg and Gall model in this study ensures that the SETS learning module is developed with a comprehensive approach based on solid pedagogical principles, aiming to enhance the critical thinking skills of elementary school students.

2.2. Sample and setting

This study was conducted on elementary school students, with a specific focus on fourth-grade students, considering that at this age, students begin to develop more complex critical thinking abilities [32]. The initial testing phase was administered to 10 fourth-grade students, whereas the final main trial phase was conducted with 24 students as the experimental group and 24 students as the control group. Sample selection was based on specific criteria relevant to the study's objective, which is to test the effectiveness of the SETS-based module in enhancing critical thinking skills. According to [33] appropriate sample selection is key to obtaining accurate data representative of the target population. The research setting was arranged to ensure a conducive environment for learning and assessment. A supportive learning environment is crucial for facilitating an effective learning process, especially in the context of educational research [34]. This setting includes suitable classrooms, relevant learning materials, and support from teachers and school staff.

2.3. Instruments

To measure critical thinking abilities, the researcher utilized a critical thinking instrument composed of 15 items that assess four indicators: i) building basic skills, ii) drawing inferences, iii) providing further explanation, and iv) organizing strategies and techniques. The importance of instrument validation and reliability in educational research is emphasized by [35], states that validity determines the extent to which an instrument measures what it is supposed to measure, while reliability refers to the consistency of measurement results. Instrument validation involves experts in relevant fields to ensure that the content and construction of the instrument meet academic standards and research objectives. This process also involves assessment in terms of language and pedagogy to ensure that the instrument is well understood and appropriate for the educational context [36].

The reliability of the instrument is measured using appropriate statistical techniques, such as test-retest or internal consistency analysis, to ensure that the obtained results are reliable and free from measurement errors [37]. In this study, the instrument has undergone a series of validation processes and reliability tests to ensure that the evaluation tools used can accurately measure the effectiveness of the SETS module in enhancing critical thinking skills. Based on the subject matter expert's assessment, the module's conformity with SETS and the quality of the module's content received an average score of 0.92, categorizing it as highly valid. In terms of media validation, the module achieved an average score of 0.87 for didactic requirements, construction requirements, and technical requirements, which also placed it in the highly valid category. In the language evaluation, the module scored an average of 0.90 for communicative clarity, writing, and the use of terms and symbols, marking it as highly valid. Finally, from a pedagogical perspective, the module was assessed on learning components, conformity with enhanced Indonesian spelling system (EYD), ability to motivate students, and several other aspects, achieving an average score of 0.93, also falling within the highly valid category. Overall, these validation results affirm that the developed module meets standard process requirements and has undergone the research and development stages according to the Borg and Gall method, thus considered valid and suitable for use in educational settings.

2.4. Procedures

The research procedures followed in this study include key steps for developing the SETS-based module, conducting trials, and evaluating its effectiveness in enhancing the critical thinking skills of elementary school students. The module development phase involves planning, design, and creation of the SETS-based module, taking into consideration aspects of content, media, language, and pedagogy [30], [38]. This process includes need analysis, the creation of initial drafts, and adjustment of module content to current educational standards.

The next step is module trials conducted in several stages, from small-scale tests to main field trials. This stage is crucial for evaluating the practicality and effectiveness of the module in a real classroom

context [39]. After the trials, researchers evaluate the module's effectiveness by collecting and analyzing data from pretests and posttests to measure improvements in students' critical thinking abilities. Statistical methods such as the independent t-test are used to determine the significance of differences between the experimental and control groups [40], [41]. This analysis is conducted using the statistical package for the social sciences (SPSS) program, which provides robust tools for managing and analyzing quantitative data. SPSS enables researchers to perform a variety of statistical tests to assess data trends, relationships, and patterns, ensuring the reliability and validity of the study's findings. Based on trial and evaluation results, the module is refined, considering feedback from learners and educators. This revision ensures that the final module has been optimized for effectiveness in learning [22].

2.5. Data analysis

Data were collected through pretests and posttests to measure students' critical thinking abilities before and after the module implementation. These tests include questions designed to assess aspects of critical thinking, such as analysis, evaluation, and synthesis of information [20]. The collected data were analyzed using statistical methods, such as the independent t-test, to determine whether there is a significant difference between the experimental and control groups [35]. This includes calculating N-gain scores to assess improvements in critical thinking abilities.

Practicality is assessed through scores reflecting the material's quality, language clarity, and display interest as perceived by the learners. The criteria for practicality are based on a Likert scale, where scores nearing the maximum indicate higher practicality. The scores of 96 for material, 97 for language, and 94 for display interest, with an average of 96, suggest that the module is considered highly practical by the learners. These criteria and their interpretation are grounded in established educational research methodologies, which have been documented in the literature [42]. This literature provides the framework for our practicality assessment and supports the validity of our findings.

The analysis results are interpreted to understand the module's effectiveness. In this context, effectiveness is measured using the N-gain value, which is a standard method for assessing the improvement in students' conceptual understanding following an educational intervention. An N-gain value of 0.41 is categorized as effective according to the criteria established by Hake [43] in his research on interactive learning. These criteria have been widely used in educational research to evaluate changes in students' conceptual understanding. This reference will be further elaborated in the data analysis section, providing scientific justification for the claims of effectiveness of the developed module. For instance, a significant increase in posttest scores or high N-gain values indicates the module's effectiveness in enhancing critical thinking [40]. Results are analyzed in the context of existing literature and previous research to draw meaningful conclusions about the module's effectiveness [41].

3. RESULTS

3.1. Initial information gathering

At the start of the study, the researcher identified the importance of science and social studies subjects at primary school (SD) Negeri 5 Penengahan, particularly in the context of developing students' abilities to solve everyday problems. To comprehend the challenges encountered in science learning, the researcher conducted direct observations in a classroom of 29 fourth-grade students. These observations revealed several key issues: i) Science learning was teacher-focused, leading to students being less independent when the teacher was not present in the classroom; ii) It was observed that students were not actively engaged in the learning process; iii) The learning methods used were not optimal; iv) The existing learning modules did not support student activities and were not aligned with their needs; and v) The modules used did not facilitate students to think critically in analyzing problems and seeking appropriate solutions.

Next, the researcher conducted preliminary research that involved identifying learning processes and collecting documents of learning outcomes in the fourth grade. The purpose of this step was to gather empirical data that would serve as the foundation for developing the SETS-based module. This research also included a literature review covering journal analysis, learning objectives, and the flow of learning objectives. The results of this preliminary research were then taken into consideration in the design and development of the natural and social sciences (IPAS) Module, ensuring that the developed module matched the students' needs and profiles and the subjects studied.

3.2. Product planning

The planning of the product for the learning module is a pivotal step in this research, focusing on the development of a module that is integrated with the SETS approach. The product planning phases included

the creation of the module cover, module description, concept maps, and learning activities designed to support the enhancement of students' critical thinking skills. The module cover was crafted to be visually appealing to students, featuring images that resonate with their lives. The module's title and its purpose were articulated clearly, offering an initial overview of the module's content and objectives. This section introduces the module description and the SETS learning trajectory, beginning with the initiation stage, progressing to exploration, application, and then to concept comprehension. It aids students in grasping the learning structure and enables them to systematically follow the content flow. The subsequent section of the module comprises concept maps for the lesson material alongside SETS concept maps, aimed at giving students a lucid picture of what they will learn and how the material connects to the SETS concepts. In the concept reinforcement part, students engage in direct observations through simple experiments, for instance, concerning changes in substances. The explicit guidance provided in the module is anticipated to assist students in independently discovering the concept of substances. The application phase offers examples of the utilization of changes in states of matter in daily life, particularly within the realm of technology. This detailed description aims to demonstrate the innovative aspects of the developed product, highlighting its unique features and the specific, new approach it brings to SETS integrated learning.

3.3. Design development

The SETS module design development process involved product validation by experts in several critical fields. The module's validity was obtained based on assessments by experts and practitioners for content and constructiveness. The validation process, conducted by three validators and six educators as practitioners aimed to validate the developed product to ensure it met the development requirements and was valid for testing. The module was packaged following the SETS learning model syntax.

Research findings indicated that the designed SETS-based module had been tested "valid" for application in fourth-grade IPAS learning, specifically on the water cycle topic. Content validation assessed whether the module's content was in line with SETS principles and whether the quality of content met educational standards. The assessment by the content expert resulted in an average score of 0.92, which falls into the "highly valid" category, according to the specified criteria [44]. However, to enhance the method section, it is necessary to define the validation criteria that associate specific scores with corresponding validity categories or to provide reference sources that outline these validation criteria. This will clarify how the score of 0.92 aligns with the "highly valid" classification and will substantiate the module's alignment with SETS principles and its high-quality content.

The media components within the module underwent a rigorous validation process to assess their didactic, constructional, and technical quality. This process yielded an average validation score of 0.87, also categorizing it as "highly valid." according to the specified criteria [44]. This score suggests that the media elements are well-crafted, enhance the learning experience, and effectively present the educational content. The language component of the module underwent a validation process, focusing on the clarity, communicativeness, appropriateness of writing, and the correct use of terms and symbols. This validation used a scoring range on a 1-5 scale, with the language aspect receiving an average score of 0.90, which places it in the "highly valid" category. This indicates that the module's language is clear, easily understandable, and effectively facilitates communication with students. It is important to note this scoring scale in the methods section of evaluation and data analysis to provide clarity on how the average scores were derived. The same clarity should be applied when reporting average scores for other data sets.

The pedagogical aspect of the module was reviewed to assess the learning components, conformity with Indonesian language rules, the module's ability to motivate learners, foster curiosity, problem orientation, organizing learners for study, development and presentation of outcomes, evaluation, and the application of the SETS model in the module. The result achieved an average score of 0.93, placing it in the "highly valid" category. This indicates that the module has been designed considering important pedagogical aspects to support an effective teaching and learning process.

Assessment validation was an important process in this research, aiming to ensure that the instruments used to measure learners' critical thinking abilities met the expected standards. With a score of 0.81, the substance aspect indicates that the overall content of the instrument is valid. This means that the questions in the instrument accurately reflect the aspects intended to be measured, namely students' critical thinking. However, this score also indicates room for further improvement.

A score of 0.78 on the construction aspect indicates adequate validity in the way questions are designed and structured. This is important to ensure that questions can be effectively answered by students and that they clearly measure the desired aspect. With a score of 0.75, the language aspect indicates that the language used in the instrument is sufficiently valid, but still requires improvement, particularly in terms of readability and comprehension. The suggestion given is to pay attention to the writing rules with conjunctions, which is important to ensure that the instrument is easily understood by students. Based on these validation results, it can be concluded that the assessment instrument is in the valid classification with

an average score of 0.78. However, there are some areas that need to be improved to enhance the quality of the instrument, especially in terms of language and question construction.

The validation of the environmental love instrument was conducted to assess the extent to which the instrument is capable of measuring attitudes of environmental love as a corollary effect of the use of the SETS-based module. A score of 0.66 in this aspect indicates that the instrument is sufficiently valid in measuring environmental love attitudes. This signifies that the questions in the instrument are valid enough in assessing students' attitudes towards the environment. However, this score also indicates a need for further refinement and sharpening of the instrument. Based on this validation, the environmental love instrument was deemed sufficiently valid, with a score of 0.66. Similar to the assessment instrument, the suggestion given is to pay attention to writing rules, including the use of conjunctions, which will improve the readability and effectiveness of the instrument.

The comprehensive validation suggests that the developed SETS-based module contains high-quality and relevant material, and supports the learning process. However, to claim effectiveness in enhancing students' critical thinking skills, empirical evidence from actual classroom implementation is required beyond expert and practitioner validation. Validation by experts is an important step to ensure that the developed module meets high educational standards and is effective for use in the learning environment. Based on all the validation results by experts, it is concluded that the developed module is in accordance with the process standards and has gone through the development research stages according to the Borg and Gall method, thus considered valid and suitable for use in learning [30]. After the validation process, the next stage was the improvement and refinement of the module based on suggestions and comments given by the validators. Data obtained from the validation results indicate that the product already meets the criteria of being theoretically, thus it can be used by learners.

3.4. Initial small-scale group trial

The initial small-scale group trial is an important step in this research to assess the effectiveness of the SETS-based module in enhancing learners' critical thinking abilities. This trial involved 10 fourth-grade students from SD Negeri 5 Penengahan, selected based on their IPAS PAS scores, with representation from high, medium, and low ability groups. This trial was designed to observe changes in learners' critical thinking abilities after using the module. Learners were given a pretest before and a posttest after using the module.

Based on the pretest and posttest results, there was an increase in the average score from 47 to 64, with an N-gain value of 0.41, indicating a "moderate" improvement in critical thinking skills. This suggests that the SETS-based module is effective in enhancing critical thinking abilities in this small group. These results provide a positive indication that the module can be used on a larger scale, with revisions and adjustments based on field conditions and feedback from this trial.

3.4.1. Learner practicality test

The practicality test was conducted to determine the learners' response to the feasibility of the developed module. This test involved 10 learners as the target for the teaching material needs survey. Data were collected through questionnaires filled out by the learners and analyzed descriptively with a qualitative approach using a Likert scale. The scores obtained showed very positive results for the material (96), language (97), and display interest (94), with an average of 96, indicating that the module is highly practical from the learners' perspective.

3.4.2. Practitioner’s test

The practitioner test was conducted to assess educators' response to the feasibility of the developed module. This test involved 6 educators as the target for the teaching material needs survey. Similar to the practicality test, data were collected through questionnaires filled out by the educators and analyzed descriptively using a Likert scale. The practitioner assessment scores by educators yielded very positive values for material aspects (90), language (90), module presentation (96), graphics (92), and proportional print margin (93), with an average of 94, indicating that the module is highly practical from the educators' perspective.

3.5. Main product trial

After the SETS-based module was declared valid through the revision stage, a main product trial was conducted in the field. This trial was held in class four A of SD Negeri 1 Penengahan with 25 learners. As an initial step, the learners were given a pretest to assess their critical thinking skills before learning using the module. After participating in the learning process, a posttest was conducted to measure changes in critical thinking abilities. The main product trial aimed to evaluate the effectiveness of the SETS-based module in enhancing learners' critical thinking skills. Evaluation was performed through the analysis of pretest and posttest data and the calculation of N-gain values from 15 multiple-choice questions. The

effectiveness of the module was tested by comparing the experimental and control groups using an independent sample t-test.

Hypothesis testing was conducted using the Sig (2-tailed) criterion, with the alternative hypothesis (Ha) being accepted if Sig is less than 0.05 and the null hypothesis (H0) being rejected if Sig is greater than 0.05. The hypothesis statements for the statistical tests used are as follows: for the independent sample t-test, the null hypothesis (H0) posits that there is no significant improvement in critical thinking skills between the pretest and posttest scores, while the alternative hypothesis (Ha) suggests that there is a significant improvement. The normality test's null hypothesis (H0) assumes that the pretest and posttest data are not normally distributed, whereas the alternative hypothesis (Ha) contends that they are normally distributed. Lastly, for the homogeneity test, the null hypothesis (H0) states that the variances of posttest data are not homogeneous, and the alternative hypothesis (Ha) indicates that they are homogeneous. These hypotheses are integral in interpreting the results of the independent sample t-test, which showed a significant improvement in critical thinking skills, as well as the normality and homogeneity tests.

The analysis of the students' critical thinking ability test in this study was conducted by comparing the pretest and posttest results between the experimental (E) and control (K) classes. Table 1 indicates that for the normality test, both for the pretest and posttest, the significance values (Sig.) for both classes were greater than 0.05 (Sig. 0.199 for E and 0.058 for K in the pretest; Sig. 0.171 for E and 0.124 for K in the posttest). This suggests that the distribution of critical thinking test scores in both the experimental and control classes is normally distributed. Furthermore, in the homogeneity test for the posttest, the Sig. value is 0.144, which is greater than 0.05, indicating that the variance of data in both groups is homogeneous. Most importantly, the results of the independent sample t-test on the posttest (Sig. 0.00) show a significant difference between the experimental and control classes. This indicates that the use of the SETS-based module in the experimental class had a significant impact on improving critical thinking abilities compared to the control class that did not use the module.

Additionally, Table 2 presents the average N-gain scores for both groups. In the experimental class, the average pretest score was 58.1, which increased to 86.4 in the posttest, resulting in an N-gain of 0.52, which falls within the medium category An N-gain value of 0.52 is categorized as effective according to the criteria established by Hake [43] in his research on interactive learning. Meanwhile, the control class had an average pretest score of 57.5 and a posttest score of 64.7, with an N-gain of only 0.22. The stark difference in N-gain between the two groups indicates that learning with the SETS-based module is significantly more effective in enhancing critical thinking abilities compared to the conventional teaching methods applied in the control class.

Table 1. Analysis of students' critical thinking ability test

Data	Group	Normality test	Homogeneity test	Independent sample t-test	Note
Pretest	Experiment	Sig.0.199>0.05			
	Control	Sig.0.058>0.05			
Posttest	Experiment	Sig.0.171>0.05	Sig. 0.144>0.05	Sig. 00<0.05	Difference exists
	Control	Sig.0.124>0.05			

Table 2. Average N-gain for experimental and control classe

No	Pre experimental	Post experimental	Pre control	Post control	N gain experimental	N gain control
Average	58.1	86.4	57.5	64.7	0.52	0.22

Thus, the results of the analysis demonstrate that the implementation of the SETS-based module in the experimental class contributed significantly to the enhancement of the students' critical thinking abilities, compared to the control class, which did not use the module. This provides strong evidence of the effectiveness of the SETS-based module in improving critical thinking abilities in an elementary school learning environment. The analysis of the effect size test was conducted to evaluate the magnitude of the impact produced by the implementation of the SETS-based module on the critical thinking abilities of students. From Table 3, it is evident that the effect size test involved two groups, namely the experimental class and the control class, focusing on the comparison of the average pretest and posttest scores as well as their respective standard deviations. The experimental class, which utilized the SETS-based module, exhibited a significant increase from an average pretest score of 58 to a posttest score of 86, with the standard deviation decreasing from 8 at the pretest to 7 at the posttest. This reduction in standard deviation indicates that the posttest scores in the experimental class were more consistent compared to the pretest scores. Meanwhile, the control class, which did not use the module, also showed an improvement, but to a lesser extent, from an

average pretest score of 58 to a posttest score of 65, with the standard deviation decreasing from 9 to 8. Although there was an increase, it was not as substantial as that observed in the experimental class.

An effect size of 0.8 is interpreted as indicating a large impact, according to Cohen's conventions [45]. This significant effect size suggests that the implementation of the SETS-based module in the experimental class has a substantial influence on enhancing students' critical thinking abilities. The magnitude of this effect is further supported by the pronounced difference in score improvements between the experimental and control classes. The criteria for interpreting effect sizes are as follows: 0.2 to 0.3 might be considered a small effect, around 0.5 a medium effect, and 0.8 or higher a large effect [45].

Table 3. Analysis of effect size test

No	Group	Average		Standard deviation		Effect size result
		Pretest	Posttest	Pretest	Posttest	0.8
1	Experimental	58	86	8	7	High category
2	Control	58	65	9	8	

In conclusion, the effect size test provides strong evidence that the use of the SETS-based module in the experimental class is highly effective in improving the critical thinking abilities of students compared to the teaching methods employed in the control class. These results affirm the importance of utilizing innovative learning approaches, such as the SETS-based module, in enhancing the quality of education, particularly in the aspect of critical thinking. The analysis of the critical thinking ability indicators of students in this study was conducted by comparing the average scores of the experimental and control classes on pretests and posttests. The four critical thinking indicators measured included establishing basic skills, drawing conclusions, providing explanations, and organizing strategies Table 4.

Table 4. Results of the interpretation of critical thinking ability indicators

No.	Critical thinking indicator	Question number	Average score experimental group			Average score control group		
			Pretest	Posttest	%	Pretest	Posttest	%
1	Building basic skills	2 and 13	56	88	57	56	69	23
2	Drawing conclusions	1, 3, 7, 9, 10, 11, 12, and 14	58	84	45	58	62	7
3	Providing explanation	4 and 5	65	79	70	58	63	9
4	Managing strategies	6, 8, 15	54	92	22	57	69	21
Average			58	86	48	58	64	10

The experimental group showed a significant improvement in building basic skills, with their average score increasing from 56 to 88, indicating a 57% improvement after the intervention. In contrast, the control group showed a smaller increase from 56 to 69, marking a 23% improvement. For the indicator of drawing conclusions, the experimental group's average score rose from 58 to 84, which is a 45% improvement. The control group experienced a minimal increase in their average score, going from 58 to 62, equating to only a 7% improvement. In providing explanations, the experimental group's average score increased from 65 to 79, showing a substantial 70% improvement. The control group, however, only improved by 9%, from an average score of 58 to 63. The experimental group’s average score for managing strategies significantly increased from 54 to 92, demonstrating a 22% improvement. The control group also showed an improvement, with their average score increasing from 57 to 69, which is a 21% improvement.

The overall average scores across all indicators show that the experimental group had an average improvement of 48%, improving from 58 to 86. The control group had a far less significant average improvement of 10%, with scores increasing from 58 to 64. This data suggests that the intervention had a notable positive impact on the experimental group's critical thinking abilities across all indicators, while the control group showed much smaller improvements. The greatest improvements in the experimental group were seen in providing explanations and managing strategies, while the least improvement was observed in drawing conclusions. The control group’s improvements were modest across all indicators.

4. DISCUSSION

4.1. Preliminary study and module development

This research began by identifying the importance of science and social studies subjects at SD Negeri 5 Penengahan, focusing on developing students' abilities to solve everyday problems. Direct observations in a fourth-grade class revealed several key issues in science learning, including teacher-

dominated instruction and a lack of student engagement, indicating a need for a more effective learning approach [46]. Teacher-centered learning processes tend to impede student independence [47]. Moreover, there was a deficiency in learning modules that did not support student activities and critical thinking, consistent with literature findings that highlight the importance of learning modules supporting active student engagement [48].

The subsequent step was preliminary research, including a literature review focused on journal analysis, learning objectives, and the flow of learning goals. This research produced a strong empirical basis for developing a SETS-based module, highlighting the importance of learning materials that match students' needs and profiles [49].

4.2. Module planning and development process

In product planning, this research developed a module integrated with the SETS approach. This approach was chosen due to its effectiveness in enhancing students' critical thinking abilities, consistent with previous studies that underscored the importance of integrating SETS in education [13]. The creation of an attractive module cover and a clear module description were designed to increase student interest and facilitate their understanding of the material [50].

4.3. Module validation

The module validation process involved assessments by experts in various fields, including content, media, language, and pedagogy. Validation results indicated that the module was highly consistent with SETS principles and contained high-quality content supporting effective learning and was communicative and clear in its use [51]. Validation of assessment and environmental love instruments also demonstrated instrument effectiveness in measuring critical thinking and environmental love attitudes, consistent with high educational standards [52].

Considering the validation results and expert recommendations, the SETS-based module developed was deemed to meet process standards and suitable for use in learning, according to Borg and Gall's method [30]. This indicates that the module has undergone adequate development research stages and is ready for implementation in classroom learning. Based on a comprehensive development and validation process, the module developed in this research has been proven to meet criteria for effectiveness and practicality and is ready for field testing. This confirms that the approach used in this research has successfully produced a valid learning module with potential for enhancing students' critical thinking skills.

4.4. Initial small-scale group trial

In this research, an initial small-scale group trial played a vital role in evaluating the effectiveness of the SETS-based module on enhancing learners' critical thinking abilities. Involving 10 students from the fourth grade of SD Negeri 5 Penengahan, this study highlighted representation from various ability groups. An increase in average scores from 47 to 64, with an N-gain score of 0.41, significantly demonstrated the module's effectiveness. This aligns with research indicating the importance of innovative learning approaches in developing students' cognitive abilities [53], [54]. This finding suggests that the use of the module can be expanded on a larger scale, consistent with literature emphasizing the importance of adapting teaching materials to field conditions [49].

The practicality test, involving 9 learners, evaluated the feasibility of the module from the user's point of view. Through a questionnaire analyzed descriptively and qualitatively using a Likert scale, very positive results were obtained in the aspects of material, language, and display attractiveness. The average score of 96 indicated that the module was very practical from the learners' perspective. Previous research has shown that students' involvement in the learning process and their perception of the learning materials greatly influence their learning outcomes [55].

The practitioner test, involving 6 educators, evaluated educators' responses to the module's feasibility. Similar to the practicality test, the method used was a questionnaire with descriptive analysis and a Likert scale. The results showed very positive scores for material, language, module presentation, graphics, and proportional margin printing aspects, with an average of 94. This indicates that the module is also highly practical from the educators' perspective. These findings are consistent with research by Guskey[56] which emphasizes the importance of educators' opinions and responses in developing learning materials.

The initial trials and practicality evaluations conducted in this research demonstrate that the SETS-based module is effective and practical, both from the learners' and educators' perspectives. These results underscore the importance of developing learning modules designed to meet the specific needs of the learning environment and focusing on enhancing students' cognitive abilities. This research contributes significantly to the development of innovative and effective learning modules in the context of elementary education.

4.5. Main product trial

This study conducted a main product trial on the revised and validated SETS-based module. The trial was carried out in fourth grade A of SD Negeri 1 Penengahan with 25 students. The evaluation process involved pretests and posttests to measure the effectiveness of the module in enhancing critical thinking skills. Analysis of pretest and posttest data, along with the calculation of N-gain from 15 multiple-choice questions, allowed for the assessment of the module's impact on students' critical thinking abilities. The effectiveness of this module was tested by comparing the experimental and control groups using an independent sample t-test [45].

The results of the independent sample t-test indicated a significant improvement in students' critical thinking abilities. Tests of normality and homogeneity confirmed that the pretest and posttest data were normally distributed and homogeneous between both groups [35]. From the analysis, it was concluded that the SETS-based module significantly impacted enhancing students' critical thinking abilities, as evidenced by the increase in scores from pretest to posttest. An effect size analysis was conducted to evaluate the magnitude of the impact of implementing the SETS-based module. The results showed a significant difference between the experimental and control groups. The experimental class, which used the module, experienced a greater increase compared to the control class that did not use the module, as seen from changes in average scores and standard deviations. An effect size of 0.8, categorized as high [45] indicates that the module has a significant influence on improving students' critical thinking skills.

Further discussion regarding critical thinking ability indicators showed significant improvements across various aspects of critical thinking, including establishing basic skills, drawing conclusions, providing explanations, and organizing strategies [20]. The greatest increase was observed in the indicator of organizing strategies in the experimental class. These findings are consistent with previous research that highlights the importance of innovative learning approaches in developing students' cognitive abilities [53].

This study demonstrates that the SETS-based module is effective in enhancing students' critical thinking skills. This effectiveness is evident not only from the significant increase in N-gain scores in the experimental class but also from the high effect size. The results of this study support the use of innovative learning approaches in elementary education to improve critical thinking skills.

5. CONCLUSION

This research successfully developed a learning module integrating SETS concepts within the context of elementary education in Indonesia. Designed to enhance fourth-grade students' critical thinking skills, this module has demonstrated its effectiveness through a series of validations, preliminary trials, and main product trials. Research findings show a significant improvement in students' critical thinking abilities measured through pretests and posttests. This improvement is reflected in N-gain values indicating medium effectiveness of the module. Effect size analysis further confirms the significant impact of this module's implementation, with a notable difference between experimental and control groups. This indicates the success of the SETS-based module in sharpening students' critical thinking skills, an essential skill for the 21st-century.

Moreover, the module also proved practical and appealing from both student and educator perspectives based on practicality tests and practitioner assessments. This indicates that the module is well-received and effective in real educational settings. In conclusion, this study succeeded in developing a learning module that is not only theoretical and meets educational standards but is also practical, engaging, and effective in improving elementary students' critical thinking skills. The module offers an innovative and contextual approach to science education, supporting the development of essential critical thinking skills for students to face future challenges.

This study, while successful in many respects, has several limitations that must be acknowledged. First, it was limited to a sample of fourth-grade students from SD Negeri 1 Penengahan, which may not fully represent the diversity of elementary school student populations in other areas. Therefore, its results may not be generalizable to a broader educational context. Second, it used a learning module specifically designed for a particular topic (the water cycle) within science and social studies subjects. This limits the scope of research to evaluate the effectiveness of SETS modules in a broader context or other learning topics. Third, the timing and duration of this research were also limited, which may affect the ability to fully assess the long-term impact of SETS modules on students' development of critical thinking skills.

Based on these limitations, recommendations for future research include conducting similar studies across different geographical locations and educational contexts to assess the effectiveness of SETS modules among more diverse populations and in various educational settings. Developing and evaluating SETS modules for different topics within science and social studies subjects, as well as applying them across various elementary school grades, to gain a more comprehensive understanding of their effectiveness.

Undertaking long-term studies to evaluate the sustained impact of SETS modules on the development of critical thinking skills and overall student academic performance. Investigating further factors influencing the effectiveness of SETS modules, including teachers' teaching styles, learning environments, and individual student characteristics. Integrating technology and other innovative learning methods into SETS modules to enhance student engagement and motivation and enrich their learning experiences.

REFERENCES

[1] R. Ennis, *Critical thinking*. Prentice Hall, 1996.
[2] P. A. Facione, *Critical thinking: What it is and why it counts*. 2015.
[3] R. Paul and L. Elder, *The miniature guide to critical thinking concepts and tools*. 2019.
[4] B. Trilling and C. Fadel, *21st century skills: Learning for life in our times*. US: Jossey-Bass/Wiley, 2009.
[5] G. ten Dam and M. Volman, "Critical thinking as a citizenship competence: Teaching strategies," *Learning and Instruction*, vol. 14, no. 4, pp. 359–379, Aug. 2004, doi: 10.1016/j.learninstruc.2004.01.005.
[6] R. Paul and L. Elder, "Critical thinking: The nature of critical and creative thought," *Journal of Developmental Education*, vol. 30, no. 2, p. 34, 2006.
[7] S. D. Brookfield, *Teaching for critical thinking: Tools and techniques to help students question their assumptions*. Wiley, 2011.
[8] L. Johnson, R Burke Christensen, *Educational research: Quantitative, qualitative, and mixed approaches*. SAGE Publications, 2016.
[9] M. Prensky, "Digital natives, digital immigrants part 1," *On the Horizon*, vol. 9, no. 5, pp. 1–6, Sep. 2001, doi: 10.1108/10748120110424816.
[10] J. Voogt and N. P. Roblin, "A comparative analysis of international frameworks for 21 st century competences: Implications for national curriculum policies," *Journal of Curriculum Studies*, vol. 44, no. 3, pp. 299–321, Jun. 2012, doi: 10.1080/00220272.2012.668938.
[11] M. Binkley *et al.*, "Defining twenty-first century skills," in *Assessment and Teaching of 21st Century Skills*, Dordrecht: Springer Netherlands, 2012, pp. 17–66.
[12] M. Astuti, B. Manurung, and J. Juriani, "The effect of science, environment, technology, and society (SETS) approach assisted by visual media on critical thinking ability and students' scientific attitudes in the material of living creator classification," *ISER (Indonesian Science Education Research)*, vol. 1, no. 1, Nov. 2019, doi: 10.24114/iser.v1i1.15497.
[13] R. W. Bybee, *The case for STEM education: Challenges and opportunities*. NSTA press, 2013.
[14] R. Tytler, "STEM education for the twenty-first century," in *Integrated Approaches to STEM Education: An International Perspective*, 2020, pp. 21–43.
[15] N. L. G. K. Widiastuti and I. P. E. Purnawijaya, "Improving science learning outcomes through the SETS (science environment technology and society) approach," *Indonesian Journal Of Educational Research and Review*, vol. 4, no. 2, p. 252, Oct. 2021, doi: 10.23887/ijerr.v4i2.38388.
[16] S. Erduran and Z. R. Dagher, *Reconceptualizing the nature of science for science education*. Dordrecht: Springer Netherlands, 2014.
[17] H. Taha, V. Suppiah, Y. Y. Khoo, A. Yahaya, T. T. Lee, and M. I. Muhamad Damanhuri, "Impact of student-initiated green chemistry experiments on their knowledge, awareness and practices of environmental sustainability," *Journal of Physics: Conference Series*, vol. 1156, p. 012022, Jan. 2019, doi: 10.1088/1742-6596/1156/1/012022.
[18] M. Littledyke, "Science education for environmental awareness: Approaches to integrating cognitive and affective domains," *Environmental Education Research*, vol. 14, no. 1, pp. 1–17, Feb. 2008, doi: 10.1080/13504620701843301.
[19] M. Karpudewan, W.-M. Roth, and M. N. S. Bin Abdullah, "Enhancing primary school students' knowledge about global warming and environmental attitude using climate change activities," *International Journal of Science Education*, vol. 37, no. 1, pp. 31–54, Jan. 2015, doi: 10.1080/09500693.2014.958600.
[20] M. D. Bloom, Benjamin Samuel Engelhart, E. J. Furst, W. H. Hill, and D. R. Krathwohl, "Taxonomy of educational objectives: The classification of educational goals," in *Handbook 1: Cognitive domain*, McKay New York, 1956.
[21] Z. Putra, A. Kaharudin, B. Rahim, and R. Nabawi, "The practicality of learning module based on jigsaw-cooperativelearning model in mediaeducation course," 2018, doi: 10.2991/aptekindo-18.2018.11.
[22] J. Southworth, "Bridging critical thinking and transformative learning: The role of perspective-taking," *Theory and Research in Education*, vol. 20, no. 1, pp. 44–63, Mar. 2022, doi: 10.1177/14778785221090853.
[23] S. Freeman *et al.*, "Active learning increases student performance in science, engineering, and mathematics," *Proceedings of the National Academy of Sciences*, vol. 111, no. 23, pp. 8410–8415, Jun. 2014, doi: 10.1073/pnas.1319030111.
[24] C. Paechter, *Learning, space and identity*. London, 2001.
[25] D. Bell, "The reality of STEM education, design and technology teachers' perceptions: A phenomenographic study," *International Journal of Technology and Design Education*, vol. 26, no. 1, pp. 61–79, Feb. 2016, doi: 10.1007/s10798-015-9300-9.
[26] J. E. Pedersen and R. K. Yerrick, "Technology in science teacher education: Survey of current uses and desired knowledge among science educators," *Journal of Science Teacher Education*, vol. 11, no. 2, pp. 131–153, May 2000, doi: 10.1023/A:1009468808876.
[27] D. L. Zeidler and B. H. Nichols, "Socioscientific issues: Theory and practice," *Journal of Elementary Science Education*, vol. 21, no. 2, pp. 49–58, Mar. 2009, doi: 10.1007/BF03173684.
[28] D. L. Zeidler, K. A. Walker, W. A. Ackett, and M. L. Simmons, "Tangled up in views: Beliefs in the nature of science and responses to socioscientific dilemmas," *Science Education*, vol. 86, no. 3, pp. 343–367, May 2002, doi: 10.1002/sce.10025.
[29] S. D. Kolstø, "'g," *International Journal of Science Education*, vol. 23, no. 9, pp. 877–901, Sep. 2001, doi: 10.1080/09500690010016102.
[30] W. R. Borg and M. D. Gall, *Educational research: An introduction*. Longman, 1983.
[31] W. R. Gall, M. D, Gall, J. P, and Borg, *Educational research: An introduction*. Boston: Pearson Education, Inc, 2007.
[32] J. Piaget, "Part I: Cognitive development in children: Piaget development and learning," *Journal of Research in Science Teaching*, vol. 2, no. 3, pp. 176–186, Sep. 1964, doi: 10.1002/tea.3660020306.
[33] J. W. Creswell, *Research design: Qualitative, quantitative, and mixed methods approaches*. SAGE Publications, 2014.
[34] B. Fraser, *Classroom environment (RLE Edu O)*. Routledge, 2012.
[35] A. Field, "Discovering statistics using SPSS," in *Introducing statistical methods*, 3rd ed., London: SAGE Publications Ltd, 2013,

pp. 821–821.
[36] L. J. Cronbach, *Essentials of psychological testing*. Harper & Row, 1990.
[37] J. C. Nunnally, *Psychometric theory*. McGraw-Hill, 1978.
[38] S. Arikunto, *Research procedures: A practical approach (in Indonesian)*. Jakarta: Rineka Cipta, 2013.
[39] W. K. Listianthy, S. Sarwanto, and M. Indrowati, "Development of SETS module on light and optical devices grade 8 junior high school (in Indonesian)," *INKUIRI: Jurnal Pendidikan IPA*, vol. 10, no. 2, p. 79, Dec. 2021, doi: 10.20961/inkuiri.v10i2.57245.
[40] R. T. Sari, S. Angreni, and R. A. Fortuna, "Development of science learning modules based on constructivism approach for grade five elementary schools (in Indonesian)," *BIO-PEDAGOGI*, vol. 8, no. 2, p. 89, Nov. 2019, doi: 10.20961/bio-pedagogi.v8i2.34725.
[41] Diyah Nur Rahmawati, Tarzan Purnomo, and Sunu Kuntjoro, "Profile of SETS approach to improve student's critical thinking skills during 2015 to 2022," *IJORER : International Journal of Recent Educational Research*, vol. 3, no. 3, pp. 340–353, May 2022, doi: 10.46245/ijorer.v3i3.214.
[42] G. Trentin and E. Vallarino, "A methodological approach to develop and evaluate tools for the follow-up analysis of teacher education in e-learning," in *Teaching and education: 21st century issues and challeges*, P. R. Weigart, Ed. New York: Nova Science Publishers, 2008, pp. 175–194.
[43] R. R. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses," *American Journal of Physics*, vol. 66, no. 1, pp. 64–74, Jan. 1998, doi: 10.1119/1.18809.
[44] D. A. Cook and R. Hatala, "Validation of educational assessments: A primer for simulation and beyond," *Advances in Simulation*, vol. 1, no. 1, p. 31, Jan. 2016, doi: 10.1186/s41077-016-0033-y.
[45] J. Cohen, *Statistical power analysis for the behavioral sciences*. Routledge, 2013.
[46] D. W. Johnson and R. T. Johnson, "An educational psychology success story: Social interdependence Theory and cooperative learning," *Educational Researcher*, vol. 38, no. 5, pp. 365–379, Jun. 2009, doi: 10.3102/0013189X09339057.
[47] P. Freire, "Pedagogy of the oppressed," in *Toward a sociology of education*, Routledge, 2020, pp. 374–386.
[48] J. G. Brooks and M. G. Brooks, *In search of understanding: The case for constructivist classrooms*. Association for Supervision and Curriculum Development, 1999.
[49] C. A. Tomlinson, *How to differentiate instruction in mixed-ability classrooms*. Association for Supervision and Curriculum Development, 2001.
[50] R. E. Mayer, *Multimedia learning*, 2nd ed. New York: Cambridge University Press, 2009.
[51] R. C. Clark, R. E. Mayer, and W. Thalheimer, "E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning," *Performance Improvement*, vol. 42, no. 5, pp. 41–43, May 2003, doi: 10.1002/pfi.4930420510.
[52] W. J. Popham, *Classroom assessment: What teachers need to know*. Pearson Education, 2017.
[53] R. J. Marzano, D. Pickering, and J. E. Pollock, *Classroom instruction that works: Research-based strategies for increasing student achievement*. Association for Supervision and Curriculum Development, 2001.
[54] J. Hattie, *Visible learning*. Routledge, 2008.
[55] J. A. Fredricks, P. C. Blumenfeld, and A. H. Paris, "School engagement: Potential of the concept, state of the evidence," *Review of Educational Research*, vol. 74, no. 1, pp. 59–109, Mar. 2004, doi: 10.3102/00346543074001059.
[56] T. R. Guskey, "Professional development and teacher change," *Teachers and Teaching*, vol. 8, no. 3, pp. 381–391, Aug. 2002, doi: 10.1080/135406002100000512.

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