PILLAR OF PHYSICS EDUCATION
Vol. 19 (2), 2026, pp. 59-69
ISSN (Print) : 2337-9618
ISSN (Online) : 2684-8880

Creation of Authentic E-Assessments Based on Critical Thinking Skills Integrated with Education for Sustainable Development in Momentum and Impulse Materials

Syahdilla Azra[1*] , Emiliannur[1] , Festiyed[1] , Selma Riyasni[1]

[1]*Department of Physics, Universitas Negeri Padang, Jl. Prof. Dr. Hamka Air Tawar Padang 25131, Indonesia*
Corresponding author. Email:syhdillazra@gmail.com

ABSTRACT

The development of 21st-century technology demands learning and assessment that fosters critical thinking skills and awareness of Education for Sustainable Development (ESD), particularly in physics learning. The use of technology plays a crucial role in supporting the sustainability of the learning process, one example being the use of electronic-based assessments. One form of assessment that can be implemented is Authentic e-Assessment, which integrates critical thinking skills assessment with the context of sustainable learning. Therefore, the development of an Authentic e-Assessment based on ESD-integrated critical thinking skills for momentum and impulse topics is necessary.

This research aims to produce an Authentic e-Assessment based on ESD-integrated critical thinking skills for momentum and impulse topics that is valid and suitable for use in physics learning. This research uses a Research and Development (R&D) method based on the Dick and Carey model, which includes identifying learning objectives, analyzing learners and learning needs, analyzing learning, formulating performance objectives, developing assessment instruments, developing learning strategies, developing learning strategies and learning media, conducting formative evaluation, revising the product, and assessing its practicality. The product validation process was conducted by three physics lecturers from Padang State University (UNP) and two physics teachers from SMAN 1 Lubuk Alung using a pre-designed validation instrument.

The analysis of the validation instrument showed that the developed Authentic e-Assessment achieved a validity score of 0.83, categorized as valid. These results indicate that the developed product meets the requirements of content, construction, and language feasibility, making it suitable for use as an innovative form of assessment in physics learning. Therefore, the Authentic e-Assessment, based on critical thinking skills integrated with ESD on momentum and impulse, can be used to support the development of students' critical thinking skills.

Keywords: *Authentic assessment*, Critical thinking skills, ESD, Momentum and impulse.

I. INTRODUCTION

21st Century Education 21st century education demands a transformation of the learning paradigm that is not only oriented towards academic achievement, but also towards strengthening the character, literacy, and essential competencies of students. Social changes, digital technology developments, and the complexity of global issues require students to have higher-order thinking skills, adaptability, and data-based decision-making skills [1]. In this framework, 21st-century skills such as critical thinking, creativity, communication, and collaboration are important components in preparing a generation capable of productively facing future challenges [2].

Indonesia's education policy through the Merdeka Curriculum directs learning towards strengthening the Pancasila Student Profile, which consists of six main dimensions, namely faith and devotion to God Almighty and noble character, global diversity, mutual cooperation, independence, critical thinking, and creativity [3]. The critical thinking dimension places critical thinking skills as a competency that must be developed consistently through learning and assessment. This is in line with the demands of modern education, which emphasizes that

critical thinking skills are an important prerequisite for students to be able to solve complex problems, assess the accuracy of information, and construct logical arguments that can be justified [4].

Critical thinking is generally understood as the ability to interpret, analyze, evaluate, and conclude information rationally, accompanied by the ability to explain reasons and consider relevant evidence [5]. This ability is not only a cognitive skill but also involves dispositions such as open-mindedness, scientific curiosity, and caution in decision-making [6]. In physics learning, critical thinking is very important because physics requires not only mastery of mathematical formulas, but also understanding of concepts, the ability to connect theory with real phenomena, and evidence-based reasoning [7]. Physics, as a science that studies natural phenomena, requires students to construct conceptual models, test hypotheses, and interpret data scientifically [8].

Critical thinking can be strengthened through learning that places students as active subjects, for example through problem-based learning, project-based learning, inquiry, and contextual experiments [9]. However, the success of such learning is largely determined by the assessment used. Assessment cannot be understood merely as an activity to measure learning outcomes at the end of learning, but also as an integral part of the learning process that can guide students' thinking [10]. Well-designed formative assessments have been shown to improve the quality of learning because they provide feedback that helps students understand their weaknesses and improve their learning strategies [11].

Assessments that support critical thinking skills must be designed to encourage learners to engage in higher-order thinking processes, such as analyzing information, evaluating evidence, comparing alternative solutions, and developing logical arguments [12]. In this case, authentic assessment is relevant because it emphasizes assessment based on real tasks, performance, and contextual experiences that are close to the lives of students [13]. Authentic assessment not only assesses the final product but also the students' thinking process in completing the task. Thus, authentic assessment can help students develop reflective skills, self-evaluation, and responsibility for learning [14]. In order for authentic assessment to measure critical thinking more objectively, a clear and structured assessment rubric is needed so that teachers can assess students' analytical, inferential, and clarification skills consistently [15].

In the context of global education, critical thinking skills also need to be linked to Education for Sustainable Development (ESD). UNESCO emphasizes that ESD aims to equip students with the knowledge, skills, values, and attitudes necessary to contribute to sustainable development [16]. ESD encourages students to understand the interrelationships between environmental, social, and economic dimensions and to develop an awareness that every decision has a long-term impact on the sustainability of life [17]. The integration of ESD in physics learning is considered relevant because physics is closely related to issues of energy, technology, transportation, and the environment. Through this approach, physics learning not only focuses on concepts but also on the meaning of concepts to solve real problems such as energy efficiency, transportation safety, and environmental impact mitigation [18].

One area of physics that has great potential for developing critical thinking skills is momentum and impulse. This material requires a strong conceptual understanding of the relationship between force, mass, time, and momentum change, as well as its application in various phenomena such as vehicle collisions, sports, occupational safety, and transportation technology [19]. The concepts of momentum and impulse also have strong relevance to sustainability issues, for example, in the aspects of public transportation safety, environmentally friendly vehicle design, and engineering technology that minimizes the risk of accidents [20]. However, various studies show that students still experience difficulties and misconceptions in momentum and impulse material, especially in understanding the concept of impulse as a change in momentum and distinguishing between impulsive and constant forces [21]. These difficulties are often influenced by low conceptual understanding, weak graph interpretation skills, and a lack of context-based practice questions [22].

This condition is in line with the results of a preliminary study conducted at SMAN 1 Lubuk Alung through interviews with physics teachers and diagnostic tests of critical thinking skills given to students in class XI Phase F. The results of the analysis show that students' critical thinking skills are still in the low category. The building basic skills indicator only reached 35%, while the making inference and advanced clarification indicators also did not show optimal results. This indicates that students still have difficulty analyzing information, drawing conclusions, and relating physics concepts to real phenomena.

In addition, the interview results showed that the assessments used in physics learning were still dominated by multiple-choice and essay questions sourced from textbooks, without being equipped with a rubric for assessing critical thinking skills. Assessment patterns that are too oriented towards final results tend to be less able to facilitate students in developing higher-order thinking skills because students only focus on right or wrong answers without understanding the reasoning process required [23]. On the other hand, assessments that measure critical thinking require questions and tasks that demand argumentation, explanation, and justification based on concepts and evidence [24]. Teachers also stated that the implementation of authentic assessment has

not been carried out consistently due to limited understanding and the unavailability of structured assessment guidelines.

This problem is reinforced by the results of a student needs survey, which shows that 67% of students stated that technology has not been optimally involved in the physics assessment process. Most assessments are still carried out conventionally using paper, so the feedback received by students tends to be slow and superficial. In fact, quick and targeted feedback is an important factor in improving learning quality because it helps students identify conceptual errors and correct them immediately [11]. This condition has an impact on the low motivation of students to reflect on their learning outcomes and the underdevelopment of critical self-evaluation skills.

The development of digital technology provides opportunities to improve the quality of assessment through the implementation of e-assessment. E-assessment allows teachers to present questions and assignments interactively, provide automatic feedback or rubric-based feedback, and manage learning outcome data more effectively [25]. Various studies show that technology-based assessments can increase student engagement, encourage learning reflection, and support the development of critical thinking through a variety of questions and richer contexts [26]. However, the implementation of e-assessment in schools still faces challenges, particularly related to infrastructure readiness, teacher digital literacy, and the ability to design assessments that are in line with learning objectives [27].

Therefore, assessment innovations are needed that are not only technology-based but also authentic and integrated with ESD. These innovations are expected to address the need for contextual, challenging physics learning that is relevant to students' lives. This study aims to test the validity of an ESD-integrated Critical Thinking Skills-based Authentic E-Assessment product on momentum and impulse material as an alternative assessment that is in line with the demands of the Merdeka Curriculum and 21st-century learning. This product was developed through the Liveworksheet and Wizer.me digital platforms so that students have access to assessments that are more interesting, interactive, and encourage the strengthening of critical thinking skills. In addition, this research is expected to be the first step in encouraging teachers to be more active in developing and using technology-based assessments, so that physics learning becomes more innovative, effective, and oriented towards 21st-century competencies.

II. METHOD

The researchers used the 4D model R&D (Research and Development) development research method. The research stages were limited to three development stages, namely the definition stage, the design stage, and the development stage. The dissemination stage was not carried out due to time constraints in its completion. This development research aims to produce an ESD-integrated critical thinking-based Authentic e-Assessment on the subject of momentum and impulse to support valid critical thinking skills in high school students.

This research began with the definition stage, which was used to determine and define the needs in the learning process. Next, it entered the planning (design) stage, which aimed to design an authentic physics e-Assessment to be used in learning. At this stage, the design most suitable for the conditions and characteristics of the students was carried out. The next stage was the development stage, which consisted of feedback and testing by experts. Expert validation was used to determine the feasibility of the e-Authentic Assessment that had been created and to obtain suggestions from experts.

This research was conducted at SMAN 1 Lubuk Alung and the Physics Department of Padang State University (UNP). This research was conducted in the even semester of the 2024/2025 academic year. The research subjects used were three physics lecturers from FMIPA UNP and two teachers at SMAN 1 Lubuk Alung as validators to test the validity of ESD-integrated Critical Thinking Ability-Based Authentic eAssessment. The object of this research was the ESD-integrated Critical Thinking Skills-Based Authentic Assessment on the subject of Momentum and Impulse to support high school students' critical thinking skills.

The data used in this study was primary data. Primary data is data obtained directly from the research subjects. The data obtained from the validators was in the form of a questionnaire to test the validity of the ESD-integrated critical thinking skills-based authentic assessment on the subject of momentum and impulse to support high school students' critical thinking skills. The validation score was obtained by analyzing the instruments provided and filled out by the validators. The validation assessment covered several aspects, including content appropriateness, language use, presentation appropriateness, and graphics to support high school students' critical thinking skills.

The data obtained from the validation process was analyzed using the Aiken validity index to determine the suitability and validity of the eAuthentic Assessment that was created. The validity analysis used a Likert scale from 1 to 5 and was then processed using the Aiken formula to obtain the validity coefficient [28]. The Aiken V formula is as follows:

$$V = \frac{\Sigma s}{[n\,(c-1)]} \text{ x100} \quad (1)$$

The final calculation results determine whether the Authentic eAssessment meets the predetermined validity criteria. The criteria used can be seen in Table 1 below.

Table 1. Product Validity Criteria

Interval	Assessment
V < 0.8	Not Valid
V > 0.8	Valid

III. RESULTS AND DISCUSSION

The purpose of this research is to produce an Authentic Assessment Based on Integrated Critical Thinking Skills for Education Sustainable Development in Momentum and Impulse Material, which aims to provide interactive digital assessments that are in line with technology-based learning needs, starting from several stages to produce a valid Authentic Assessment.

Define

Initial-Final Analysis

At this stage, the researcher conducted initial observations, interviews with teachers, and response questionnaires to students in class XI Phase F at SMAN 1 Lubuk Alung. The results of the study showed that the school still implements essay-based and multiple-choice assessments in the learning process. However, technology-based assessments are still limited in the implementation of these assessments. This finding was reinforced by the interview results, which revealed that assessments were still carried out manually using paper, with the aim of improving efficiency in measuring student understanding. However, in its implementation, the assessments carried out were not yet fully capable of assessing students' critical thinking skills, particularly in relating physics concepts to the established learning outcomes and learning objectives.

Student Analysis.

At this stage, the researcher assessed the students by giving them a test that covered critical thinking ability indicators and a questionnaire on student needs. The results of the analysis of students' critical thinking abilities per indicator can be seen in Figure 1 below.

Fig. 1. Critical Thinking Test

Based on Figure 1, the highest average score was in the category of knowing strategies and tactics, which was in the moderate range. Meanwhile, the lowest average score was in the category of building basic skills, which was in the low range. The low percentage in this indicator shows that most students had difficulty connecting the physics concepts they had learned with real phenomena and were unable to develop logical arguments based on the data obtained.

Through a questionnaire given to students in class XI Phase F at SMAN 1 Lubuk Alung, which was based on Creating a 21st Century Skills Survey Instrument for High School Students. The results of the analysis can be seen in Figure 2 below.

Fig. 2. Student Needs Questionnaire

Based on the results obtained in Figure 2 from the student needs questionnaire, the technology variable obtained the highest average score, namely (2.28), which means that students have felt the benefits of using technology in the assessment and learning process, such as ease of access, increased interaction, and the availability of faster feedback. The authentic assessment variable obtained an average score of 2.23, which means that students have sufficient understanding and experience with the application of authentic assessment in the classroom and feel that this assessment helps them understand the material and increases their motivation to learn. Meanwhile, the critical thinking variable obtained an average score of 2.17, which is the lowest score among the three variables. These results indicate that students' critical thinking skills, such as analyzing arguments, evaluating information sources, drawing conclusions, and making decisions based on careful consideration, have begun to develop but are not yet at an optimal level.

Task Analysis

Task analysis was conducted to determine the material to be delivered to students. The learning outcomes (CP) for high school physics phase F used in the creation of the ESD-integrated Critical Thinking-Based Authentic Assessment on the Material of Momentum & Motion Impulse can be seen in Table 2.

Table 2. Analysis of LOs and TP

Learning Outcomes (CP)	Learning Objectives (LO)
At the end of phase F, students understand, apply, and analyze the concepts of momentum and impulse to explain various phenomena of motion and collision that occur in everyday life. Students explain the concept of momentum as the product of mass and velocity, and impulse as the product of force and time, then demonstrate their relationship through the relationship between impulse and change in momentum. Students analyze the application of the law of conservation of momentum in closed systems such as collisions and explosions, and solve quantitative and qualitative problems involving changes in momentum and average force based on observation or experimental data. All of these efforts are	1. Students analyze the relationship between mass, velocity, force, time, and momentum change (impulse). 2. Students analyze the application of the law of conservation of momentum. 3. Students analyze internal and external forces acting on a system. 4. Students analyze the application of the law of conservation of energy with the conservation of momentum in various collision events.

directed towards achieving sustainable development goals (SDGs). Through the development of this knowledge, noble character and scientific attitudes such as honesty, objectivity, critical thinking, creativity, independence, innovation, cooperation, and diversity are also built.	

Concept Analysis

At this stage, the results of observations and discussions with the physics teacher at Lubuk Alung 1 Public High School show that students still have difficulty relating physics concepts, especially momentum and impulse, to real-life contexts and sustainability issues.

Learning Objective Analysis

The results of the formulation of learning objectives that have been adjusted to the achievement and indicators of learning objective achievement are presented in the following table.

Table 3. Learning Objective Analysis

No.	Learning Objectives	Indicators of Learning Objective Achievement	
1.	Students analyze the relationship between mass, velocity, force, time, and change in momentum (impulse).	1.1.	Students are able to scientifically analyze the relationship between vehicle speed, road conditions, and safe distance in preventing chain collisions using the concepts of force, collision time, and momentum change (impulse).
		1.2.	Students are able to scientifically explain the relationship between mass, velocity, and impact force in collisions using the concepts of momentum and impulse, and logically conclude the effects of collisions based on the changes in momentum and impulse force that occur.
		1.3.	Students are able to formulate and justify a strategy/recommendation based on the concepts of momentum ($p = m \cdot v$) and impulse ($I = \Delta p = F \cdot \Delta t$) by integrating the analysis of the effects of speed, mass, and impact force.
2.	Students analyze the application of the law of conservation of momentum	2.1	Students are able to analyze the application of the concepts of momentum ($p = m \cdot v$) and impulse ($I = F \cdot \Delta t$) in the process of kicking a ball in a soccer game, explain scientifically how the law of conservation of momentum works, and describe the physical factors that affect changes in the direction and speed of the ball logically and systematically.
		2.2	Students are able to analyze the relationship between force, mass, and momentum changes in physical events and social phenomena, and explain the scientific applicability of the concepts of impulse and momentum based on the law of conservation of momentum.
3.	Students analyze the	3.1	Students are able to analyze the

	internal and external forces acting in a system.		influence of internal and external forces in a ball kicking system, and relate it to the analogy of social momentum in regional soccer coaching, using the concepts of momentum ($p = m \cdot v$) and impulse ($I = F \cdot \Delta t = \Delta p$) to explain changes in momentum and system effectiveness scientifically and logically.
4.	Students analyze the application of the law of conservation of energy with the conservation of momentum in various collision events.	4.1	Students are able to explain the concepts of momentum and impulse and identify collisions in basketball by analyzing the relationship between mass, velocity, force, contact time, and changes in momentum in the ball and players.
		4.2	Students are able to conclude and explain the types of collisions in basketball based on the law of conservation of momentum, as well as analyze the effect of contact time on the magnitude of impulse force in relation to player safety, energy efficiency, and environmental impact.

Design Stage

The design stage is carried out to create a design for the development of ESD-integrated critical thinking-based authentic e-assessments on the subject of momentum and impulse to support students' critical thinking skills through four stages, namely assessment preparation, media selection, format selection, and initial design.

Development Stage.

The validation of the ESD-Integrated Critical Thinking Skills-Based Authentic eAssessment product on Momentum and Impulse material to support students' critical thinking skills has been validated by five validators. The three validators were lecturers from the Department of Physics, Faculty of Mathematics and Natural Sciences, Padang State University, and two validators were physics teachers from SMAN 1 Lubuk Alung. The validators assessed the Authentic eAssessment created by the author by filling out a validation questionnaire. The aspects assessed in the validity test included content suitability, language use, presentation suitability, and assessment graphics.

The first aspect of the validity instrument is content feasibility. The results obtained can be seen in the table below in Table 4.

Table 4. Content Suitability Validation Results

No	Statement Aligned with Indicators	Percentage	Category
1	P1	0.8	**valid**
2	P2	0.8	**valid**
3	P3	0.95	**valid**
4	P4	0.8	**valid**
5	P5	0.9	**valid**
6	P6	0.95	**valid**
7	P7	0.8	**valid**
8	P8	0.85	**valid**
9	P9	0.8	**valid**
	Average	**0.85**	**valid**

Based on the results obtained in Table 4 from the content feasibility aspect, it can be explained that the value of each indicator of the content feasibility aspect in the validation assessment is valid because it has an

average value of 0.85. Therefore, the content feasibility aspect can be categorized as valid. The results of this expert validation are used to improve the shortcomings of the developed Electronic Assessment.

The second aspect of the language usage validity instrument consists of six indicators. The results obtained can be seen in Table 5 below.

Table 5. Language Usage Validation Results

No	Statement in Line with Indicator	Percentage	Category
1	P1	0.8	**valid**
2	P2	0.8	**valid**
3	P3	0.8	**valid**
4	P4	0.8	**valid**
5	P5	0.8	**valid**
6	P6	0.85	**valid**
	Average	**0.808**	**valid**

Based on Table 5, it can be explained that the language used in the development of the instrument is categorized as valid because it obtained an average score of 0.808.

The third aspect of the presentation feasibility validity instrument consists of four indicators. The results obtained can be seen in Table 6 below.

Table 6. Presentation Feasibility Validation Results

No	Statement in accordance with indicators	Percentage	Category
1	P1	0.8	**valid**
2	P2	0.8	**valid**
3	P3	0.8	**valid**
4	P4	0.8	**valid**
	Average	**0.8**	**valid**

Based on Table 6, it can be explained that from the four statements described in the presentation feasibility aspect, a score of 0.8 was obtained with a valid category.

The fourth aspect of the validity instrument is the graphic assessment, which consists of five indicators. The results obtained can be seen in Table 7 below.

Table 7. Assessment Graphicality Validation Results

No	Statement in accordance with indicators	Percentage	Category
1	P1	0.85	**valid**
2	P2	0.9	**valid**
3	P3	0.9	**valid**
4	P4	0.8	**valid**
5	P5	0.8	**valid**
	Average	**0.85**	**valid**

Based on Table 14, it can be explained that in terms of the graphic aspect of the assessment, the five statements described in the graphic aspect of the assessment obtained a score of 0.85, which is considered valid. Based on these validity results, the researchers obtained several inputs for improving the test instrument developed.

Based on the four aspects of the electronic assessment developed, the results of the analysis of the average validation score for the electronic assessment of integrated critical thinking skills in Education for Sustainable Development on the subject of Momentum & Impulse were obtained. These aspects include: 1) content feasibility, 2) language use, 3) presentation feasibility, and 4) assessment graphics. Each of these aspects plays an important role in ensuring that the resulting Authentic eAssessment is able to improve student knowledge and present an electronic-based assessment that is interesting and effective to use.
The assessment process aims to determine the validity and feasibility of Authentic eAssessment in supporting ESD-integrated critical thinking skills. High validity scores across all components indicate that Authentic

eAssessment is well structured. The following are the average validity scores for all components presented in graph form as shown in Figure 3

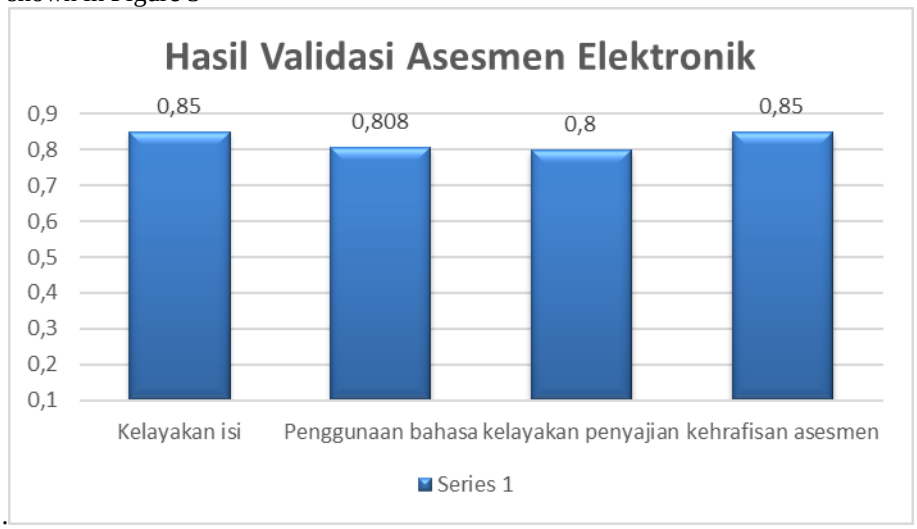

Fig. 3. Average Validation Score Results

Based on Figure 3, it can be concluded that Authentic eAssessment based on ESD integrated critical thinking skills obtained a valid validity category. It can be explained that the average value of each aspect of the validation researcher in electronic assessment varied from 0.8 to 0.85 with an average value of 0.83. Thus, the electronic assessment of critical thinking skills integrated with Education for Sustainable Development on the subject of Momentum & Impulse falls into the valid category.

With these results, it can be concluded that this Authentic eAssessment is not only theoretically and practically feasible, but also has great potential in supporting students' critical thinking skills, which makes the integration of interactive digital media, learning experiences more contextual, relevant, and enjoyable. Therefore, the application of authentic eAssessment such as this is highly recommended not only for momentum and impulse material, but can also be adapted to other physics material and similar science learning to support learning transformation that is responsive to the challenges of the 21st century.

IV. CONCLUSION

Based on the research conducted, the results show that ESD-Integrated Critical Thinking Skills-Based Authentic eAssessment obtained a validity score of 0.83, which can be categorized as valid. This validation score indicates that the authentic eAssessment created has met the established eligibility standards. The validity obtained proves that the ESD-Integrated Critical Thinking Skills-Based Authentic eAssessment meets various assessment aspects. With valid E-LWS criteria, this Authentic eAssessment can be used as one of the assessments to assist the physics learning process, especially in the subject of motion kinematics.

ACKNOWLEDGMENT

The author would like to thank all those who have helped in writing this article. Thank you for the support and assistance given to the author.

REFERENCES

[1] R. Kelley, J. G. Knowles, J. Han, and E. Sung, "Creating a 21st Century Skills Survey Instrument for High School Students," *American Journal of Educational Research*, vol. 7, no. 8, pp. 583–590, 2019.

[2] L. Darling-Hammond and F. Adamson, *Beyond the Bubble Test: How Performance Assessments Support 21st Century Learning*. John Wiley & Sons, 2019.

[3] Ministry of Education and Culture, *Dimensions, Elements, and Sub-elements of the Pancasila Student Profile in the Merdeka Curriculum*. Ministry of Education and Culture, 2022.

[4] S. M. Brookhart, *Classroom Assessment Essentials*. ASCD, 2023.

[5] P. Facione, *Critical Thinking: What It Is and Why It Counts*. Insight Assessment, 2021.

[6] R. Ennis, "Critical Thinking: Reflection and Perspective Part II," *Inquiry: Critical Thinking Across the Disciplines*, vol. 26, no. 2, pp. 5–19, 2011.

[7] L. Bao and K. Koenig, "Physics education research for 21st century learning," *Disciplinary and Interdisciplinary Science Education Research*, vol. 1, no. 1, 2019.

[8] Y. Hartawati, A. Harjono, and N. N. S. P. Verawati, "Critical thinking skills in momentum and impulse reviewed from the learning styles of students using the 5E learning cycle model," *ORBITA: Journal of Education and Physics*, vol. 6, no. 1, pp. 181–187, 2020.

[9] Kardoyo, N. Ahmad, and P. Hengky, "Problem-based learning strategy: its impact on students' critical and creative thinking skills," *European Journal of Educational Research*, vol. 9, no. 3, pp. 1141–1150, 2020.

[10] Z. Arifin, *Evaluation of Learning Principles, Techniques, Procedures*. Bandung: Remaja Rosdakarya, 2018.

[11] D. H. Schunk and J. A. Greene, "Historical, contemporary, and future perspectives on self-regulated learning and performance," in *Handbook of Self-Regulation of Learning and Performance*, Routledge, 2017.

[12] S. M. Shriner, "Critical Thinking in Higher Education," *InSight: A Journal of Scholarly Teaching*, vol. 1, pp. 59–66, 2020.

[13] J. Mueller, "The authentic assessment toolbox: enhancing student learning through online faculty development," *Journal of Online Learning and Teaching*, vol. 1, no. 1, pp. 1–7, 2020.

[14] G. Wiggins, *Educative Assessment: Designing Assessments to Inform and Improve Student Performance*. ERIC, 2021.

[15] S. Sunarti and S. Rahmawati, *Assessment in the 2013 Curriculum*. Yogyakarta: ANDI, 2022.

[16] UNESCO, *Education for Sustainable Development: A Roadmap*. Paris: UNESCO, 2020.

[17] V. Kioupi and N. Voulvoulis, "Education for sustainable development: A systemic framework for connecting the SDGs to educational outcomes," *Sustainability*, vol. 11, no. 21, 2019.

[18] A. R. Pratiwi and H. Susilo, "Integration of Education for Sustainable Development (ESD) in the Development of Physics E-Assessment," *Journal of Science Education Innovation*, vol. 7, no. 2, pp. 123–132, 2021.

[19] S. Aprisilia, F. Festiyed, H. Hamdi, and W. S. Dewi, "Creating authentic assessments of the 5E learning cycle model for momentum, impulse, and simple harmonic motion for high school," *Pillar of Physics Education*, vol. 12, no. 3, 2019.

[20] U. A. Pangestika and G. Hamdu, "Implementation of ESD-Based Critical Thinking Performance Assessment in Online Learning in Elementary Schools," 2021.

[21] D. Maulidiyah, S. Wahyuni, and A. Rahmawati, "Analysis of students' learning difficulties in physics on the subject of momentum and impulse," *Journal of Education and Science*, vol. 10, no. 1, pp. 88–97, 2022.

[22] P. Sinaga, F. Sirait, and P. Harahap, "Identification of students' misconceptions on momentum and impulse using CRI (Certainty of Response Index)," *Journal of Physics and Technology Education*, vol. 6, no. 1, pp. 1–9, 2020.

[23] Uno and S. Koni, *Learning Assessment*. Jakarta: Bumi Aksara, 2020.

[24] P. Sari, A. Widodo, and S. Nurhayati, "Development of HOTS-based assessment instruments integrated with environmental issues to improve the critical thinking skills of high school students," *Journal of Science Education*, vol. 9, no. 2, pp. 98–109, 2021.

[25] R. A. Pratama and N. Hidayati, "Digital-based authentic e-assessment to measure students' critical thinking skills in science learning," *Journal of Educational Research and Evaluation*, vol. 27, no. 2, pp. 201–213, 2023.

[26] W. J. Wiono and N. Meriza, "Efforts to Improve Critical Thinking Skills with Scientific and Gender-Based Liveworksheets," *Phenomenon: Journal of Science Education*, vol. 13, no. 1, pp. 31–46, 2023.

[27] Y. Anggraena et al., *Learning and Assessment Guidelines*. Agency for Education Standards, Curriculum, and Assessment, Ministry of Education, Culture, Research, and Technology, 2022.

[28] LR Aiken, "Three coefficients for analyzing the reliability and validity of assessment, educational and psychological measurement," Educ Psychol Meas, vol. 45, no. 1, pp. 131–142, 1985.