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Design and Validity of Electronic Assessments to Assess Students' Creative Thinking Abilities on The Topic of Newton's Laws

Rofifah Widara[1*], Fatni Mufit[1], Yenni Darvina[1], Dea Stivani Suherman[1]

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

ABSTRACT

This study aims to develop and validate a comprehensive electronic assessment package to measure students' creative thinking abilities on the topic of Newton's Laws. While creative thinking abilities are important to foster creativity, as one of 21st century skills, physics assessments often do not specifically measure this ability. This research addresses that gap by designing a complete and modern assessment system that uniquely integrates diagnostic, formative, and summative instruments into a single package. The study employed a Research and Development (R&D) method, adapting the Plomp model with a focus on the preliminary and prototyping stages. The feasibility of the product was tested through content validation by three experts, with the data analyzed using the Aiken's V index. The results show that all three instruments (diagnostic, formative, and summative), achieved a high validity category. In conclusion, the developed electronic assessment package is a valid and feasible instrument for comprehensively assessing creative thinking abilities in physics.

Keywords: *Electronic Assessment; Creative Thinking; Newton's Laws; Validity; Research and Development.*

I. INTRODUCTION

In this modern era, students are expected to have the basic skills to compete globally, known as 21st-century skills, which consist of the 4Cs (Communication, Collaboration, Critical Thinking, and Creativity), one of which is creativity [1]. To foster creativity, as one of the key competencies, requires the ability to think creatively, which can be seen as the capacity to find a variety of possible answers to a problem, with an emphasis on the quality, diversity, and relevance of the solutions produced [2].

The importance of creative thinking ability is highly aligned with the Merdeka Curriculum. In the learning outcome documents for physics subjects, it is stated that one of the main goals is for students to have the experience of being "able to creatively formulate problems," which naturally requires creative thinking abilities. Furthermore, in the learning outcomes for phase F, students are expected to develop their scientific inquiry skills. These scientific inquiry skills refer to a blend of science process skills, content knowledge, creativity, and critical thinking [3]. Furthermore, the element of conceptual understanding consistently emphasizes the demand to apply and utilize various physics concepts in real-world contexts. Key phrases like "its application in daily life" and "explaining natural phenomena" appear repeatedly for various physics topics. The demand to "apply" concepts in a daily-life context will encourage students to think creatively.

As a discipline based on concepts and application, physics strongly supports the development of this dimension [4]. The application of creative thinking abilities in physics learning plays an important role in helping students understand concepts in-depth, as well as develop original and flexible solutions to real-world problems [5]. Creative thinking also enables students to generate various alternative answers related to an event or problem [6]. In this regard, the topic of Newton's Laws becomes highly relevant. As a fundamental concept in the dynamics of motion, Newton's Laws offers a rich context for applying physics to various authentic problems in everyday life [7]. This material, which discusses the relationship between force, mass, and acceleration, becomes a strategic space for training students to think broadly and innovatively [8].

This topic selection was based on two main reasons. First, Newton's Laws are a fundamental concept in mechanics, and their relevance is easily found by students in various phenomena in daily life. Second, and most importantly, the Learning Outcomes (CP) explicitly demand the use of this concept for the purpose of "design" and "structural engineering." The demand to design and engineer provides ample space to assess creative

thinking abilities, where students are encouraged to create practical solutions. This makes the topic of Newton's Laws a rich and relevant context for measuring indicators of creative thinking ability, both in the cognitive and psychomotor domains. To fully utilize the potential of Newton's Laws in applying students' creative thinking abilities, an appropriate assessment is needed.

Assessment, as an integral element in education, doesn't just function as a measurement tool but also as a systematic process to gather information about a student's learning achievements [9][10]. To assess creative thinking abilities, an assessment must be able to measure a student's ability to generate new ideas, solve problems in different ways, and connect their existing knowledge [11]. It is important to note that to measure creative thinking abilities, the assessment should clearly highlight the application of the creative thinking indicators.

Based on the demands of the curriculum and the ideal assessment framework that has been outlined, the reality in the field shows a significant gap. Based on the results of interviews with two physics teachers at SMAN 3 Pariaman, it was found that the teachers understood the importance of creative thinking as one of the abilities that should be possessed to foster the creativity expected in 21st-century learning. Regarding current assessment practices, teachers have indeed used technology like Quizziz for objective questions, but this use of technology has not yet touched the domain of assessing creative thinking abilities, which should use essay questions. The main reason is the lack of instruments specifically designed for creative thinking abilities. The teachers' answer stating they "have never" conducted a creative thinking assessment directly indicates that all existing forms of assessment have not been utilized to measure this ability.

It is known that the assessment questions used in schools have not been designed to stimulate creative thinking. The questions presented are generally convergent, only requiring students to follow a single standard procedure to get a single correct answer. This characteristic of closed-ended questions automatically doesn't provide space for students to explore and use their creative thinking abilities. In reality, 11th-grade students, who are generally 16 to 17 years old, are psychologically in the formal operational stage, where one of the expected abilities is creative thinking [12].

The lack of an assessment instrument for creative thinking abilities in physics education at this school becomes a deeper problem when viewed in a broader context. Various relevant research findings consistently show that students' creative thinking abilities in Physics in Indonesia are still at a level that needs improvement, such as in the topics of Newton's Law of Gravitation [13], Newton's Laws [14], Vibrations and Waves [15], Electric Current and Resistance [16], Global Warming Phenomena [16] [17], Static Fluids [18], Dynamics of Motion [19], and Optics (Anjiana et al., 2024), as well as in physics learning where the topic is not specifically mentioned [20]. This indicates a general, identified challenge. Consequently, without a valid assessment tool at SMAN 3 Pariaman, teachers lack the data to know the extent to which their students are facing this common challenge. Ultimately, potential problems cannot be detected, and targeted improvement efforts through instruction are difficult to implement.

Various studies have been conducted to develop assessment instruments for creative thinking abilities, which is the focus the author has taken [8][11][21][22], but these studies only developed general assessments and were not specific to diagnostic, formative, and summative assessments, to assess cognitive and psychomotor domains of creative thinking. Based on the gaps that have been described, it is important to make an innovation in the field of educational assessment. To address this need, this developmental research aims to produce a complete and modern assessment system by uniquely developing a comprehensive electronic assessment package that integrates diagnostic, formative, and summative instruments, which can simultaneously assess both the cognitive and psychomotor domains of creative thinking. The use of an electronic format is considered highly relevant to the current developments in educational technology, as the assessment process will become more interactive with image/video elements, as well as being flexible and practical to use [23]. Thus, this developmental research is expected to produce a complete and modern assessment system. It is hoped that this assessment product is not only valid, practical, and reliable but also a tangible contribution to promoting creative thinking assessment practices that align with the demands of the Merdeka Curriculum.

II. METHOD

This research is a Research and Development (R&D) study aiming to produce a product in the form of a comprehensive electronic assessment instrument to assess students' creative thinking abilities on the topic of Newton's Laws. The study adapted the Plomp model [24], but its procedure was limited on two of the three main stages, namely the preliminary research stage and the development or prototyping phase. This limitation was set because the primary objective was to produce a theoretically and content-valid prototype of the instrument, rather than to test its effectiveness in a real classroom setting.The preliminary research stage was carried out to conduct a needs analysis, and a review of relevant literature, using Curriculum analysis sheets, interview transcripts, document analysis sheets, and literature study sheets. The results from this stage became the foundation for designing the product specifications. Subsequently, in the development stage, a product prototype

was designed and created in the form of a complete assessment package that includes diagnostic, formative, and summative assessments. The diagnostic and summative assessments were developed as essay tests implemented on the Jotform platform, with soft files for the complete assessment instruments, while the formative assessment was developed as a project assessment instrument in a soft file format for teachers to use. All components of this product are integrated into a main portal based on Google Sites to facilitate accessibility.

Before being validated by experts, the researcher conducted a self-evaluation using a self-evaluation sheet to check the initial completeness and suitability of the product. To test the product's feasibility, a content validity test was conducted through an expert review by three expert validators. The three validators were lecturers from the Physics Department at Universitas Negeri Padang, chosen based on their expertise in the development of physics assessment instruments and learning**.** The data collection process used a validation sheet in a questionnaire format with a 1-5 Likert scale.

Table 1. Likert Scale for Expert Validation Sheet

Score	Description
1	Strongly Disagree
2	Disagree
3	Neutral
4	Agree
5	Strongly Agree

The validated aspects included substance, learning design, visual communication, and software utilization. However, the software utilization aspect was not assessed in the formative assessment because it does not utilize a specific interactive application. The specific indicators for each validated aspect are summarized in the table below.

Table 2. Summary of Validated Aspects and Indicators

Aspects	Indicators	Number of Items		
		Diagnostic	Formative	Summative
Content Substance	Assessment alignment with Newton's Law concepts and creative thinking indicators.	2	3	2
	Problems are presented in clear language and are relevant to real-world and current life.	5	1	5
Learning Design	Assessment and grading rubrics align with learning objectives.	3	2	3
	Assessment is tailored to measure creative thinking abilities.	1	2	1
Visual Communication	Assessment formulation, illustrations, and other visual elements are communicative, clear, and neat.	4	3	4
Software Utilization	The software used is interactive and functions properly.	2	0	2

Quantitative data from the questionnaire were analyzed using the Aiken's V validity index with the following formula:

$$V = \frac{\Sigma s}{n(c-1)} \quad (1)$$

Where s is the score given by the validator minus the lowest score, n is the number of validators, and c is the highest score. The product is declared feasible if it obtains a validity category of "High" ($V > 0.8$) or "Medium" ($0.4 < V \leq 0.8$) [25]. In addition to quantitative data, qualitative data in the form of comments and suggestions for improvement from the validators were also collected and used as a basis for revising and refining the final prototype.

III. RESULTS AND DISCUSSION

1. Preliminary Research

The preliminary research stage is the initial phase in this development research, which aims to identify problems and needs in the field as a basis for product development. The results of the preliminary research systematically reveal a significant gap between the importance of creative thinking abilities facilitated by the curriculum and the assessment practices in the field.

The preliminary research started with a curriculum and material analysis to identify the policy and conceptual foundations for the assessment's development. This analysis revealed a strong alignment between the curriculum's general goals and specific learning outcomes, which explicitly demand students develop creative thinking abilities, especially in the context of Newton’s Laws for design and engineering, it is also confirmed

that Newton's Laws are a highly relevant and strategic topic, as it offers a rich context for application in authentic problems [8] and becomes an ideal space to apply innovative thinking [26].

This finding provided solid justification for the assessment. The research then proceeded to an interview analysis with two physics teachers from SMAN 3 Pariaman. They confirmed the importance of creative thinking but admitted they lacked specific tools to assess it. They noted that their current digital and paper-based assessments fail to include creative thinking indicators, citing time constraints and the complexity of developing such instruments as key challenges. The next step was a document analysis of existing test questions on Newton's Laws used at the school. This analysis showed that none of the questions reviewed gave students the opportunity to demonstrate creative thinking. The questions did not meet the four key indicators: fluency, flexibility, originality, and elaboration. The final stage involved a literature study, which provided a strong conceptual basis for the product's design. This review confirmed that creative thinking can be systematically measured using the indicators identified by Torrance[27]. It also supported the use of electronic assessments for their efficiency and flexibility, and it provided the necessary theoretical foundation on Newton's Laws.

2. Development/Prototyping Phase

Based on the analysis in the previous stage, a product prototype was produced in the form of a comprehensive electronic assessment package to assess students' creative thinking abilities on the topic of Newton's Laws. Substantively, this assessment was designed based on Torrance's theory of creative thinking ability, with a focus on two main domains: cognitive (assessed through essay tests in diagnostic and summative assessment) and psychomotor (assessed through projects in formative assessment). The affective domain is not assessed in this assessment, in line with modern research findings that consider creative thinking abilities and self-efficacy (an affective construct) as two different variables [28]. Similarly, research on the development of project-based creative thinking assessment instruments also tends to focus on assessing students' abilities in producing a product (psychomotor)[29].

The implementation of the product in an electronic format through soft files, Google Sites, and Jotform also supports efficiency and flexibility in use, in line with findings regarding the benefits of technology in assessment[23]. All product components are integrated into a single main portal based on Google Sites to facilitate access for teachers and students. The cover page display of the developed assessment portal is presented below.

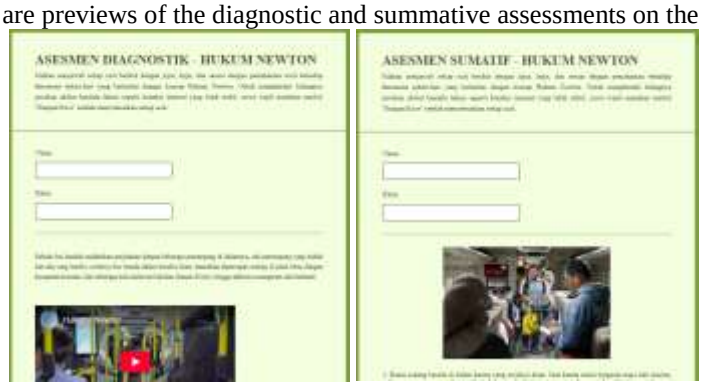
Fig 1. Cover Page of the Assessment Google Site.

From the cover page, users are then directed to the main page which functions as a navigation hub to access the three types of assessment (diagnostic, formative, and summative) along with their components.

Fig 2. Main Page Display and Assessment Access on the Google Site.

The system integrates all assessment components (diagnostic, formative, and summative) within a Google Sites portal for easy teacher access. This portal includes Jotform icons to access the interactive diagnostic and summative tests, as well as document icons that link to the complete assessment instruments for all three types. The diagnostic and summative assessments each consist of 12 interactive essay questions designed to measure creative thinking in the cognitive domain. The diagnostic assessment has 12 questions that divided into 3

contexts of Newton's Laws, with each context containing 4 questions that represent a specific creative thinking indicator. Similarly, the summative assessment has 12 questions in different contexts to assess these same abilities. These tests are implemented via the Jotform platform, which is enhanced with visual elements such as videos or images. Here are previews of the diagnostic and summative assessments on the Jotform platform.



(a) (b)

Fig 3. Display of the Diagnostic (a) and Summative (b) Assessment on Jotform.

As we can see, the Jotform platform is designed for user-friendliness, allowing students to easily fill out their name and class, and submit their answers to each question. In contrast, the formative assessment is a project-based task focusing on the psychomotor domain, where students design and create a simple product applying Newton's Laws. This assessment is evaluated through direct observation and the final product, and its detailed instrument is provided to the teacher as a complete document rather than an interactive platform for students. To provide a more visual overview, here are the cover pages of the developed diagnostic, formative, and summative assessment instrument documents.

(a) (b) (c)

Fig 4. Cover Page of Diagnostic (a), Formative (b), and Summative (b) Assessment Instruments.

Each of these documents contains comprehensive and systematic components. These include objectives, implementation instructions, test items or project descriptions, scoring guides, and a results recapitulation sheet. The entire instrument is designed to guide teachers in effectively and structurally measuring students' creative thinking abilities in the context of Newton's Laws.

Before being submitted to expert validators, the completed prototype first went through a self-evaluation stage, which involved a thorough examination of all assessment components. After being deemed feasible based on the self-evaluation, the prototype proceeded to the expert review stage to be tested for its feasibility through a content validity test. The results of the quantitative analysis for the diagnostic assessment are presented in the following table.

Table 3. Results of the Diagnostic Assessment Validity Analysis

Aspects	V	Category
Content Substance	0.83	High
Learning Design	0.81	High
Visual Communication	0.89	High
Software Utilization	0.83	High
Average	0.84	High

The average validity score of 0.84 indicates that the diagnostic instrument is highly feasible for use. This high score confirms that the instrument's design and content are well-aligned with the four key indicators of

creative thinking identified by Torrance: fluency, flexibility, originality, and elaboration. Furthermore, the results of the analysis for the formative assessment are shown in the table below.

Table 4. Results of the Formative Assessment Validity Analysis

Aspects	V	Category
Content Substance	0.81	High
Learning Design	0.83	High
Visual Communication	0.86	High
Average	0.83	High

The formative assessment's average validity score of 0.83 indicates a high level of feasibility. This validates the instrument's design for measuring creative thinking in a project-based context, which aligns with research emphasizing the importance of psychomotor output in creative assessment. Lastly, the data from the validity analysis of the summative assessment are presented in the table below.

Table 5. Results of the Summative Assessment Validity Analysis

Aspects	V	Category
Content Substance	0.84	High
Learning Design	0.83	High
Visual Communication	0.88	High
Software Utilization	0.88	High
Average	0.85	High

The summative assessment obtained the highest average validity score of 0.85 which falls into the "High" category, and confirms its feasibility as an assessment instrument. With the highest average validity score of 0.85, the summative assessment is highly feasible. This confirms its strong alignment with the conceptual foundations of creative thinking and its effectiveness in measuring higher-order abilities in the context of Newton's Laws. This achievement is consistent with previous instrument development research that also produced valid products, both for assessing concept understanding [30][31][32], as well as creative thinking ability[8][11][21][22].

In addition to quantitative data, the validators also provided constructive qualitative feedback, which was then used as a basis for revising and refining the final product that can be seen in the table below.

Table 6. Validator's Feedback on the Assessment

Validator	Feedback
Validator 1	1. There are questions in the diagnostic assessment that have the potential to make students answer without linking them to Newton's Laws, thus making the function of diagnosing students' initial abilities ineffective. 2. The answer key for the summative assessment has options that are essentially equivalent (meaning the answer choices are very similar), which does not effectively elicit flexibility.
Validator 2	1. The concepts of Newton's Laws are still not entirely correct. 2. There are still many typos; please check the entire document. 3. Punctuation marks, such as periods and commas, have not been used correctly.
Validator 3	1. For the diagnostic assessment, fluency is not yet in line with the learning objectives. 2. Several sentences were found to be less effective. 3. The elaboration question on the summative assessment is not yet appropriate for the creative thinking indicator.

Based on the validators' qualitative feedback, a series of revisions were implemented to refine the assessment prototype. These improvements were specifically focused on the diagnostic and summative assessments, while general corrections, such as fixing typos and inconsistent punctuation, were applied across the entire document.

Revisions to the diagnostic assessment addressed expert feedback that some questions could potentially be answered without applying a physics concept. To ensure the questions explicitly required a conceptual link to Newton's Laws, several were revised. For example, a question that originally asked "Why can the trolley move faster when pushed by Ana's father?" was revised to explicitly instruct students to use Newton's Second Law in their explanation. This revision emphasizes the importance of designing questions that demand deep conceptual application, not just recall. Additionally, the question for the "fluency" indicator was refined to align with learning objectives. The original question, "Write four things that can make the trolley move slower," was changed to "Write four conditions from the event above that are related to force, mass, and acceleration," making it more specific and focused.

Revisions to the summative assessment were made based on expert input. To address the comment that the "flexibility" question did not elicit diverse answers, the original question was revised. For example, the original question which required repetitive calculations for friction was replaced with a question asking students to formulate four conceptually distinct strategies (e.g., adding more force, reducing friction) to make a sofa easier

to move. This aligns with research arguing that effective flexibility assessment should provide space for multiple, non-standard solutions to a single problem. Similarly, the "elaboration" question was refined to better measure the intended indicator. The original question, which focused on calculations and drawing diagrams, was replaced with a question that requires students to provide a detailed conceptual explanation of the recoil phenomenon. This revision supports the principle that elaboration questions should measure a student's ability to provide a comprehensive, detailed explanation of the recoil phenomenon.

Based on the validation results and a series of revisions, it is clear that the developed assessment product meets the required validity standards. Moreover, the uniqueness of this research, which does not focus on just one type of assessment but rather an integrated package, provides a strong basis for further studies on how this assessment can assess students' creative thinking abilities in a real learning environment.

IV. CONCLUSION

Based on the research findings, it is concluded that an electronic assessment package for the topic of Newton's Laws was successfully developed and is valid for measuring students' creative thinking abilities. The three types of instruments (diagnostic, formative, and summative), were declared to have a "High" level of validity based on expert assessments, with an average Aiken's V score above 0.80 for all three. This success confirms that the developed product is not only statistically valid but also conceptually and pedagogically sound, as ensured by the revision process based on qualitative feedback from the validators. The development of this comprehensive assessment package, which includes diagnostic, formative, and summative instruments, and its ability to assess both cognitive and psychomotor domains, provides significant novelty compared to previous research.

This assessment package has important implications for physics teachers, providing a practical tool to systematically integrate the assessment of creative thinking in the classroom. Teachers can use the diagnostic instrument at the beginning of a lesson to identify students' initial level of creative thinking on the topic of Newton's Laws. The formative instrument, which is project-focused, allows teachers to monitor the development of students' creative thinking abilities throughout the learning process. Meanwhile, the summative instrument can be used at the end of the chapter to measure students' final achievement in the creative thinking domain. By implementing this assessment package, teachers can not only measure student learning outcomes but also actively encourage the development of creative thinking that is relevant to the demands of the curriculum.

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