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[Research Article]

DEVELOPMENT OF WORK AND ENERGY ASSESSMENT WITH *EVIDENCE-CENTERED DESIGN* APPROACH

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ABSTRACT

The purpose of this study is to develop work and energy assessment with an Evidence-Centered Design (ECD) approach. ECD is a framework of thinking that focuses on evidence of learners' abilities. ECD has three main components which are claims, evidence, and questions. Competencies in the assessment using Scientific Practices consist of the ability to use and develop representations, analyze and interpret data, explain arguments accompanied by evidence, and evaluate information. The development model used is Research and Development (R&D) with stages: analysis, design, development, implementation, and evaluation. These assessments are validated by validators and analyzed using Aiken indexes. The validation results showed a very high validity value of 0.87. Then, this assessment is carried out in one-to-one tests and small-scale trials. Based on the results of validation and trial of this assessment, it is suitable to be used by teachers as a guideline in compiling assessments.

Keywords: R&D, Work and Energy, Evidence-Centered Design, Scientific Practices

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1. INTRODUCTION

Physics is a natural science whose aspects of reasoning and application are needed in an effort to master science and technology. This is because physics has a connection to human life (Permata et al., 2024). Therefore, the main purpose of physics learning is to develop students' knowledge, understanding, and ability to analyze the environment and surroundings (Azizah et al., 2015). Learning objectives are the learning lives that are used as learning targets, so learning should not deviate from learning objectives (Fanani, 2021). These objectives become the teacher's reference in carrying out the learning process. If the learning process is not in accordance with the learning objectives, the desired results will not be achieved optimally. These learning outcomes can be known by using assessment.

Assessment is an assessment in various ways and utilizes various assessment tools to obtain information on the extent of student learning outcomes (Teresia, 2021). Assessment and learning are inseparable. In learning, assessment serves to determine students' abilities, constraints, and needs in learning (Priyanto et al., 2024). According to Yusuf (2017), assessment can also be intended to motivate students to continue learning. This is because assessment is a tool to determine the learning outcomes of students. Assessment refers to various sources in terms of cognitive, behavior, and skills of learners, besides that it can refer to a particular event or instrument (Agustianti et al., 2022).

Therefore, the success of a lesson is also determined by the assessment used. This is because the teacher's job is not only to teach students, but also to ensure that students understand the material presented. If the assessment made by the teacher is able to measure the ability of students well, then the teacher can find out the obstacles and determine the right solution. To maximize the measurement results, the assessment must be adjusted to the learning outcomes of the current independent curriculum. In addition, it is very important to ensure that the assessment is in accordance with the learning objectives. This is because learning objectives are the benchmark for the achievement of student learning outcomes.

Currently, there are still some assessments made at the high school level in Indonesia that are not in accordance with the learning objectives. This is because there are still teachers who do not understand how to make good assessments. Therefore, teachers provide assessments taken from books or collections of previous questions, so that these questions pay less attention to suitability with learning objectives. One example can be seen from the results of research conducted by Phito et al. (2019) in one of the high schools in Padang city, the impact of the questions given comes from books or collections of previous questions, these questions tend to test more aspects of remembering, understanding, and applying. Meanwhile, questions that test other aspects of physics learning have not been tested much. In fact, according to Permendikbud No. 1 of 2016, the competencies that students must have include attitudes, knowledge, and skills. Attitude competencies are spiritual and social while knowledge competencies are the ability to remember, understand, apply, analyze, and evaluate factual, conceptual, procedural, and metacognitive knowledge. The expected skills are observing, questioning, trying, reasoning, presenting, and creating (Sirait & Oktavianty, 2021).

This makes the abilities/competencies tested on students unclear parameters. Thus, the teacher does not know what kind of ability/competence needs to be improved. From these problems, teachers need help in preparing assessment questions. Therefore, one of the solutions to overcome these problems is to create assessments with the *Evidence-Centered Design* approach.

Evidence-Centered Design (ECD) is a framework for developing assessments. ECD develops tests to ensure consideration and collection of validation evidence from the beginning of test design (Arieli-Attali et al., 2019). There are three components of ECD, namely: (1) claims, serves as the basis for the entire assessment design, ensuring that all elements of the assessment consistently contribute to measuring the desired ability, (2) evidence, defines the type of evidence needed to support claims about learners' competencies. In addition, it can be used to ensure that learners' responses to given tasks can be interpreted as valid evidence of the competence being measured, (3) questions, this component defines the types of questions or assessments that will collect the required evidence. It includes specifications on how the task will be presented and how learners will respond. This component directs the development of questions that match the assessment objectives and ensures tasks are relevant and effective in collecting evidence of competence (Arieli-Attali et al., 2019).

The purpose of this research is to develop valid assessments that are aligned with learning objectives and have clear evidence. In achieving this goal, the competency used is *Scientific Practices.* This is what distinguishes this research from previous studies. If learning objectives are usually compiled using Bloom's Taxonomy, the assessment development in this study uses *Scientific Practices*. Competencies in Bloom's Taxonomy focus on the abilities that learners should have in general. Case studies at various levels of education show that Bloom's Taxonomy can be applied to diverse learning environments (Krzyzanowski et al., 2024). While *Scientific Practices* makes competencies in learning objectives more focused on science. This is very important because in learning that uses a scientific approach the steps will provide students with analytical and critical thinking experiences (Oktavianty et al., 2020).

Scientific Practices is a skill/competency that reflects the various scientific ways of exploring and understanding the world, as well as how to solve problems (Costa & Broietti, 2021). *Scientific Practices* has seven parts in its framework, namely: (1) asking questions, (2) developing and using representations, (3) designing investigations, (4) analyzing and interpreting data, (5) using mathematics and computational thinking, (6) explaining arguments with evidence, (7) evaluating information; (Costa & Broietti, 2021). *Scientific Practices* make learning objectives more science-focused. *Scientific Practices* can help students: (a) develop a deeper and broader understanding of what we know, how we know, and epistemic and procedural constructs, (b) if it is a more effective way to develop such knowledge, and (c) present a more authentic picture of the endeavor called science (Osborn, 2014).

2. METHOD

This research aims to produce an effective assessment to measure the extent of students' abilities in learning based on the learning objectives that have been determined by the teacher. The development method used in this research is the *Research and Development* (R&D) method. This method is the process of developing a new product or improving existing products, but can be accounted for (Setiawan et al., 2021). In this study, the resulting product is a question instrument developed using the *Evidence-Centered Design* (ECD) framework. In this study, the development model used was the ADDIE development model. According to Sugiyono (2019), this model consists of five stages, namely *Analysis*, *Design*, *Development*, *Implementation*, and *Evaluation*. In this study, only up to the *Development* stage. The stages are shown in Figure 1.

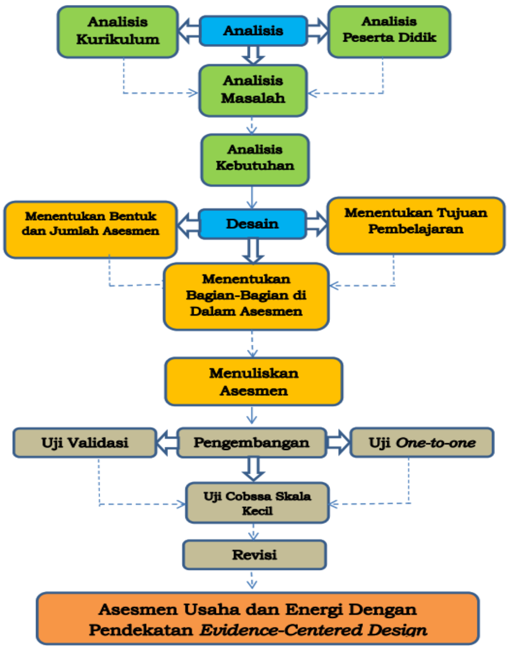


Figure 1. Flow of Work and Energy Assets Development

The first stage is analysis. The analysis stage is carried out to collect all information or requirements used for reference in the development (Setiani et al., 2024). At this stage, a review of the curriculum is carried out to understand the basic competencies and indicators that are relevant to the concept of effort and energy. In addition, the characteristics of learners are analyzed to ensure that the assessments developed are in accordance with the needs of students in grade XI SMA. The analysis stage also includes the identification of learning problems and needs to ensure the designed assessment is able to overcome the limitations of existing assessments.

After the analysis stage was completed, the design stage continued by determining the form and number of assessments to be made. In this stage, the learning objectives were designed based on *Scientific Practices*, an approach that emphasizes scientific activities such as using and developing representations, analyzing and interpreting data, constructing explanations with arguments accompanied by evidence, and evaluating information. Furthermore, the assessment sections are designed with reference to the principles of *Evidence-Centered Design* (ECD). Each part of the assessment is structured to collect*evidence* that supports the achievement of the learning objectives that have been set. ECD directs this process by ensuring that assessments include three main components: *claims* (statements about what students should know), *evidence* (the evidence needed to support those statements), and *tasks* (questions designed to generate that evidence). The claimconsists of: (1) learning outcomes, (2) learning objectives organized based on *Scientific Practices*. The evidence in question consists of: (1) knowledge, skills, and abilities that grade XI high school students must master before working on questions on the assessment, (2) evidence that is an important component to show the achievement of learning objectives that must be present in the questions that students work on. The last is the questionwhich consists of: (1) question characteristics that explain the form of questions, (2) questions designed to measure learning objectives, (3) assessment rubrics that are used as guidelines for scoring the results of students' work. The last thing in this design stage is to write the assessment itself according to the components that have been determined.

The next step is the development stage. At this stage the assessment that has been designed is validated by competent experts. The validators consisted of 3 high school physics teachers and 3 physics education lecturers. This process aims to ensure the quality and accuracy of the assessment. In addition, this process also aims to obtain quantitative values. The quantitative value used is the Aiken Index, where r is the score given by the assessor, l_0 is the lowest validity score, n is the number of raters, and c is the highest validity score, generally formulated as follows.

$$\mathbf{V = \frac{\sum s}{n\,(c-1)}\,;\ s = r - l_0}$$

Aiken index scores range from 0.00 to 1.00, where higher values indicate better validity. The scores fall into several categories such as: (1) a very high category with scores ranging from (0.81-1.00), which indicates that the majority of experts gave a very good assessment of the item, (2) a high category with scores ranging from (0.61-0.80), which indicates that the item has good relevance according to the majority of experts, (3) a moderate category with scores ranging from (0.41-0.60), which indicates that the item is considered quite relevant, but require significant revisions to improve their quality, (4) a low category with scores ranging from (0.21-0.40), which indicates that the items are considered less relevant by the experts and require considerable revisions to be used properly, (3) a very low category with scores ranging from (0.00-0.20), which indicates that the items are not considered relevant by the experts and need to be replaced or completely remade.

The next process is to revise the questions based on the suggestions and input from the validators. Then, after the questions have been revised, the next stage is the *one-to-one* test. The process aims to identify initial deficiencies in the assessment, improve the quality of the assessment, determine the efficiency of testing, and as a basis for the next stage of research. After the process is complete, it is continued with a small-scale trial to determine the extent to which students understand the assessments that have been made, as well as to find out how long it takes students to work on the effort and energy assessment.

3. RESULT AND DISCUSSION

3.1 Analysis Stage

The analysis stage is the first step in developing an effort and energy assessment with the *Evidence-Centered Design* (ECD) approach. The analysis stage aims to determine the problems and solutions to be developed (Haspen & Syafriani, 2022). At this stage, various important aspects are analyzed to ensure that the assessments developed are relevant, effective, and in line with learning needs. This analysis includes curriculum, learner analysis, problem analysis and needs analysis, all of which form the foundation for the assessment design and development process.

The first step is curriculum analysis. Curriculum analysis involves not only learning objectives, but also evaluation structures and practices to ensure the curriculum meets educational needs and supports student learning outcomes (Ornstein & Hunkins, 2017). In curriculum analysis, this step begins by reviewing the basic competencies and learning indicators listed in the curriculum document. The curriculum specifies various competencies that students must master, such as understanding the relationship between effort and energy. Based on the results of this analysis, it was found that the assessment to be developed must be able to measure various aspects of learning, ranging from conceptual understanding to students' analytical skills. The emphasis on evidence-based assessment is important because each item is designed to measure students' success in achieving these competencies. In the context of the ECD approach, the curriculum is the basis for determining claims or statements about the abilities that students should have, which are then measured through questions in the assessment.

Next is the analysis of learners, at this stage the research is focused on grade XI students as the main subject of developing effort and energy assessments with the *Evidence-Centered Design* (ECD) approach. Grade XI students were chosen because the concepts of effort and energy are part of the physics material taught at this level in accordance with the applicable curriculum. In addition, grade XI students are considered to have a more mature knowledge and skill base than previous grades, allowing them to engage in more complex and contextualized assessments. As explained by Molefe (2014), it is important to create a learning environment that supports students' ability to analyze and solve problems.

The next step is problem analysis. In this problem analysis, there is a gap between assessments and the evidence needed to support learning claims. A report from the OECD (2021) highlights the importance of ensuring a link between the competencies being measured, the assessment tasks and the evidence collected. In this context, problem analysis is crucial to identify the gap between the learning objectives to be achieved and the ability of assessments to provide valid and relevant evidence to support these claims. Ideally, every assessment is designed to provide tangible evidence of student competency achievement. However, in some cases, existing assessments have not been fully designed to explore this evidence, so that the results obtained from the assessment do not reflect students' abilities comprehensively. Therefore, a needs analysis was conducted to design an assessment that is more in line with the learning objectives and able to overcome the previously identified problems. This needs analysis aims to determine the elements that must be present in the assessment in order to measure students' abilities thoroughly and provide appropriate evidence of learning achievement. The *Evidence-Centered Design* approach is the main framework for this process, as ECD allows assessments to be systematically designed based on the relationship between claims, evidence and questions in the assessment.

3.2 Design Stage

The next stage in this research is the design stage. This stage begins with designing the form and determining the number of assessments to be used. The assessment in this study consisted of 8 essay questions. Then, parts of the assessment were designed such as: (1) the *Scientific Practices* competencies to be achieved, (2) designing learning objectives based on the competencies in *Scientific Practices*, (3) writing the knowledge, abilities, and skills that students must master before working on the questions in the assessment, (4) writing the evidence that must be present in student answers to show the achievement of learning objectives, (5) writing the characteristics of the questions.

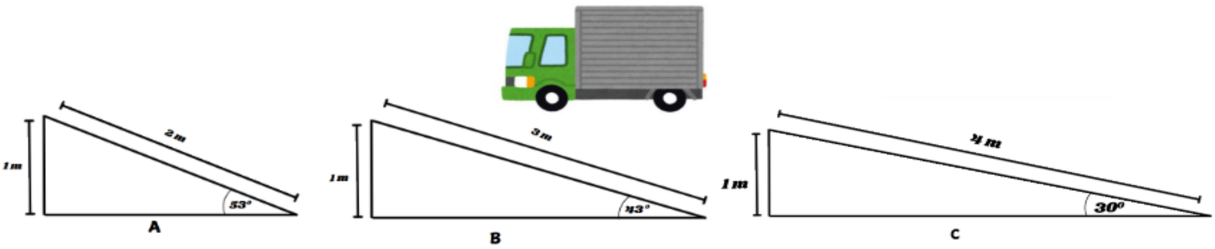
The assessment was developed based on the components of *Evidence-Centered Design*, namely claims, evidence, and questions. The claims in the development of this assessment consist of several parts. First, physics learning outcomes in phase F for grade XI are formulated so that students are able to understand the relationship between effort and energy and its application in the analysis of object motion and technological design. Second, the learning objectives are designed with a *Scientific Practices* approach that focuses on four competencies: using and developing representations, analyzing and interpreting data, constructing explanations; engaging in arguments with evidence, and critically evaluating information. The evidence component of the assessment includes two main aspects. The first aspect is the knowledge, skills and abilities that learners must have before doing the questions to achieve the learning objectives. The second aspect is the evidence of success that shows that learners have achieved the learning objectives. The final component is the questions, which are designed to measure the achievement of the learning objectives. These questions have three important elements. First, the characteristics of the question are designed to reflect the question form. Second, the questions should be designed in such a way that they measure the learning objectives directly. Third, the assessment rubric that is prepared as a guide to score the students' work, covering aspects of accuracy, clarity, relevance of arguments, and ability to evaluate information. Examples of these components are shown in Table 1 below:

Table 1: Example of effort and energy assessment components

Work and Energy Assessment	
Scientific Practices	Explaining arguments with evidence
Learning Objectives	Learners can explain effort in everyday life with evidence.
Knowledge, Skills and Abilities	• Ability to analyze representations. • Understand the concept of motion dynamics. • Ability to use the formula for effort on an inclined plane.
Evidence	• Write the formula of effort and force correctly $w = \vec{F}.\vec{s}$ and $\vec{F} = m.g\sin\theta$. • Calculate force and effort correctly. • Medraw conclusions about inclined planes that can produce smaller forces.
Characteristics Question	Learners can analyze pictures of trajectories of different lengths to determine the difference in effort and determine the trajectory with the smallest effort required to push the box.

The above components are an example of the framework components of a question focusing on the competency of constructing explanations; engaging in arguments with evidence. Furthermore, Figure 2 shows one example of a question from this framework.

Budi adalah pegawai sebuah toko yang setiap hari harus memindahkan kotak-kotak berisi barang belanjaan ke sebuah truk untuk di antar ke pembeli. Saat ini, ia sedang kesulitan mengangkat kotak belanjaan karena memiliki berat 30 kg dan harus dipindahkan ke truk setinggi 1 m. Oleh karena itu, ia membutuhkan bantuan bidang miring untuk dapat mendorong kotak ke atas truk. Toko tempat Budi bekerja memiliki tiga bidang miring dengan permukaan yang licin tanpa gesekkan dengan sudut masing-masing 53^o, 43^o, dan 30^o. Ketiga bidang itu memiliki panjang lintasan yang berbeda seperti terlihat pada gambar di bawah ini:



Ilustrasi Truk dan Bidang Miring

Berdasarkan informasi di atas, bidang miring mana yang akan anda usulkan untuk budi pilih? Berikan penjelasan disertai bukti untuk memperkuat jawaban anda! (sin 53^o = 0.8, sin 43^o =0.6, sin 30^o =0.5) atau (cos 53^o = 0.6, cos 43^o = 0.7, cos 30^o=0.8)

Figure 2: Example of an energy and effort assessment question

After the assessment has been designed, the next step is to design scoring guidelines or scoring rubrics. In designing an assessment rubric, it is necessary to emphasize clear evidence to measure the ability of students in working on problems according to predetermined competencies. An example of an assessment rubric on the competency of building explanations; engaging in arguments with evidence is shown in Table 2.

Table 2: Sample rubric for assessing effort and energy assessment

Evidence	Assessment Indicator	Score
Learners can write the formula of Effort and Force correctly.	Both formulas are written correctly.	3
	Only one formula is written correctly.	2
	No formula is written down.	0
Learners can calculate force and effort correctly.	The calculation method and result are correct.	4
	There is a small error in the calculation.	2
	Calculations not performed or incorrect.	0
Learners can make decisions correctly.	Provides a complete and correct conclusion.	3
	Provides an incomplete conclusion	2
	Conclusion is missing or incorrect	1
MAXIMUM SCORE 10		

The maximum score that students can get is 10 if they are able to answer questions with all the evidence that has been determined. However, if learners answer questions with inaccurate answers, learners can still get scores according to predetermined categories. The assessment rubric is a guideline for researchers to give scores to students.

3.3 Development Stage

In this research, the development stage is the last stage in the development of work and energy assessment with *Evidence-Centered Design* approach. The development stage in the assessment of effort and energy with the *Evidence-Centered Design* (ECD) approach is very important to ensure that the assessments developed can measure competencies effectively and are relevant to learning objectives. The first step in this stage is the validation test. Validation of assessment instruments has a very important role to ensure that the instruments used are of high quality and suitable for use (Karotowagiran & Jaedun, 2016). This validation process involves experts to ensure that the assessment is in accordance with the learning objectives that have been set and in accordance with the applicable curriculum standards. Validation also includes checking the content and construct of the questions to ensure that all aspects of the material being tested are accurately covered. The higher the validity of the instrument indicates the more accurately the measuring instrument measures a data (Amanda, at al., 2019). In this research, validation involved 3 high school physics teachers and 3 physics education lecturers. The following shows the validation results by experts in Table 3:

Table 3. Validation Result

Question Number	Value	Category	Description
1	0,86	Very High	Valid
2	0,85	Very High	Valid
3	0,88	Very High	Valid
4	0,88	Very High	Valid
5	0,87	Very High	Valid
6	0,84	Very High	Valid
7	0,87	Very High	Valid
8	0,87	Very High	Valid

In addition to obtaining validation scores, researchers also received various constructive suggestions and input from validators. The input includes refining the symbols used in the questions to be more consistent and in accordance with scientific standards, revising operational verbs in learning to reflect clearer and more measurable actions, and adding explanations to some questions so that students can better understand the purpose and context of the questions presented. Nagdi et al., (2020) emphasized that validator suggestions help identify ambiguous or irrelevant items, thus improving the clarity and quality of the instrument.

After going through the validation process, the questions were revised. After the revision, a *one-to-one* trial was conducted involving one grade XI high school student. The *one-to-one* trial is an important step to evaluate the effectiveness of the instrument in terms of processing time, readability, and respondents' understanding of the questions (Liu et al., 2022). Direct feedback from participants also helps identify weaknesses in the instrument that may not have been detected during the initial validation stage. In the pilot test, students worked on the questions for 60 minutes under the direct supervision of the researcher. As a result, students successfully completed all questions with a score of 76 out of a maximum score of 80, where all answers were correct except for the writing of formula symbols that were less precise and incomplete. Then, students were given a questionnaire to find out their opinions about the assessment given. Through the questionnaire, students can feel more empowered as their voice is taken into account in the evaluation process that affects their learning. This reinforces fairness in the assessment process and ensures that the evaluation strategies implemented can reflect students' abilities more accurately (Carless, 2020).

From the questionnaires given, students stated that the processing time given was sufficient, the instructions were clear, and the questions and terms in the questions were easy to understand. This shows that the revised assessment has a good level of readability and clarity, thus supporting the learning process..

The next stage was a small-scale trial involving 8 students of class XI SMA with a question duration of 60 minutes, most students felt that the time given was sufficient to solve the problem. However, there were three students who felt that the time provided was inadequate. Some of these students were only able to do part of the problem, with one student revealing that it took him 90 minutes, while the other two students felt it took up to 120 minutes to complete the problem. This finding illustrates the variation in students' ability and speed in solving the problem. This is in line with the views of Carless & Winstone (2019) who emphasize the importance of paying attention to diversity in student learning speed, so that assessment design can be more inclusive and fair, covering variations in ability and time required by each student.

In addition to the questionnaires given to students, the researcher also conducted interviews with teachers to gain a more in-depth perspective on the implementation of the assessment, the challenges faced by students and teachers, and how the assessment can be improved to achieve more effective educational goals. In the interview, the teacher stated that there was an update to the effort and energy assessment questions with the *Evidence-Centered Design* (ECD) approach, which allows for a review of the evidence expected to emerge from students. This makes the assessment process more focused on students' ability to present the right answer, in accordance with the knowledge and skills that have been developed through learning objectives. The teacher also added that the developed assessment is relevant to the developing curriculum, which requires students to provide answers more independently. This assessment provides such freedom through*open-ended* questions and encourages students to present answers using various representations. Tan & Boud (2019) emphasized the importance of providing freedom in assessment through open-ended questions, which can encourage students to think critically and creatively in presenting answers.

This research only covers the development of assessments up to the development stage. It is hoped that this assessment can be a useful reference for teachers in designing and developing more effective assessments. The purpose of this assessment is to provide a structured and clear guide to evaluate learners' understanding, while supporting a more in-depth assessment of abilities and skills relevant to the learning objectives. Thus, teachers can more easily assess learners' learning outcomes and design more appropriate learning strategies.

4. CONCLUSION

This research produces an assessment of effort and energy with an *Evidence-Centered Design* approach that is systematically designed to support optimal learning of the concepts of effort and energy. The assessment development process is carried out through the stages of the ADDIE model, including analysis, design, and development, with an emphasis on improving students' conceptual understanding. The validation results show that this instrument has a very high level of validity with (average Aiken score of 0.87), making it suitable to be used to evaluate the achievement of learning objectives comprehensively. These results show that this assessment is valid. In addition, based on teacher responses through interviews, this assessment can be used to support the measurement of students' conceptual understanding related to effort and energy materials. This assessment is not only relevant for measuring learners' abilities, but can also be a reference for teachers in developing assessments that are more structured, relevant, and in line with the demands of 21st century learning. This assessment has the potential to be a deep and meaningful evaluation tool in the context of science learning.

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