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# The Development of Concept Inventory Assessment Integrated with STEM Literacy to Measure Students' Creative Thinking Skills: A Need Analysis

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**Abstract:** Improving 21st-century skills and STEM literacy is the main goal of STEM education for students. Assessment is crucial since it is the outcome of the learning process that can be used as a benchmark for students' abilities. This study aimed to analyze teacher needs for product development in an integrated concept inventory assessment with STEM literacy to measure creative thinking skills. This is descriptive qualitative research. Closed surveys, unstructured interviews, and documentation studies were all used to obtain data. The participants in this study were 30 physics teachers from various Indonesian high schools. The results showed that teachers have a diverse understanding of the development concept inventory integrated with STEM literacy, so it is very important to develop this happens because the teachers do not have sufficient experience in making assessments. The teacher made the assessment, and still, in the form of questions towards mathematical completion, there is no literacy charge and is not associated with phenomena in the real world. In addition, the assessment that the teacher has made has not been tested for validity and reliability. The obstacles teachers face are short, and they do not have a deep understanding of STEM literacy in their learning. Therefore, those teachers want a good assessment that can combine the concepts of physics and its application. The teachers' interest in product development shows that 96.7% (29) of teachers are interested and need the development of a STEM literacy-based concept inventory assessment to measure creative thinking skills.

**Keywords:** assessment, concept inventory, STEM literacy, creative thinking skills, needs analysis.

# 发展与 幹素养相结合的概念清单评估以衡量学生的创造性思维技能：需求分析

**摘要:** 提高 21 世纪技能和 幹素养是学生 幹教育的主要目标。评估是至关重要的，因为它是学习过程的结果，可以用作学生能力的基准。本研究的目的是以综合概念清单评估和 幹素养的形式分析教师对产品开发的需求，以衡量创造性思维技能。这是一项描述性的定性研究。封闭式调查、非结构化访谈和文献研究都用于获取数据。本研究的参与者是来自印度尼西亚各高中的 30 名物理教师。 结果表明，教师对结合 幹素养的发展概念清单有不同的理解，因此发展这种情况非常重要，因为教师没有足够的经验在进行评估时。评估由老师进行，仍然以数学完成问题的形式进行，没有识字费用，也与现实世界中发生的现象无关。此外，教师所做的评估尚未经过有效性和可靠性测试。教师面临的障碍是学习时间短，对幹素养没有深入了解。因此，教师想要一个能够结合物理概念及其应用的良好评估。教师对产品开发的兴趣表明 96.7%（29）教师感兴趣并需要开发基于 幹识字的概念清单评估来衡量创造性思维技能。

**关键词：** 评估、概念盘点、幹素养、创造性思维技能、需求分析。

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# 1. Introduction

Education is an important element in developing knowledge and human resources to be reliable, quality, and competitive global suit the demands of the times [1]. The 21st-century skills include a wide range of competencies [2]. One of them is creative thinking skills [3, 4], which requires the student to tackle the complex creatively and structured [5]. Creative thinking skills are an important cognitive aspect required for meaningful learning across all disciplines [6]. Previous research has shown that schools do not understand the importance of creative thinking skills in learning, and educators lack a straightforward and predictable way to educate execution or assessment [7].

Over the last years, various arguments have suggested the value of STEM-integrated education as useful for developing multidisciplinary knowledge and a set of abilities, skills, and perspectives that align with the needs of young people in the future who will function productively and ethically in dynamic work, social, and political environments that are complex and challenging [8]. STEM literacy and competence in the twenty-first century are improved because of STEM-integrated education [9]. STEM literacy is essential for students entering the labor market due to their role as a core competence of 21st-century workers [10, 11]. Literacy is essential. STEM literature involves content-related expertise and understanding scientific data representation and interpretation, explanation, projection, and scientific process [12, 13]. It also entails cognitive and metacognitive talents and the ability to speak logically about global concerns, coordinate numerous perspectives, and convince others to decide based on scientific evidence [14].

The learning process cannot be separated from an assessment [15]. Standardized assessment has assumed a significant part in instructing and educational program advancement [16]. Assessment involves gathering information about the quality or quantity of improvements made by a school, a teacher, or an administrator. Assessment helps teachers understand what students know and can do after instruction, and it provides evidence of how well students are achieving learning objectives [17]. Appropriate assessment instruments can arouse students to learn through creative thinking skills based on their conceptual understanding of physics in everyday problems appropriately [18]. Many teachers have discussed innovative teaching, while assessment is still a problem in learning [19].

Concept Inventory (CI) is a branch of physics education research (PER) based on an assessment to see students' understanding of certain physics concepts [20]. Many studies have been directed into students' conceptual understanding by looking into their misconceptions [21]. This conceptual understanding contains skills to understand the concept of physics appropriately, in the sense of understanding the concept of physics universally applicable worldwide [22].

However, the assessment of concept inventory in some physics lessons has not all been tested for validity and reliability, so that the instrument that the teacher has made is not yet known for its feasibility. In addition, it will be much more meaningful if the assessment is also associated with various phenomena that occur in the real world so that it is expected that students can understand the concept, know, and be able to solve problems creatively [6].

Today, the primary goal of science, technology, engineering, and mathematics (STEM) education is to organize students to solve real-world problems like experts, which necessitates developing and applying a thorough understanding of scientific principles and concepts. On the other hand, traditional learners are frequently found to rely on memorizing rules and algorithms in problem-solving and lack a deep conceptual understanding [23].

The challenge with multidisciplinary assessment arises because most techniques now focus on teaching and assessing conceptual understanding within a single field, with little attention devoted to how precise knowledge integrates and helps solve problems [8]. STEM literacy refers to the ability to apply, question, collaborate, value, engage, persist, and comprehend STEM concepts and skills to solve STEM-related personal, social, and global concerns that cannot be solved by a single discipline [24].

Teachers, in reality, still have a confused concept over what STEM is and what it implies for their students' learning [25]. One of the key issues is that most teachers are more accustomed to connecting scientific and mathematics topics in their assessments, whereas procedures and technology are still uncommon in student evaluations [26]. This is both a challenge and an opportunity for teachers to develop assessments that are integrated with STEM. Therefore, it is necessary to collaborate with institutions with research and assessment development expertise to assess and measure thinking skills in STEM integrated education [9].

Needs analysis has become the main process determining the actual needs in learning and plays an important role as a mandatory phase in the curriculum design process [27]. The needs analysis approach is useful for gathering information about teachers' or students' attitudes, beliefs, and opinions [28].

The systematic evaluation of all subjective and objective information required for curriculum reform or assessment formulation is considered needs analysis [29]. Needs analysis refers to a technique for collecting and assessing information relevant to the assessment design and as a means to establish how the assessment is expected [30]. Needs analysis is a process to determine the priority of various data collection tools that can provide an overview of student learning

progress and determine the difference between the desired/should or common conditions with the existing conditions in the physics assessment used by the teachers.

Based on the information presented above, the authors were interested in conducting a needs analysis of the idea inventory assessment combined with STEM literacy to test creative thinking skills. As a result, the purpose of this research is to outline the needs analysis of the idea inventory assessment, which is used in conjunction with STEM literacy to test creative thinking skills. This research is expected to yield a result that may be utilized as a foundational development assessment idea inventory coupled with STEM literacy to assess creative thinking abilities.

## 2. Methods

This research utilizes a qualitative approach with descriptive methods [31].

### 2.1. Population and Sample

This study looks at the population as an occurring social situation that comprises [32]. Physics teachers in Indonesia become resource persons with teaching activities in high school. Then the sample was taken using a purposive sampling technique with 30 high school physics teachers as resource persons spread across several cities in Indonesia.

### 2.2. Data Collection Techniques

This study used triangulation techniques with unstructured interviews, closed questionnaires, and document studies to acquire data. Table 1 describes the aspects in the needs analysis that were adopted and modified from [33-35].

### 2.3. Data Analysis Techniques

Data analysis was carried out by systematically arranging notes or research data to increase the researcher's understanding of the case being studied and presenting it as a finding. The data analysis in this article uses the theory of Miles and Huberman, which consists of three streams of activities that occur simultaneously. Data analysis consists of three steps: condensing, displaying data, and making conclusions [36].

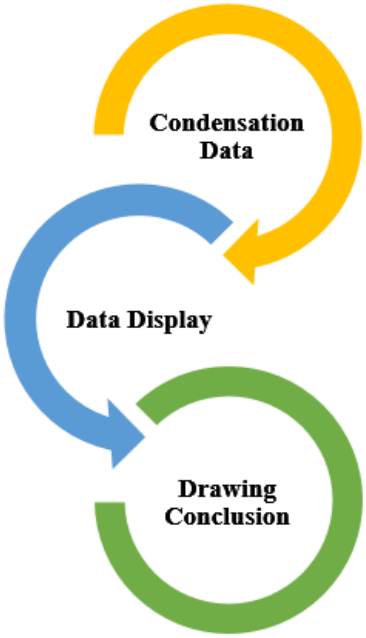



Fig. 1 Research procedure

Data condensation is the method of choosing or modifying supporting data from written field notes, interviews, papers, and other empirical materials and then filtering the data to determine which data are the most relevant to be utilized in research. Data display organizes and codes data necessary to design a row of columns a qualitative matrix to facilitate reading data. The last stage is making conclusions, which contains all important information from the study [36].

Table 1 Aspects and indicators of needs analysis

| No. | Aspect | Indicator |
|---|---|---|
| 1 | Teacher-developed assessment instruments | Time for assessment<br>Types/models of assessment used by teachers<br>Steps in the preparation of the assessment instrument<br>Sources for making assessment instruments |
| 2 | The importance of product development | The teacher's understanding of concept inventory assessment integrated with STEM literacy to measure creative thinking skills<br>The importance of concept inventory assessment integrated with STEM literacy to measure creative thinking skills<br>The experience of teachers in the preparation of concept inventory assessment integrated with STEM literacy to measure creative thinking skills |
| 3 | Products that users want | The assessment criteria for the concept inventory are integrated with STEM literacy to measure creative thinking skills |
| 4 | Interest in using the product | Interest in using concept inventory assessment integrated with STEM literacy to measure creative thinking skills |

# 3. Results and Discussion

## 3.1. Teacher-Made Assessment Instruments

Seeing the teacher's assessment will give an idea of the instrument used by the teacher in assessing his students. The teacher's response can be seen in table 2.

Determining when the assessment is carried out is useful for determining the purpose of the assessment itself [37]. Most teachers more often conduct assessments at the end of the lesson and rarely do it initially. Based on interviews with several teachers, they argue that the assessment at the end of the lesson provides information about students' understanding in determining students' understanding of the material that the teacher has given during the learning that has been carried out.

Table 2 Teacher responses to the instruments that have been used

| Indicator | Statement | Often | Rarely |
|---|---|---|---|
| Time for assessment | I assess at the beginning of physics learning | 30% | 70% |
| | I assess at the end of the physics lesson | 96.7% | 3.3% |
| Types/models of assessment used by teachers | I use the multiple-choice technique | 66.7% | 33.3% |
| | I use the description technique | 86.7% | 13.3% |
| | I use an open-ended technique | 36.7 % | 63.3% |
| Steps in the preparation of the assessment instrument | I compile an assessment instrument that is under basic competencies and basic competencies, syllabus, learning achievement indicators | 96.7% | 3.3% |
| | I use assessment instruments that validity and reliability has been tested | 27.7% | 73.3% |
| Sources for making assessment instruments | I made an assessment instrument from a book | 76.7% | 23.3% |
| | I made an assessment instrument from the internet/website | 43.3% | 56.7% |
| | I make the assessment instrument independently | 90% | 10% |

Teachers also conduct assessments with description techniques rather than multiple-choice, while assessments with open-ended techniques are rarely carried out. According to the assessment with the description, the technique will provide a deeper understanding of students' insight. Form questions are frequently assessed using rubrics and take longer than multiple-choice questions, but they can provide teachers with greater insight into their students' understanding. [20]. However, during the COVID-19 pandemic, assessment in a description is a challenge for teachers.

Then in making assessment instruments, almost all teachers have adjusted to basic competencies and basic competencies, syllabus, learning achievement indicators. It is very important to find the results of the learning objectives. However, the instruments developed by the teacher are still rarely tested for validity and reliability, so the instrument's feasibility is still questionable. A valid and accurate test instrument is required to determine how the subject material can develop a deeper understanding of students' awareness [38].

## 3.2. Importance of Product Development

Table 3 is the teacher's response to the importance of the product to be developed. Teachers' understanding of various concepts in developing concept inventory assessment integrated with STEM literacy to measure creative thinking skills, the majority agree with the statement given by the researcher, although some teachers do not agree. This indicates that these statements are indeed under what the teacher expects from this assessment. The teachers also feel it is important to develop an assessment, as shown in indicator 2.2. The majority of teachers agree with the statement given.

Table 3 Teacher's response to the importance of product development

| Indicator | Statement | Agree | Disagree |
|---|---|---|---|
| The teacher's understanding of the integrated concept inventory assessment of STEM literacy to measure creative thinking skills | STEM literacy is described as understanding and using scientific and mathematical concepts and procedures to make decisions. | 93.4% | 6.6% |
| | The two basic components of STEM education literacy are scientific research (science) and engineering design (engineering). | 86.2% | 13.8% |
| | In the preparation of the assessment instrument, it must be integrated between knowledge and application of physics | 93.3% | 6.7% |
| | Creative thinking is an ability that students must possess and is a 21st-century skill | 100% | 0% |
| The importance of an integrated concept inventory assessment of STEM literacy to measure creative thinking skills | STEM is very important in learning physics | 96.7% | 3.3% |
| | Creative thinking is very important in Physics assessment | 100% | 0% |
| | Concept inventory assessment of integrated STEM literacy is essential for the development | 93.3% | 6.7% |

| | | | |
|---|---|---|---|
| The experience of teachers in the preparation of an integrated concept inventory assessment of STEM literacy to measure creative thinking skills | The difficulty in developing STEM literacy is that it is integrated with assessment or student learning outcomes | 93.3% | 6.7% |
| | The difficulty in developing STEM literacy is setting extra time for teachers | 86.3% | 13.3% |
| | Statement | Often | Rarely |
| | I use an assessment instrument that is integrated with STEM | 36.7% | 63.3% |
| | I use physics assessment instruments tend to mathematical questions | 70% | 30% |

Meanwhile, the difficulties faced by teachers in developing instruments are difficult to integrate between STEM components and are more inclined towards mathematical questions. In addition, another difficulty is that there is limited time in development, resulting in teachers not being able to make instruments that are integrated with STEM. Empirical research shows that increasing knowledge in related STEM subfields and managing extra time to study are the two main difficulties in implementing STEM education [15]. This has resulted in teachers not having experience in making assessments that are integrated with STEM.

### 3.3. Products, Which Users Want

The criteria expected by teachers for the assessment to be developed are shown in Table 4.

Table 4 Teacher's response to the desired product

| Indicator | Statement | Agree | Disagree |
|---|---|---|---|
| 3.1 Vote concept inventory criteria regarding integrated STEM literacy to measure creative thinking skills | The assessment is tested for validity and reliability | 86.7% | 13.3% |
| | Easy to use for teachers | 100% | 0% |
| | There is a connection between the application and the concept of physics | 96.7% | 3.3% |
| | Can measure students' thinking skills | 96.7% | 3.3% |

Designing validated and accurate assessments of differentiated learning in STEM has proven to challenge [39]. Twenty-six teachers wanted a valid and reliable instrument because the questions or instruments that the teacher made had not been tested for the validity of the questions. Then the teachers agreed that this instrument was easy to use, meaning that it did not make it difficult for the teacher to understand the flow of making the instrument, and the questions in the instrument could describe the relationship between concepts and the application of physics in reality. In addition, the teachers also agreed that this instrument could measure students' thinking skills. Based on interviews with several teachers, the instrument they made only measured students' understanding and did not know whether they had measured their thinking skills well.

The interview results explained that the teacher's anxiety in conducting assessments during the COVID 19 pandemic could not use an assessment to determine students' understanding, so they wanted multiple-choice assessments to facilitate assessment, but the teachers had not been able to make tested multiple-choice questions.

### 3.4. Product Usage Interest

Table 5 shows the teacher's interest in this instrument. Twenty-nine teachers are interested in developing it and hope they can use it in their learning in the classroom. This teacher's interest was used as an initial study to obtain a better assessment instrument to develop the instrument.

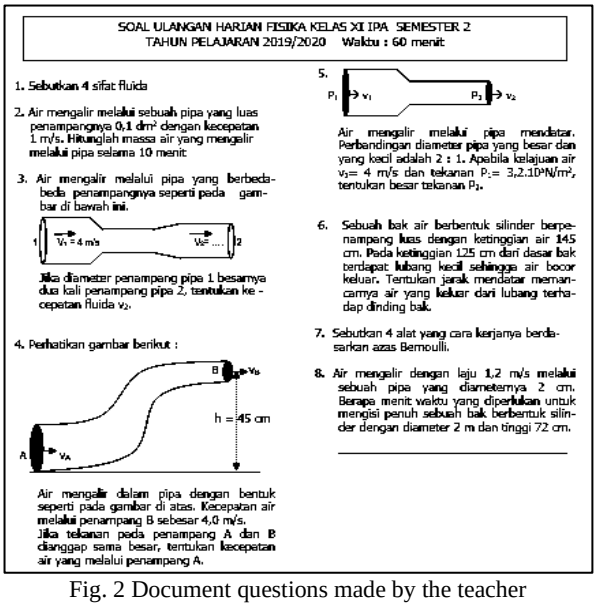
Table 5 Teacher's interest response to the product

| Indicator | Statement | Interested | Not Interested |
|---|---|---|---|
| Interest in using an integrated STEM literacy concept inventory assessment to measure creative thinking skills | I am interested and need a concept inventory assessment instrument that integrates STEM literacy to measure creative thinking skills | 96.7% | 3.3% |

This interest is, of course, without reason. The teachers feel the need to develop an assessment like this as a guide in making better questions.

### 3.5. Document Study

The document study is a complementary study of the interview method and the distribution of questionnaires to teachers.


SOAL ULANGAN HARIAN FISIKA KELAS XI IPA SEMESTER 2
TAHUN PELAJARAN 2019/2020 Waktu : 60 menit

1. Sebutkan 4 sifat fluida

2. Air mengalir melalui sebuah pipa yang luas penampangnya 0,1 dm² dengan kecepatan 1 m/s. Hitunglah massa air yang mengalir melalui pipa selama 10 menit

3. Air mengalir melalui pipa yang berbeda-beda penampangnya seperti pada gambar di bawah ini.

Jika diameter penampang pipa 1 besarnya dua kali penampang pipa 2, tentukan kecepatan fluida $v_2$.

4. Perhatikan gambar berikut :

h = 45 cm

Air mengalir dalam pipa dengan bentuk seperti pada gambar di atas. Kecepatan air melalui penampang B sebesar 4,0 m/s. Jika tekanan pada penampang A dan B dianggap sama besar, tentukan kecepatan air yang melalui penampang A.

5.

Air mengalir melalui pipa mendatar. Perbandingan diameter pipa yang besar dan yang kecil adalah 2 : 1. Apabila kelajuan air $v_2$= 4 m/s dan tekanan $P_2$= 3,2.10⁴N/m², tentukan besar tekanan $P_1$.

6. Sebuah bak air berbentuk silinder berpenampang luas dengan ketinggian air 145 cm. Pada ketinggian 125 cm dari dasar bak terdapat lubang kecil sehingga air bocor keluar. Tentukan jarak mendatar memancarnya air yang keluar dari lubang terhadap dinding bak.

7. Sebutkan 4 alat yang cara kerjanya berdasarkan azas Bernoulli.

8. Air mengalir dengan laju 1,2 m/s melalui sebuah pipa yang diameternya 2 cm. Berapa menit waktu yang diperlukan untuk mengisi penuh sebuah bak berbentuk silinder dengan diameter 2 m dan tinggi 72 cm.

Fig. 2 Document questions made by the teacher

Figure 2 provides authentic evidence of the assessment made by the teacher [40]. It can be seen that the daily assessment of dynamic fluid material with eight questions is in the form of descriptions. If analyzed more deeply, the questions made by the teacher are good but only integrate science and mathematics in their solution and do not provide phenomena that occur in the real world. Contextually made assessments play an important role in the development of student's creative thinking and problem-solving skills, which are necessary when managing real-world situations in the profession outside of the classroom [41].

In addition, the questions made by the teacher have not shown the literacy dimension and are more likely to be questions that lead to mathematical equations. Questions like this, of course, do not shape students' thinking skills and make students tend to memorize many physics equations. Students need a more practical, integrated, and authentic learning experience. This task focuses on developing STEM literacy specifically from that integrated approach, as we know that to solve complex problems in our community and, more broadly, the world, knowledge from multiple disciplines must be applied [24].

Understanding the importance of STEM literacy and how it is applied is a complex process. The assessment to measure the conceptual understanding of physics integrated with STEM literacy has not been carried out properly. Assessments that teachers have made tend to focus on knowledge in one discipline only. Therefore, researchers are trying to get teachers' perceptions of developing an integrated STEM literacy concept inventory assessment to fill this gap.

A needs analysis was conducted to obtain in-depth information on difficulties, experiences, the importance of the product, the assessment that the teacher wanted, and the teacher's interest in developing a concept inventory assessment based on STEM literacy. This needs analysis is a novelty that the researchers did as a first step in developing an assessment under the theoretical study and the teachers' expectations so that a concept inventory assessment product integrated with STEM literacy will be produced.

## 4. Conclusion

Based on the results presented and data analysis, it can be stated that:

The assessment that the teacher uses is mostly in the form of a description and is carried out at the end of the lesson. In making assessments, the teachers have adjusted to the learning objectives, and most teachers make questions independently, but the instruments made have not been tested for validity and reliability.

The teachers have a diverse understanding of concept inventory assessment integrated with STEM literacy to measure creative thinking skills, which is very important to develop. This happens because the teachers do not have sufficient experience in making assessments like this, the questions made by the teacher are still in the form of questions towards mathematical completion, and there is no literacy charge for phenomena that occur in the real world.

Teachers' expectations in developing this assessment are that most teachers want an assessment that has the quality and is easy to use well by teachers. In addition, the form of assessment can be in the form of multiple-choice due to the COVID-19 pandemic.

The teacher's interest in product development shows that 3.3% of teachers are not interested, and 96.7% of teachers are interested and need the development of a STEM literacy-based concept inventory assessment to measure creative thinking skills.

From this needs analysis, more in-depth research will be carried out to develop a concept inventory assessment based on STEM literacy to measure creative thinking skills that have been tested for validity and reliability so that teachers in assessment practice can use them.

This study has limitations because it only analyzes teachers' perceptions of developing an integrated STEM literacy concept inventory assessment and does not analyze students' perspectives. This is an opportunity for researchers to analyze students' difficulties and expectations of the concept inventory assessment.

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