Validation of questions-based STEM (Science, Technology, Engineering, and Mathematics) for Elementary School Teacher Education

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Abstract

This study was to validate questions based STEM for elementary school education students, they are categorized as quantitative descriptive. The product of this research was aimed at class 2019 elementary school education students of Universitas PGRI Ronggolawe Tuban (UNIROW). The research time was started from April 2020 to July 2020. These products have not been tested extensively because they have been hampered by the Covid-19 pandemic. The questions based STEM developed were essay questions consisting of pretest questions, practice questions, and posttest questions. Each question shows one of the STEM ability profiles. The validation results show that all aspects of the assessment have very good criteria. The aspect that got the highest percentage score was the content suitability aspect with a score percentage of 84.38%. While the aspect that got the lowest score percentage was the graphic aspect with a score percentage of 82.14%. The language aspect got a score percentage of 82.50%.

Keywords: Science, Technology, Engineering, Mathematics

1. Introduction

In this century, each knowledge no longer has to work alone, but various branches of knowledge can work together, not only within science, technology or social science and humanities groups, but in many cases between several groups (Bybee, 2013). In line with this, the 21st century learning paradigm emphasizes the ability of students to find out from various sources, formulate problems, think analytically and collaborate in solving problems that are often called 21st century skills (21st-century Skills) (Trilling and Fadel, 2009). Based on Trilling and Fadel (2009), 21st century skills are generally divided into three skills, namely Learning and Innovation Skills, Information, Media, and Technology Skills and Life and Career Skills.

One of the lessons that can integrate 21st-century Skills is STEM (Science, Technology, Engineering, and Mathematics). STEM is an approach in education in which Science, Technology, Engineering, Mathematics is integrated with the educational process focusing on solving problems in real everyday life as well as in professional life (Research, 2011). STEM shows students how concepts, principles, engineering science, technology, engineering and mathematics (STEM) are used in an

integrated manner to develop products, processes and systems that benefit human life (Wang *et al.*, 2011).

The use of the STEM approach in education aims to prepare students to compete and be ready to work in their respective fields. STEM provides educators with the opportunity to demonstrate to students that the concepts, principles and techniques of STEM are used in an integrated manner in the development of products, processes and systems used in their daily lives. Therefore, the STEM definition is adopted as an interdisciplinary approach to learning (Reeve, 2013). In STEM-based learning students use science, technology, engineering, and mathematics in real contexts that connect schools, the world of work, and the global world to develop STEM literacy that allows students to be able to compete in the 21st-century. The STEM-based questions were developed in the form of essay questions of 8 questions, consisting of 4 pretest questions and 4 posttest questions.

2. Research Method

This research was the quantitative descriptive design developed by (Sugiyono, 2008) and has been simplified into two stages, namely the preliminary stage and the development stage. The preliminary stage is through the process of literature review, description and analysis of findings (factual model). The development stage includes the initial product design stage (hypothetical product), expert testing, analysis of expert validation results and revisions to get the final product.

Validation was got by providing a validation sheet to the validator before the limited scale test selected as the respondent. The validation sheet was used to determine the opinion and validity level of STEM-based questions. The validity of the STEM-based questions that had been compiled, the researcher obtained using the results of content validity and construct validity (Arikunto, 2012). The content validity was obtained from the suitability between the STEM-based questions developed with competence criteria, indicators, and the course material being studied by students. The construct validity was obtained from the opinions of validator about the developed STEM-based questions. The questions to evaluate students' STEM abilities and 21st Century Skills on simple machine material are presented in the form of a pretest and posttest.

3. Result and Discussion

The STEM skills presented in questions are the aspects of Science, Technology, Engineering, and Mathematics. Each of these four aspects is divided into 2 indicators. The STEM-based questions that have been developed are validated by two validators, they were: Prof. Dr. Supiana Dian Nurtjahyani, M. Kes. and Ir. Hernik Pujiastuti, M. Pd. The aspects that were assessed by the two validators included the suitability of content and language. The indicators for each aspect are presented in Table 1.

Table 1. STEM Indicators

STEM aspects	Indicators
Science	1. Mention more than piece information related to the problem given
	2. Linking information with theoretical basis Technology
Technology	1. Estimating the solution to the problems given.
	2. Design simple tool/technology from the solutions given Engineering
Engineering	1. Conclude from the technology or tools that have been created
	2. Using technology or tools that have been created Mathematics
Mathematics	1. Calculating the benefits of using the technology that has been created
	2. Calculating the disadvantages of not using the technology that has been created

3.1 Content Aspects

The content suitability aspect consists of four assessment indicators, they were explained in Table 2.

Table 2. Content Aspect of Validation Results

No	Assessment Indicators	Validation Result		
		1	2	Average
1	Suitability of STEM-based questions with competence standard	4	4	4
2	Suitabiltiy systematics in the preparation of STEM-based questions	4	4	4
3	The clarity of each component in STEM-based questions	2	3	2,5
4	The questions in the pretest and posttest sheets correspond to STEM-based learning materials and describe 21st Century Skills	3	4	3,5

The data obtained from the results of the validation on the aspect of content suitability is presented in Fig 1.
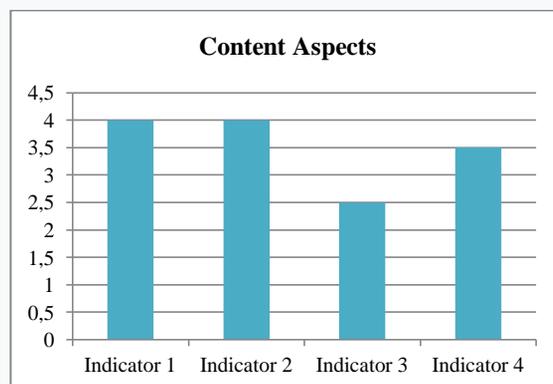

Fig 1. Content Aspect of Validation Results

Based on the data presented in Figure 1, indicators 1 and 2 obtain the maximum score from the validator. The lowest score is obtained on indicator 3, which is the clarity of each component of the STEM-based questions. Validators considered a lack of clarity on STEM charts. Suggestions from the validator, researchers should provide clear instructions for STEM charts so that students do not have difficulty using them. The aspect of content suitability obtained a percentage of 87,50% with very good criteria.

3.2. Lingustic Aspect

The linguistic aspect consists of four assessment indicators, they were explained in Table 3.

Table 3. Linguistic Aspect of Validation Results

No	Assessment Indicators	Validation Result		
		1	2	Average
1	The sentence structure in STEM-based questions sheet guide is easy to understand	3	3	3
2	The sentences used in the STEM-based questions are in accordance with the proper and correct Indonesian language rules	4	4	4
3	The language used in communicative	4	4	4
4	The choice of grammar on the STEM-based questions in accordance with the student's intellectual level	4	4	4

The data obtained from the results of the validation on the aspect of language aspect is presented in Fig 2.
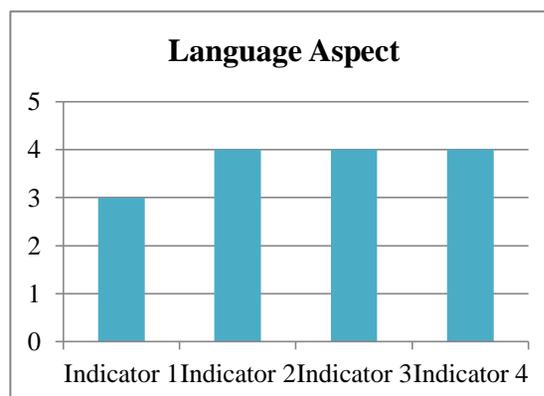

Fig 2. Language Aspect of Validation Results

The validator gives an average score of 3.5 for indicators 2, 3, and 4 in the linguistic aspect. Indicators 1 get a score of 3. The STEM-based questions that will be used by lecturers, validators, observers, and students have met the linguistic aspects, among

others, the sentences in The STEM-based questions are easy to understand, in accordance with the rules of Indonesian that are good and correct, communicative, and according to the student's intellectual level. The aspect of content suitability obtained a percentage of 93,75 % with very good criteria.

4. Conclusion

The STEM-based questions developed have very high validity with a score of 87.50% for the aspect of content suitability, 93.75% for the linguistic aspect so that they can be used to describe the STEM profile of trial students. Critical abilities are obtained from the science aspect, creative abilities are obtained from the technology aspect, collaborative abilities are obtained from the engineering aspect, and communicative skills are obtained from mathematics abilities.

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