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Exploring Students' Creativity Using STEAM-Based Reading Texts

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ABSTRACT

Creative thinking is one of the important skills required to face the 21st century challenges. However, students' creativity assessment is challenging. Grounded on the paradigm that creativity is a tangible parameter, this study aims to explore students' creative thinking skill via a reading-based creativity test. The test was developed by considering the creativity indicators defined by Paul Torrance, i.e., fluency, flexibility, originality, and elaboration. In this creativity test, the reading and the questions were designed to make students integrate their science, technology, engineering, arts, and mathematics (STEAM) knowledge. Based on the empirical validation, the creativity test had a reliability of 0.897, indicating that the test was reliable to measure students' creativity. Due to the Covid-19 pandemic, the test was conducted online to 108 junior high school students in East Java, Indonesia. In general, the students achieved the highest level of creativity in terms of originality that gained average score of 3.63 (with scale 4.00). Meanwhile, they underperformed on the aspects of elaboration having average score of 2.40. There were 93 and 79 students who responded very well on the originality and fluency aspects, respectively. In contrast, respectively over 30% and 50% of students showed a lack of creativity on the aspect of flexibility and elaboration. These creativity assessment data are beneficial for educational stakeholders especially to increase the quality of teaching and learning related to STEAM education.

1. Introduction

In the 21st century, creativity is regarded as one of the most important skills. It enables people to remain adaptable and capable of dealing with the opportunities and challenges that this complicated world presents [1]. The ability to observe and evaluate issues from various viewpoints, devise new solutions, and achieve new cognitive capacities are all examples of creativity [2]. Thus, creativity is crucial for long-term success for individuals, companies, and countries [3]. Educational experts suggested that measuring students' creativity is vital in education [1]. The main reason is because

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creativity can improve other individual abilities, such as problem-solving skills and self-achievement [4,5]. However, the profile of students' creativity has unfortunately not been widely reported in the literature. Therefore, in this present study, a creativity test was developed to measure the creativity levels of Indonesian students, especially from East Java province. The students' creativity was profiled in accordance with the Torrance's creativity indicators, namely originality, flexibility, fluency, and elaboration [6]. Originality is the ability to generate new ideas with one's own mind. Flexibility is a person's ability to have openness to various kinds of ideas. Fluency is the ability to generate ideas. Elaboration is the ability to provide more complex ideas.

Until recently, creativity tests have been developed by some researchers. In general, researchers used the Torrance indicator in measuring students' creativity levels. Some researchers used the original version of Torrance questions to capture students' creativity in biology [7]. Unfortunately, this test is likely to be irrelevance with scientific context, especially for biology. That is because the original version of Torrance questions for creativity are too general. Other researchers employed the Torrance indicators to capture students' creativity with modified questions following the science context [8-10]. This type of test is quite appropriate to the content of science and in accordance with the chosen creativity indicators. However, the questions are too conceptual and are not based on the real-world phenomena. As far as creativity is concerned, presenting real-world problems, for example environmental pollution, to students is important for their creativity development [11]. The real-world problems have multiple solutions and finding the best solution to a given real-world problem is a creative thinking activity [12].

In school education context, students gain knowledge much from reading. While some educators believe that reading is important for students to learn [13], others put more emphasize on the power of reading towards creativity. Popov was one educator who believed that reading is a creative process [14]. Mourgues and his colleagues have proven that higher verbal ability correlates with greater creativity [15]. A text is not just a compilation of words and sentences. It expresses situations where concepts and ideas are related to one another in some specific ways. Therefore, the process of text understanding is considered as a process of creative thinking [14]. This view dictates the measurement of creativity by means of reading text comprehension.

Provided the fact that reading is crucial for students, Organisation for Economic Co-operation and Development (OECD) conducts Program for International Student Assessment (PISA) that includes reading, science, and mathematics. Based on the PISA scores in reading, science, and mathematics, it is revealed that Indonesian schoolchildren rank below their fellows living in 79 countries (OECD). Consequently, Indonesian government has been making serious educational reforms since the last few decades. The latest educational reform, called *Merdeka Belajar* (Emancipated Learning), was launched by the Ministry of Education and Culture of Indonesia in the end of 2019 [16]. This policy opens more rooms for teachers to innovate during the teaching and learning process. With that, STEAM (science, technology, engineering, arts, and mathematics) education is one of the most recommended approaches for Indonesian schools.

The discourse of STE(A)M education in Indonesia has been improving quite rapidly [17-19]. Suwarma and Kumano found that the national curriculum (Curriculum 2013) is appropriate with the inclusion of STEM education [20]. The Curriculum 2013 was designed by taking into consideration the 21st century challenge. Therefore, there is a room for integrating two or more lessons in schools in accordance with that curriculum [20]. STE(A)M teaching projects, which is based on the lesson integration, have been applied in some schools under the supervision form professional association [17]. Moreover, with the launching of the Emancipated Learning national program, the movement of STEAM education is now becoming more promising for Indonesian education. Since 2020, the Ministry of Education and Culture of Indonesia has also been promoting students to be familiar with

STE(A)M projects, namely KIHAJAR STEM. It is a national competition to encourage Indonesian students to perform the 21st century skills via STEM education.

The heart of STEAM education is the integration of each discipline to solve real-world problems, for example environmental pollution [21]. The S-T-E-A-M integration is essential to comprehensively understand the environmental pollution phenomena. Furthermore, that comprehensive understanding will lead to the creation of creative solution to real-world environmental problems. Therefore, STEAM education can promote student creativity [22]. Herein, we report the exploration of student creativity by means of STEAM-based reading test.

2. Methods

In this study, an assessment of creative thinking skill embedded STEAM-related real-world problems was developed to explore students' creativity. Figure 1 illustrates how the STEAM-based reading texts were developed to measure students' creativity. The indicators of creativity used four measures from Torrance, i.e., originality, fluency, flexibility, and elaboration [4]. The reading-based problems were about the environmental pollutions that required students to integrate their understanding of science, technology, engineering, arts, and mathematics (STEAM). The creativity test development was done by taking the following steps:

i. Competency analysis
ii. indicator identification
iii. text generation
iv. question formulation
v. expert validation
vi. pilot testing

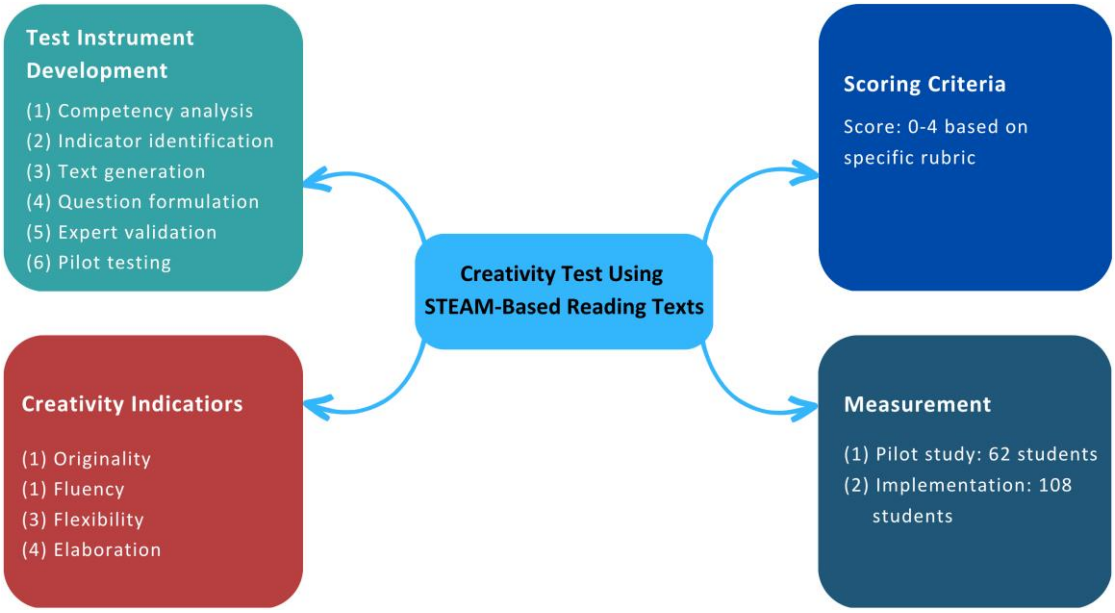

Fig. 1. Development of STEAM-based reading texts for creativity assessment

The initial draft was validated by experts, namely a science education lecturer a physics teacher who had teaching experiences over 5 years. Their comments, which were mainly on the figure's arrangements and passages length, were taken into consideration to improve the instrument. Afterwards, the revised instrument was then tested for readability evaluation and pilot testing. The

pilot study was done to 62 students from some schools in East Java Province. When the developed creativity test was validated and reliable, it was then ready to implement to students. There were 108 students as the research participants, with different students from the pilot study. They were from junior high schools from various districts in East Java province, Indonesia. Students would obtain scores from 0 to 4 for each indicator of creativity. The scoring criteria is provided in Table 1. The students' creativity performance was analysed based on their scores in originality, fluency, flexibility, and elaboration aspects.

Table 1
Scoring Criteria

Score	Criterion
0	No answer
1	The answer is rewritten from the text
2	The answer is taken from the text with minor modification
3	The answer is taken from the text with mayor modification
4	The answer is based on the text with student's own sentences

3. Results and Discussion

The instrument validation results are provided in Table 2. The expert validation results for the STEAM-based reading instrument aimed at assessing students' creativity revealed highly feasible aspects across various criteria. As depicted in Table 2, the content exhibited strong alignment with students' learning outcomes and its relevance with the STEAM approach as well as creativity. Meanwhile, the instrument's constructs, including layout and integration of STEAM aspects, were deemed very feasible. Although the scoring mechanism scored 80 which suggested room for improvement, this average score still in the feasible criterion. Thus, the overall results for validation suggested that the instrument is valid for creativity assessment.

Table 2
Results of expert validation

Validation	Aspect	Average Score	Criteria
Content	The relevance of texts and questions with students learning outcomes	100	Very feasible
	The relevance of texts and questions with STEAM approach	96	Very feasible
	The relevance of texts and questions with creativity	100	Very feasible
Construct	Layout	90	Very feasible
	STEAM aspects	93	Very feasible
	Scoring	80	Feasible

Furthermore, the developed creativity test has met the very high reliability level with score of 0.897. Therefore, it can be applied for the real measurement. Table 3 depicts students' creativity levels in terms of originality, fluency, flexibility, and elaboration. It is recorded that majority of students showed very good performance on the originality and fluency aspects. Out of 108 students, there were 93 and 79 students who obtained score 4 on the indicators of originality and fluency, respectively. Although the number of students with scores 0 and 1 was doubled from 9 in originality to 18 in fluency, yet these numbers were still small compared to the number of students with the top scores. On the other hand, the top score students significantly decreased on the flexibility and elaboration parts. Only half of total students could obtain score 4 in flexibility and even only one-third of the total students could achieve the top score in elaboration. At the same time, more students achieved scores 1-2 especially on elaboration. Thus, students' creativity from the aspects of

flexibility and elaboration was not as good as their originality and fluency. Students tended to have the best performance of creativity on the aspect of originality. The originality measure of creativity has the highest total and average scores, i.e., 392 (out of 432) and 3.63 (out of 4.00). The worst performance on students' creativity was in the aspect of elaboration, as indicated by its lowest total and average scores (see Table 3).

Table 3
Students' creativity scores

Score	Number of Students			
	Originality	Fluency	Flexibility	Elaboration
4	93	79	54	35
3	3	8	17	11
2	3	3	23	29
1	5	9	13	28
0	4	9	1	5
Total Score	392	355	326	259
Average Score	3.63	3.29	3.02	2.40

Figure 2 shows samples of students' responses on the aspect of elaboration with score 4 (left) and 1 (right). The left side of the figure reflected that the student has excellent elaboration skill. That shows an ability to elaborate student previous understanding to create new model of technology in solving the given environmental pollution problem. Therefore, this diagram deserved score 4. Meanwhile, the diagram presented by the student on the right side in Figure 2 can be commonly seen in many textbooks or internet resources. It indicated that this student did not elaborate his/her previous knowledge to create a new breakthrough for a given problem. Thus, this diagram deserved score 1 for elaboration aspect even though the answer in terms of conceptual understanding is correct. In this study, it was found that students were fluent in showing their ideas to problems, but students' ability to detail ideas still needed to be improved. Flexibility indicator on the topic of global warming obtained the lowest percentage. Flexibility can be interpreted as the ability of students to generate diverse ideas in solving problems or answering questions and students can see problems or questions from various points of view [6].

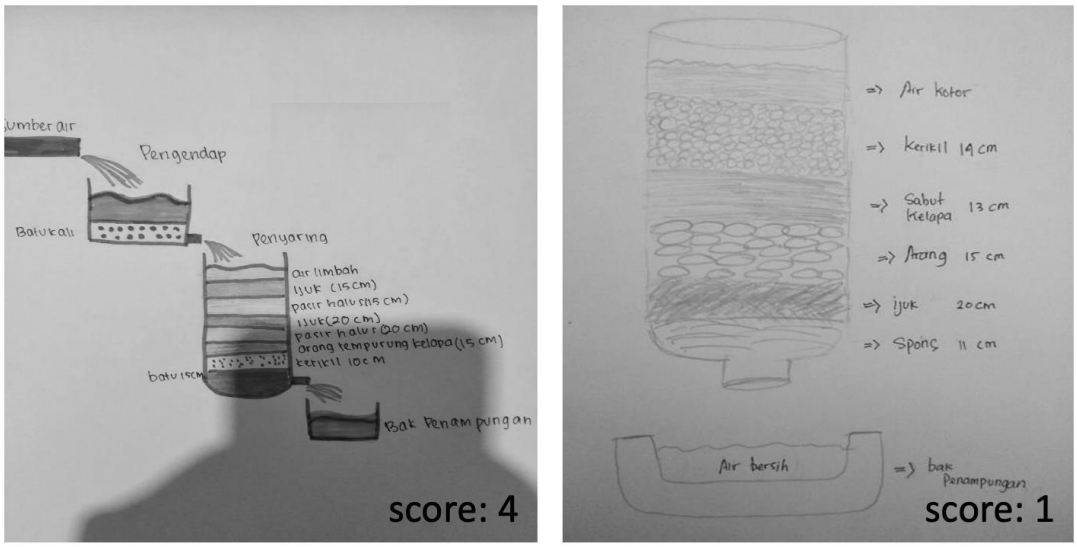

Fig. 2. Sample of students' answers on the aspect of elaboration

Visualization of image to present ideas can be viewed as a creative work. Students' imagination is also triggered when they are given real-world problems with certain scenarios [12]. In this study, the STEAM-based reading text is the main part to activate student imagination and creative thinking. STEAM activity is proven to be an effective approach to develop student creativity due to its ability to make student feels more enthusiastic in learning [22]. At the same time, the authentic real-world problems also support student creativity. Students feel more confident to express their creative ideas because there is no single correct solution to a real-world problem [12]. Students can gain experience in the entire self-directed process of creative design [23].

Torrance [6] viewed creativity as a complex process to perceive problems, generate possible solutions, and present the results to others. In STEAM education, the arts are often referred to "creativity" in education [23]. For that consensus, experts have agreed that STEAM education is designed to develop student creativity [19,22,23]. It is therefore argued that the involvement of the STEAM-based reading text to activate student creativity is an accepted consequence. Torrance [6] also provided the constructs for the creativity test in terms of originality (uniqueness of ideas), fluency (generation of ideas), flexibility (variation of ideas), and elaboration (explanation of ideas). The Torrance measures are the well-known and widely used construct to measure creativity [12]. Thus, the four scoring indicators serves to make the creativity, which is a complex thinking process, quantifiable [24]. As presented in this study, the quantification of student creativity was done by considering the four measures of Torrance creativity test.

4. Conclusions

A creativity test based on Torrance indicators has been developed with a very high reliability. By evaluating originality, flexibility, fluency, and elaboration, this test has provided valuable insights. The results revealed that Indonesian students, especially from junior high schools in East Java province, showed excellent performance on the originality part with average score of 3.63 (of scale 4.00). Meanwhile, elaboration was the creativity measure in which the students performed the worst with average score of 2.40. These findings underscore the urgency of addressing elaboration skills among students. This profiling sets the stage for a more nuanced and effective approach to 21st century education, more importantly in preparing students to thrive in an ever-evolving global landscape.

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