Jurnal Pendidikan MIPA
e-ISSN: 2685-5488 | p-ISSN: 1411-2531
URL: https://jpmipa.fkip.unila.ac.id/index.php/jpmipa
Jounal's DOI: http://doi.org/10.23960/jpmipa

Vol. 27, No. 1, 2026
Article ID: 1207
Pages: 433-451

From General to Contextual: Developing a Subject-Specific Scientific Creativity Test on Simple Machines

Mayaika[1], Suwito Singgih[1,*], Riva Ismawati[1], & Galih Albarra Shidiq[2,3]
[1]Department of Science Education, Universitas Tidar, Indonesia
[2]Universitas Bhayangkara Jakarta Raya, Indonesia
[3]Department of Educational Technology and Communications, Chulalongkorn University, Thailand

*Corresponding email: suwitosinggih@untidar.ac.id

Received: 08 January 2026 *Accepted: 26 February 2026* *Published: 30 March 2026*

Abstract: This study aimed to develop an instrument for assessing junior high school students' scientific creativity based on the Scientific Structure Creativity Model (SSCM) in the topic of Work and Simple Machines. The research employed a Research and Development method using the 4D model (Define, Design, Develop, and Disseminate), and was limited to the Develop stage. The research subjects consisted of 100 eighth-grade students from four public junior high schools in Magelang City, selected through purposive sampling, and nine validators (four lecturers and five science teachers) for content validity testing. The define stage included a needs analysis based on the SSCM, a review of the subject matter, and an analysis of learning outcomes. The design stage involved constructing a test blueprint comprising seven essay items and a scoring rubric based on fluency, flexibility, and originality. The develop stage included expert validation, instrument revision, and a limited field trial. The instrument consisted of seven essay questions, adapted from the seven aspects of the SSCM, along with an expert validation sheet assessing content, construct, and language. Content validity was analyzed using Aiken's V, construct validity was examined through Exploratory Factor Analysis, reliability was measured using McDonald's Omega, and age differences were tested using One-Way ANOVA. The results indicated Aiken's V values ranging from 0.786 to 0.819, demonstrating good content validity. The KMO value of 0.655 and a significant Bartlett's Test ($p < 0.001$) indicated that the data were suitable for factor analysis. McDonald's Omega yielded a value of 0.739, indicating adequate internal consistency. The ANOVA test ($p = 0.775$) showed no significant difference in scientific creativity scores between students aged 13 and 14 years. The findings indicate that the developed instrument is valid and demonstrates adequate reliability for measuring junior high school students' scientific creativity in the topic of Work and Simple Machines.

Keywords: instrument development, scientific creativity, scientific structure creativity model, work, simple machines.

Article's DOI: https://doi.org/10.23960/jpmipa.v27i1.pp433-451

INTRODUCTION

The 21st century is known for rapid advancements in many fields, ranging from technology and information and communication to industry and education. These demand human resources who can adapt quickly and possess skills aligned with global issues and challenges (Vlachopoulos & Makri, 2024). Education plays a crucial role in helping students acquire 21st-century skills, usually referred to as the 4Cs: critical thinking, creativity, collaboration, and communication (Isnaini et al., 2023). Among these, creativity plays an essential role, as it underpins innovation, complex problem-solving, and the creation of new knowledge (Hong, Park, & Song, 2022). Creativity can be understood as an integration of skills, knowledge, motivation, and attitudes that enables individuals to evaluate ideas from multiple perspectives and dimensions, generating novel, valuable, and original ideas or products (Henriksen, Mishra, & Fisser, 2016). Creativity constitutes a fundamental competence for addressing reform-era competition and future challenges, which require a creative generation capable of innovation (Ritter, Gu, Crijns, & Biekens, 2020; Sisman, Aydogan, & Cankaya, 2024). Therefore, creativity can be considered a fundamental skill that should be developed through learning processes in schools (Kirana, 2020; Rosidin, Herliani, & Viyanti, 2023).

Creativity in science learning is getting manifested in the form of scientific creativity, which relates to the capability to generate ideas, solve problems, design experiments, and generate many scientific products (Hu & Adey, 2002). Scientific creativity has characteristics that are different from general creativity (Sisman et al., 2024). Torrance (1966) defined creativity in education as the ability to be sensitive to problems, reflected in the indicators of fluency, flexibility, and originality. In the context of science education, scientific creativity is not measured solely by the number of ideas generated or the uniqueness of those ideas, but also by their alignment with scientific concepts, the ability to design experimental procedures, and the application of scientific knowledge to solve problems (Hebebci & Usta, 2022). Therefore, scientific creativity cannot be measured using general creativity instruments such as the Torrance Test of Creative Thinking (TTCT), the Test of Creative Thinking-Divergent Production (TCT-DP), or the Creative Reasoning Test, as these instruments are general in nature and are not specifically designed for the science domain (Nogueira, Almeida, & Lima, 2017; Rababah, 2018; Schoen, Bowler, & Schilpzand, 2018). This indicates the need to develop specialized instruments to assess scientific creativity in science learning contexts.

One of the frameworks applied on purpose to help assess scientific creativity is the Scientific Structure Creativity Model (SSCM), as stated by Hu & Adey (2002). This model tended to assess scientific creativity by considering seven aspects: unusual use and real advance, technical product, scientific imagination, problem-solving, creative experimentation, and science product. This model holds that scientific creativity is not solely measured by the number of ideas created, but also by their novelty and scientific appropriateness. The SSCM's strength lies in its flexibility, and it is also easy to adapt to various descriptions of learning without compromising its scientific creativity indicators. Hu et al. (2013)the SSCM has three main dimensions, namely the dimension of trait of characteristics from creative thinking, then the process dimension of scientific thinking, and the product dimension of scientific outcomes, and also generating a more comprehensive assessment of scientific creativity, and also contextual (Eroglu & Bektas, 2022). The items of test developed within this model remain general and are not yet directed toward specific subject matter. Hu & Adey (2002) also strengthens the need for cultural and content adaptations so that the model can be applied to assess scientific creativity across different ages and learning topics.

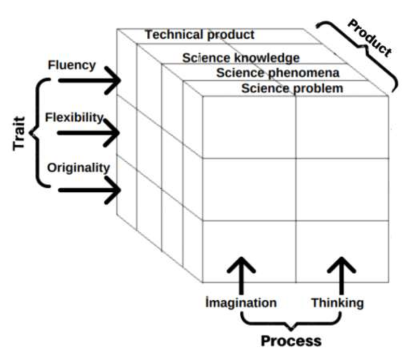


Figure 1. Illustration of the SSCM (Hu & Adey, 2002)

Several prior studies have applied instruments according to the Hu and Adey framework in instructional settings. Astutik et al. (2020) adapted the Hu and Adey instrument on purpose to help measure junior high school students' scientific creativity through the model of CCL in learning physics. Dewi et al. (2024) integrated the Hu and Adey scientific creativity indicators into the Creative Problem-Solving (CPS) model on static fluid topics on purpose to help measuring creativity abilities of students. In addition, Prahani et al. (2021) stated an Online Scientific Creativity Learning (OSCL) approach according to the model of Wademan in order to help measure the scientific university students' physics creativity. These also indicate that the Hu and Adey instrument can be used to support the effectiveness of instructional models. However, these existing studies still focus primarily on applying existing models rather than on developing new ones or on more specific instruments related to specific instructional content. Wiyanto et al. (2020) emphasized that the study on scientific creativity in Indonesia was still limited, particularly in instrument development. So, it is necessary to develop instruments of scientific creativity tailored to specific instructional content in school.

From a developmental psychology perspective, the ages 13-14 are considered an important phase in the development of creativity. Torrance, (1968) identified the phenomenon known as the fourth-grade slump, referring to a decline in creativity at the elementary school level around the ages of 9-10, followed by a subsequent increase during adolescence. Smith & Carlsson (1983) also found that creativity peaks at ages 10-11, declines at 12, and then gradually increases to a second peak around age 16. Thus, eighth-grade junior high school students (aged 13-15 years) are in a developmental phase in which scientific creativity potential begins to increase again after a period of decline (Claxton, Pannells, & Rhoads, 2005). This makes the development of scientific creativity instruments for junior high school students increasingly relevant, as such instruments can help teachers identify and stimulate scientific creativity at an appropriate stage of development.

Although several previous studies have adapted the Hu and Adey model in science learning contexts, most have focused primarily on implementing instructional models and quantifying improvements in students' creativity, rather than on developing and validating scientific creativity assessment instruments. In contrast, the present study positions the scientific creativity instrument as the central focus of investigation, particularly in examining its content, construct, and reliability validity within the context of junior high school science learning. Furthermore, the instrument, based on the Scientific Structure Creativity Model (SSCM) developed by Hu and Adey, is essentially general in nature and not bound to specific subject matter. Hu & Adey (2002) also emphasized the need for cultural and content adaptations to ensure its appropriateness for assessing students' scientific creativity across different ages and subject areas. Therefore, developing an instrument explicitly aligned with the characteristics of the instructional content and the intended learning outcomes is necessary to ensure that the measurement of scientific creativity is more relevant and contextualized. With this contribution, the present study is expected to enrich the body of research on scientific creativity assessment at the junior high school level and to provide teachers with an instrument to assess and foster students' scientific creativity. Based on this rationale, the study aims to develop an SSCM-based instrument for scientific creativity on the topic of Work and Simple Machines. The research questions focus on: (1) the content validity and construct validity of the developed scientific creativity instrument; (2) the reliability of the instrument based on students' responses; and (3) the consistency of the instrument's measurement among Grade VIII junior high school students aged 13-15 years.

METHOD

Participants

This study was conducted with Grade VIII students from public junior high schools in Magelang City who had completed instruction on the topic of Work and Simple Machines. The sample consisted of 100 Grade VIII students drawn from four public junior high schools: SMPN 1 Magelang, SMPN 2 Magelang, SMPN 4 Magelang, and SMPN 6 Magelang. The participants were aged 13-15 years. A purposive sampling technique was employed. The sample was selected based on the following criteria: students had received instruction on Work and Simple Machines, and the schools agreed to participate as pilot-testing sites. Students' academic ability was not strictly controlled; therefore, learners with diverse academic backgrounds were included in the pilot test. This decision was made because the study aimed to conduct an initial instrument trial and construct analysis. By involving students with diverse academic abilities, the authentic characteristics of classroom conditions were maintained, allowing the findings to more accurately reflect real classroom contexts. The study also involved nine validators, consisting of four university lecturers and five junior high school science teachers. These expert validators assessed the instrument's content validity, focusing on content relevance, item construction, and language clarity.

Research Design and Procedures

This study employed a Research and Development (R&D) approach using the 4D model (Define, Design, Develop, and Disseminate) proposed by Thiagarajan (1974). However, the study was limited to the third stage (Develop), as it focused on instrument development and the testing of validity and reliability.

Define

The define stage involved a needs analysis for instrument development. This stage included a literature review of instruments based on the Scientific Structure Creativity Model (SSCM), an analysis of the characteristics of the Work and Simple Machines topic, and an examination of the learning outcomes outlined in the *Merdeka* Curriculum.

Design

During the design stage, a test blueprint was constructed comprising seven open-ended essay items aligned with the seven aspects of the SSCM. A scoring rubric was also developed at this stage.

Develop

The develop stage began with expert content validation, followed by revisions based on the validators' feedback. After revisions were completed, a limited field test was conducted with 100 students to obtain empirical data. The entire research process was carried out over one semester during the 2025/2026 academic year.

Instruments

The instrument used in this study consisted of a scientific creativity test developed by the researcher specifically for this research, along with an expert validation sheet. The scientific creativity test consisted of open-ended essay questions developed based on the Scientific Structure Creativity Model (SSCM) proposed by Hu and Adey (2002). The original instrument by Hu and Adey was general in nature and not limited to specific subject content. Therefore, in this study, a conceptual and contextual adaptation was conducted to align it with the Grade VIII topic of Work and Simple Machines. The instrument comprised seven items, each representing one aspect of scientific creativity: unusual use, real advance, technical product, scientific imagination, problem solving, creative experimental, and science product. Each item was assessed using three indicators of creativity proposed by Torrance (1966), which were also adopted in SSCM (Hu & Adey, 2002): fluency, flexibility, and originality.

The example item presented in Table 1 illustrates the unusual-use aspect. Hu & Adey (2002) asked students to write down as many scientific uses as possible for a piece of glass. In this study, the context was adapted into alternative uses of a screwdriver based on the principles of work and simple machines. This modification preserves the structure of a divergent-thinking task while linking it to the physics concepts students are currently studying. Thus, the construct being measured remains the same: the ability to generate multiple scientific ideas (fluency), variations in approaches (flexibility), and the novelty of ideas (originality), but within a context relevant to the learning material.

Table 1. Example of scientific creativity test item

Aspect of Scientific Creativity (*Unusual Use*)	
Original item by Hu & Adey	Please write down as many as possible scientific uses as you can for a piece of glass.
Developed item	At home, we often find simple tools that have multiple functions beyond their primary use. For example, a flat-head screwdriver. Besides being used to loosen screws, write down as many other uses of a screwdriver as possible based on the principles of work and simple machines!

The supporting instrument used in this study was an expert validation sheet designed to assess the instrument's content validity. The validation sheet was arranged as a Likert scale, in which validators were asked to provide ratings from 1 to 5, with 1 indicating "poor" and 5 indicating "very good." The validation sheet covered three assessment aspects: content relevance, item construction, and clarity of language.

Data Analysis

Expert validation data were analyzed using Aiken's V index to determine the level of content validity for each test item. Data obtained from the student field trial were analyzed using Exploratory Factor Analysis (EFA) to assess the instrument's construct validity. The suitability of the data for factor analysis was determined through the Kaiser-Meyer-Olkin (KMO) test and Bartlett's Test of Sphericity. The instrument was considered appropriate for factor analysis if the KMO value was e > 0.50 and the significance value of Bartlett's Test was < 0.001 (Kaiser, 1974; Watkins, 2018). Instrument reliability was assessed using McDonald's Omega coefficient to determine the internal consistency of the instrument, with the analysis conducted using Jamovi software version 2.6.44 (Budiastuti & Bandur, 2018). In addition, a one-way ANOVA test was employed to examine differences in scientific creativity scores based on students' age groups (Wahid, Latiff, & Ahmad, 2017).

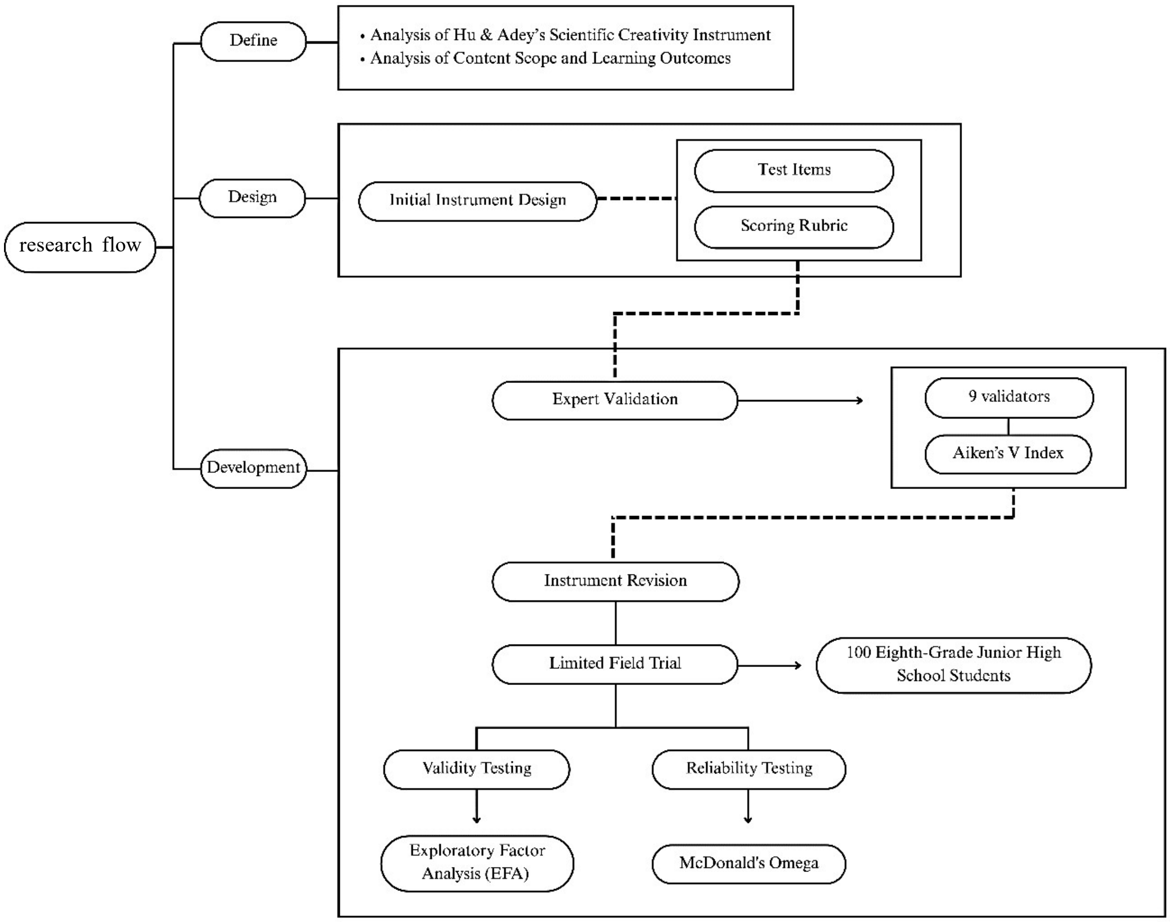


Figure 2. Research procedure flowchart

RESULT AND DISCUSSION

Define

A needs analysis was conducted by reviewing the literature on scientific instruments for creativity development at the define stage. This framework, applied as the basis for the development, was the SSCM by Hu & Adey (2002). It includes three main dimensions called the characteristics of creative thinking (flexibility, fluency, and originality), then processes of scientific thinking (thinking and imagination), and products of scientific thinking (technical products, knowledge of science, phenomena of science, and problems of science). This SSCM assesses scientific creativity according to seven main factors: unusual use, real advance, technical product, scientific imagination, problem-solving, creative experimentation, and science product. Each of those had such specific characteristics to help measure students' scientific creativity. The assessment of the test items was developed according to three creativity indicators: fluency, flexibility, and originality. Fluency refers to the ability to generate many ideas; the greater the number of scientific ideas a student can produce, the higher the level of fluency. Flexibility refers to the ability to think from multiple perspectives, whereas originality refers to the ability to provide responses that are rarely found in the population. Students who generate new and uncommon ideas while remaining logical and scientifically sound are considered to have higher levels of originality than other students (Hu & Adey, 2002; Siew, Chong, & Chin, 2014).

Table 2. Mapping of items to SSCM aspects

Item	Aspect	Description	Measured Indicators of Scientific Creativity
Item 1	Unusual use	This item requires students to generate as many alternative uses of an object as possible within a scientific context.	Fluency, Flexibility, and Originality
Item 2	Real advance	This item requires students to propose new scientific questions, demonstrating sensitivity to scientific problems.	Fluency, Flexibility, and Originality
Item 3	Technical product	This item measures students' ability to develop and refine a product based on scientific principles.	Fluency, Flexibility, and Originality
Item 4	Scientific imagination	This item requires scientific imagination regarding new phenomena, enabling students to conceptualize new scientific ideas.	Fluency, Flexibility, and Originality
Item 5	Problem solving	This item assesses students' ability to solve scientific problems.	Flexibility and Originality
Item 6	Creative experimental	This item measures creativity in designing an experimental procedure to test a scientific hypothesis.	Flexibility and Originality
Item 7	Science product	This item requires students to generate a new product or tool based on scientific principles.	Flexibility and Originality

Each item in the instrument was designed to represent one primary aspect of the Scientific Structure Creativity Model (SSCM). The mapping between items and SSCM aspects was established based on the defining characteristics of each aspect and the cognitive demands imposed on students.

The define stage also included an analysis of the science content and learning outcomes embedded in the instrument. The content selected was Work and Simple Machines for Grade VIII junior high school students. This topic was chosen because it is contextual in nature and closely related to everyday life. The material enables students to connect the concepts of force, energy, and work through the application of simple machine principles such as levers, inclined planes, wheel-and-axle systems, and pulleys. Based on the science learning outcomes for Phase D of the *Merdeka* Curriculum, students are expected to explain the relationship between work and energy, describe how simple machines operate in daily life, and select appropriate types of simple machines to solve problems encountered in their surroundings. The characteristics of this content are well-suited to stimulating scientific creativity, as it requires tool design, the application of physics concepts, and scientific reasoning. This is consistent with the findings of Fortus (2005), which indicates that design- and engineering-based tasks in science learning significantly enhance students' problem-solving skills, scientific imagination, and creativity. Other studies have also shown that physics learning contextualized through simple machines can train students to think divergently and generate multiple creative solutions to real-world problems (Zalya, Zulirfan, Azizahwati, & Feniwati, 2025).

Design

At the design stage, the instrument development process included developing a test blueprint that contained the test items and scoring guidelines. The test items were constructed in the form of open-ended questions to provide students with opportunities for divergent thinking (Aschauer, Haim, & Weber, 2022; Wiyanto & Hidayah, 2021). The questions were designed to require students to generate multiple ideas, explain their scientific reasoning, and propose creative solutions related to work and simple machines in everyday life (Fadllan, Hartono, Susilo, & Saptono, 2019). Each item represents one aspect of the SSCM. The following are the seven final test items developed, namely:

Item 1

At home, we often find simple tools that have multiple functions beyond their primary use. For example, a flat-head screwdriver. Besides being used to loosen screws, write down as many other uses of a screwdriver as possible based on the principles of work and simple machines!

This item belongs to the unusual-use aspect, which measures students' ability to identify uncommon functions or uses of an object based on scientific principles. This question is designed to assess fluency, flexibility, and originality of ideas in using an object. Within the SSCM framework, this item represents the product dimension (science knowledge) as well as the trait dimension (fluency, flexibility, originality) and the scientific thinking process (thinking process).

Item 2

During a journey to a difficult-to-reach location, such as climbing a mountain peak while carrying heavy loads, various challenges may arise. Write down as many scientific questions as possible based on potential problems related to the principles of work and simple machines!

This item represents the real advance aspect, namely the ability to identify and formulate scientific questions that require imagination and new perspectives. This question measures sensitivity to scientific problems (problem finding). Within the SSCM framework, this item involves a combination of fluency (science problem), flexibility, and originality (thinking and imagination).

Item 3

During a school service activity, students use a wheelbarrow to transport goods. However, the wheelbarrow feels heavy when carrying large loads. How can the design of the wheelbarrow be improved so that it can be used to transport heavier loads with minimal effort?

This question measures the technical product aspect, namely the ability to improve a technical product. Through this item, students are expected to demonstrate original ideas in improving a tool based on simple machine principles. Within the SSCM framework, this item is related to fluency (technical product), flexibility, and originality (thinking and imagination).

Item 4

If the concept of simple machines had never been discovered, human life would certainly be very different. Write down as many possible consequences that might occur in everyday life!

The purpose of this item is to measure the scientific imagination aspect, which refers to the ability to imagine situations that do not exist in the real world while remaining grounded in scientific concepts. This aspect measures students' scientific imaginative capacity. Within the SSCM framework, this item includes fluency (science phenomena), flexibility, and originality (imagination).

Item 5

A farmer uses an inclined plane (ramp) to load hay onto a truck. The farmer has the option of constructing a longer or a shorter inclined plane. Determine which inclined plane would be easier to use so that the required force is smaller and the work becomes easier. Explain your reasoning!

This item measures the problem-solving aspect, which refers to the ability to solve scientific problems by applying the principles of work and simple machines. This question tests students' logical and creative thinking skills to help them develop solutions based on physics concepts. Within the framework of SSCM, this item demonstrates such flexibility and originality.

Item 6

We often observe pulleys in everyday life, such as when lifting a bucket out of a well or raising a flag. Those devices tend to help reduce human effort. How can you prove that using a pulley makes lifting a load easier? Create such a simple experiment which is able to be done at school!

This item assesses students' ability to design and conduct scientific experiments purposefully. Within the framework of SSCM, this item reflects such flexibility and originality as it requires implementing certain concepts in a real experimental setup.

Item 7

Many tools make human work easier by using more than one type of simple machine in everyday life, such as jacks, scissors, and wheelbarrows. Design a tool that uses two types of simple machines simultaneously. Draw and also explain the tool and also the function of each of its parts!

This item tends to measure the aspect of the science product that relates to the creation of product designs according to particular principles. This also assesses students' ability to integrate concepts from multiple physics disciplines into a single functional system. Within the framework of SSCM, this item takes flexibility and originality.

The scoring procedure was also settled with the SSCM. Each test item was assessed against three main indicators: fluency, flexibility, and originality. Items 1-4 encouraged students to generate as many ideas as possible without restrictions. Therefore, these four items were evaluated using all three indicators: fluency, flexibility, and originality. The fluency score was obtained by counting all responses provided by students, regardless of their quality (Torrance, 1966). Flexibility scores were assigned to each student's response. Originality scores were also assigned to each response based on the probability of occurrence, with responses occurring at a probability of < 5% awarded 3 points, 5-10% awarded 2 points, 10-15% awarded 1 point, and > 15% awarded 0 points. Items 5-7 were designed to require a single primary solution, such as problem solving, experimental design, or product design. For these types of items, students were not expected to generate multiple ideas but rather to demonstrate reasoning and the novelty of their solutions. Consequently, the fluency indicator was not applied to Items 5-7, and the assessment focused on flexibility and originality (Hu & Adey, 2002). The frequency and percentage of each response were calculated to determine the originality scores. Responses with a probability of occurrence < 5% were awarded 3 points, 5-10% were awarded 2 points, 10-15% were awarded 1 point, and > 15% were awarded 0 points. Probability-based originality assessment is sample-dependent, meaning that the level of originality of an idea may vary across different groups or contexts. Nevertheless, this approach remains relevant and acceptable in early-stage instrument development research, as it aims to identify variations in students' creative ideas within a specific learning population (Bahar & June Maker, 2025).

Develop

After the seven test items were developed according to the SSCM framework, the next step included expert validation to help ensure the instrument's content and structural appropriateness. This validation was conducted by nine validators, including lecturers from four universities and science teachers from five junior high schools. Those who evaluated the instrument's feasibility considered three aspects: content, construct, and language. The content aspect assessed the test items' alignment with junior high school students' level of conceptual understanding and with scientific creativity indicators. The aspect of construct relied on the clarity and coherence of the test instructions with the scoring guidelines. Meanwhile, the aspect of language evaluated compliance with Indonesian language conventions, clarity of wording, and the avoidance ambiguous meanings. The outcomes were analyzed using Aiken's V formulas.

Validity Measurement

Based on the analysis results presented in Table 3, the values of Aiken's V ranged from 0.786 to 0.819, which exceeded the critical value of Aiken's V (> 0.72), indicating that the seven items were considered valid. However, several items also receive suggestions for improvement. These revisions took the form of simplifying the wording, adding contextual illustrations to narratives, or making them easier for students to understand.

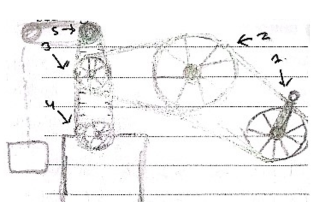
Table 3. Calculation of aiken's V index

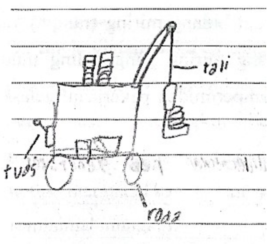
Question Item	Rater									*Σs*	V count	V table	Criteria
	1	2	3	4	5	6	7	8	9				
Item 1	4	4.7	4	4.5	3.9	4.6	4.6	3.9	3.9	29.1	0.808		Valid
Item 2	4	4.8	4	4.6	3.3	4.5	4.6	3.8	4	28.6	0.794		Valid
Item 3	3.9	4.7	4	4.3	4	4.8	4.8	3.8	4	29.3	0.814		Valid
Item 4	4	4.6	4	4	3	4.9	4.9	3.9	4	28.3	0.786	0.72	Valid
Item 5	3.7	4.8	4	4.3	3.9	5	4.8	4.2	3.6	29.3	0.814		Valid
Item 6	4	4.8	4	4.3	3.8	5	4.9	4	3.7	29.5	0.819		Valid
Item 7	3.6	4.8	4	4.2	3.7	4.9	4.9	4.1	4	29.2	0.811		Valid

The revised instrument was then administered to 100 students at an eighth-grade junior high school (13-15 years old). The trial was done in four schools in Magelang City. Before scoring, all student responses were first transcribed to compile the range of response variations within the research sample. These were used as a reference to assign scores for originality. The scores were summed to obtain the cumulative score on the test of scientific creativity.

Student response examples presented in Table 4 indicate variation in the level of originality in students' answers. In this study, based on the scoring guidelines, responses with a probability of occurrence < 5% were categorized as high originality, those with a probability of 5-15% as moderate originality, and those with a probability> 15% as low originality. In the unusual use aspect, the response "as a tool to pry open a can lid" was provided by 44 students and was therefore classified as low originality. This response reflects a common pattern of thinking, as its probability of occurrence exceeded 15%. In contrast, the response "as a lever to retrieve rubber from a gas cylinder" appeared in only 3 students' answers and was categorized as high originality because its probability was < 5%. This indicates that the fewer students who provide similar responses, the higher the level of originality in this research sample. Most student responses were still categorized as low to moderate originality, while responses demonstrating high originality appeared in very limited numbers. This is illustrated in Figure 3, where the originality scores are relatively lower than those for fluency and flexibility.

Table 4. Examples of student responses

Item	Aspect	Responses	Frequency	Originality
1	Unusual use	As a tool to pry open a can lid	44	Low
		As an inclined plane for carving wood	14	Moderate
		As a lever to retrieve rubber from a gas cylinder	3	High
2	Real advance	What simple machine can be used to pull a load uphill?	19	Low
		How can a heavy load be carried with less effort?	5	Moderate
		How can wood be utilized as a lever?	1	High
3	Technical product	The wheel is replaced with a larger wheel	16	Low
		The handle is made longer (longer effort arm)	7	Moderate
		The wheel is replaced with a toothed wheel	1	High
4	Scientific imagination	Human work would take a long time	17	Low
		Human labor would be relied upon more	7	Moderate
		Modern machines would not exist, resulting in difficulty constructing tall dams	1	High
5	Problem solving	A long ramp. Because with a long ramp it is lighter when pushed. If the ramp is short, more force is required	20	Low
		A long ramp. Because the force required becomes smaller, although the distance is farther and takes longer	2	High
6	Creative experimental	The way to prove it is by hoisting a flag using a pulley and comparing it with hoisting without a pulley. Tools used: rope, pole, flag.	16	Low
		Tools: pulley, rope, load, pole Steps: 1. Prepare the tools 2. Install the pulley and rope on the pole 3. Attach the load to the rope, then pull 4. Compare by pulling without using a pulley	4	High
7	Science product	A device for moving goods 	6	Moderate

A tile-installing device	1	High
		

The average score of students' scientific creativity is presented in Figure 3, which shows that the unusual use aspect (item 1) received the highest score among the other aspects. This finding indicates that students were relatively more capable of generating various alternative uses for a given object. In contrast, the creative experimental aspect (item 6) and the problem-solving aspect (item 5) demonstrated lower average scores. These results suggest that students experienced difficulties when required to design experiments or formulate solutions. In terms of indicators, flexibility scores tended to be higher than fluency and originality scores across several aspects, particularly in the unusual-use aspect. This indicates that students were reasonably able to vary their ideas appropriately and in alignment with the underlying concepts. However, originality scores were generally lower across nearly all aspects. This finding suggests that although students were able to produce multiple ideas, most were relatively common and occurred frequently within the sample.

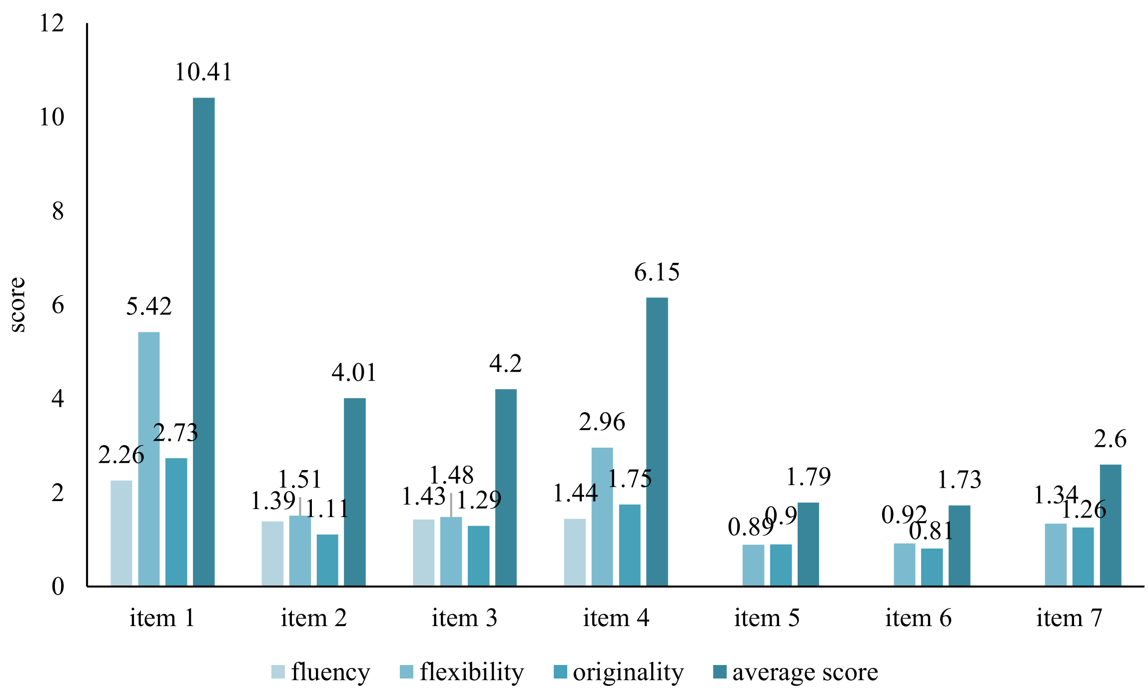


Figure 3. Scientific creativity score results

The data on student responses were analyzed for construct validity using Exploratory Factor Analysis (EFA) in Jamovi, with the KMO Measure of Sampling Adequacy and Bartlett's Test of Sphericity. The outcomes are shown as follows:

Table 5. Bartlett's test of sphericity calculation

χ^2	df	p
123	21	<.001

The outcomes indicated that Bartlett's Sphericity Test had a significance value of $p < 0.001$, indicating that the data were good for further analysis (Guinovart-Pedescoll & Palau, 2025). Watkins (2018), a p-value of < 0.001 shows that the size of sample is adequate for factor analysis.

Table 6. KMO measure of sampling adequacy calculation

	MSA
Overall	**0.747**
item1	0.736
item2	0.766
item3	0.751
item4	0.733
item5	0.701
item6	0.821
item7	0.729

Factor analysis was conducted with an adequate sample size, yielding a value of 0.747 (KMO > 0.5), as shown in Table 6. The Measure of Sampling Adequacy (MSA) values for all items exceeded 0.5, indicating that all items were considered appropriate and did not require elimination. Although the KMO value of 0.747 and the significance of Bartlett's Test ($p < 0.001$) indicate that the data statistically met the prerequisites for factor analysis, these results do not automatically guarantee the consistency of the resulting factor structure. The sample size in this study (n = 100) was at the minimum threshold for conducting Exploratory Factor Analysis (EFA). A simulation study by Farag et al. (2025) A sample size of n = 100 demonstrated that factor structures tend to be unstable and exhibit low recovery rates. Small sample sizes may produce less stable estimates of factor loadings and inter-item correlations, thereby affecting the consistency of the instrument (Farag et al., 2025; Winter, Dodou, & Wieringa, 2009).

Reliability Measurement

Reliability testing was conducted to assess item consistency using McDonald's Omega coefficient (Retnawati, 2016).

Table 7. Reliability statistics calculation

	McDonald's ω
scale	0.734

The analysis results showed a McDonald's Omega value of 0.734. This value exceeds the minimum threshold of 0.70, which generally indicates adequate reliability for exploratory research (Dunn, Baguley, & Brunsden, 2014; Hayes & Coutts, 2020). This finding indicates that the scientific creativity instrument developed in this study demonstrates acceptable internal consistency. However, since the factor structure obtained remains exploratory in nature and the sample size is relatively limited, this reliability estimate still requires further confirmation through Confirmatory Factor Analysis (CFA) with a larger sample size in subsequent research (Farag et al., 2025; Osborne & Costello, 2004).

Based on Table 8, the item-rest correlation values indicate the extent to which each test item is associated with the total instrument score. Items with positive correlation values consistently represent the construct being measured. Conversely, low correlation values may indicate weaknesses in item construction, thereby requiring

Table 8. Item reliability statistics calculation

	Mean	Item-rest correlation
Item 1	10.41	0.395
Item 2	4.01	0.478
Item 3	4.20	0.467
Item 4	6.15	0.572
Item 5	1.79	0.345
Item 6	1.73	0.435
Item 7	2.60	0.381

revision or elimination. The results of the analysis show that all items have reasonably adequate item-rest correlations; however, several items exhibit relatively low correlations. Items with lower correlations, namely item 1, item 5, and item 7, indicate weaker associations with the total score, although they still maintain positive correlations (Murti, 2011).

Analysis of Differences Based on Age

In the trial, the implications for comparing age groups were analyzed using one-way analysis of variance (One-Way ANOVA) to determine whether there were differences in students' scientific creativity levels across age groups.

The analysis of differences in scientific creativity scores by age was conducted using a One-Way ANOVA with students aged 13 and 14 years (n = 98). The 15-year-old group was excluded from the analysis due to the very small sample size (n = 2), which could lead to unstable variance estimates. The ANOVA results presented in Table 9 indicate an F-value of 0.003, with a significance level of p = 0.959 (p > 0.05), suggesting no significant difference in scientific creativity scores between students aged 13 and 14 years. From a developmental perspective, both age groups remain in early adolescence with relatively similar cognitive characteristics; therefore, marked differences in scientific creativity are not yet evident. These findings are consistent with Torrance (1968) and Smith & Carlsson (1983) who reported that creativity tends to increase again during early adolescence after declining in the elementary school years. Further analysis in Table 11, examined differences in scientific creativity scores across the four participating schools and yielded an F value of

Table 9. Comparison based on age

Age	n	Mean	Std. Deviation
13	38	30.60	10.13
14	60	30.73	11.37
15	2	43.50	24.75

Table 10. One-Way ANOVA calculation for age differences

	Sum of Squares	df	F	Sig.
Between Groups	.382	1	.003	.959
Within Groups	13958.812	96		
Total	13959.194	97		

Table 11. One-Way ANOVA calculation for the four participating schools

	Sum of Squares	df	F	Sig.
Between Groups	40.443	3	.089	.966
Within Groups	14577.347	96		
Total	14617.790	99		

0.089 with a significance level of $p = 0.966$ ($p > 0.05$) (Wahid et al., 2017). This result indicates that there are no significant differences among the four schools involved. The consistency of findings between the age-based and school-based analyses suggests that variation in scientific creativity scores in this study is relatively homogeneous across age groups and schools.

Based on the student response data, most students produced common answers with high frequency, indicating a predominance of convergent thinking patterns. Convergent thinking is oriented toward identifying a single answer considered most logical based on prior learning experiences. This tendency is reflected in responses such as using a screwdriver to pry open a can lid or modifying a wheel by making it larger, which, although conceptually correct, remain within conventional lines of reasoning. In contrast, responses with low frequency and high originality reflect divergent thinking processes, defined as the ability to generate varied, uncommon, and infrequently expressed ideas (De Vries & Lubart, 2019; Runco & Acar, 2012). In this study, fluency appeared higher than originality, as students generated multiple ideas; however, the level of originality remained low. This finding is consistent with Silvia et al. (2008), who reported that, within formal education settings, students are often trained to seek correct (convergent) answers, thereby limiting the stimulation of alternative (divergent) exploration. Furthermore, Cropley (2006) emphasized that overly structured science instruction may inadvertently reinforce convergent thinking patterns and inhibit the exploration of alternative ideas. This condition explains why most students in this study provided safe and conventional responses, while genuinely unique ideas emerged only among a small proportion of students.

The findings of this study indicate that the instrument meets the minimum standards of validity and reliability to serve as a preliminary measure of junior high school students' scientific creativity. In this study, the sample size of 100 was at the minimum threshold for conducting Exploratory Factor Analysis (EFA). A small sample size still carries the risk of producing factor solutions that are less stable and difficult to replicate in other samples, particularly when the factor structure is not robust. This limitation may affect the stability of factor loading estimates and contribute to internal consistency that is not yet optimal. Therefore, further research with a larger sample size (e.g., $n > 200$) and subsequent analysis using Confirmatory Factor Analysis (CFA) is required to more rigorously examine the stability and fit of the measurement model.

■ CONCLUSION

This study has developed an instrument to assess junior high school students' scientific creativity, based on the Scientific Structure Creativity Model (SSCM) proposed by Hu and Adey (2002) and adapted to the context of science instruction on the topic of Work and Simple Machines. The findings indicate that the instrument has met the criteria for validity and reliability. The Aiken's V values demonstrate that all items are valid in terms of content validity, and the EFA results indicate that the data meet the prerequisites for factor analysis. The instrument's reliability, as measured by McDonald's Omega, indicates adequate internal consistency. The results of the ANOVA conducted on the 13- and 14-year-old age groups indicate no significant differences in scientific creativity scores. This finding is consistent with the developmental phase of early adolescence, during which creativity tends to remain relatively stable.

The limitation of this study lies in the limited sample size used in the exploratory factor analysis, indicating the need for further research with a larger number of respondents and testing through Confirmatory Factor Analysis (CFA) to strengthen construct validity. Future studies should also ensure a more balanced age distribution to enhance the robustness of the findings.

DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS

During the writing of this manuscript, the author employed QuillBot to assist with paraphrasing to avoid unintentional plagiarism; DeepL to support language translation; Grammarly to assist with grammar checking; and GPTZero Checker to examine AI-generated text detection. The author has reviewed and edited the content generated by this tool and assumes full responsibility for the content of the published article.

REFERENCES

Aschauer, W., Haim, K., & Weber, C. (2022). A contribution to scientific creativity: a validation study measuring divergent problem solving ability. *Creativity Research Journal*,*34*(2), 195–212. https://doi.org/10.1080/10400419.2021.1968656

Astutik, S., Susantini, E., Madlazim, N., M., & Supeno. (2020). The effectiveness of collaborative creativity learning models (CCL) on secondary schools scientific creativity skills. *International Journal of Instruction*, *13*(3), 525-238. https://doi.org/10.29333/iji.2020.13336a

Bahar, K., & June Maker, C. (2025). A new perspective on scoring children's originality: a standards-based criterion-referenced assessment approach. *Frontiers in Psychology*, *16*. https://doi.org/10.3389/fpsyg.2025.1545396

Budiastuti, D., & Bandur, A. (2018). *Validitas dan reliabilitas penelitian*. Mitra Wacana Media.

Claxton, A. F., Pannells, T. C., & Rhoads, P. A. (2005). Developmental trends in the creativity of school-age children. *Creativity Research Journal*, *17*(4), 327–335. https://doi.org/10.1207/s15326934crj1704_4

Cropley, A. (2006). In Praise of Convergent Thinking. *Creativity Research Journal*, *18*(3), 391–404. https://doi.org/10.1207/s15326934crj1803_13

De Vries, H. B., & Lubart, T. I. (2019). Scientific creativity: divergent and convergent thinking and the impact of culture. *The Journal of Creative Behavior*, *53*(2), 145–155. https://doi.org/10.1002/jocb.184

Dewi, S., Suwarna, I. P., & Suryadi, A. (2024). The effect of creative problem-solving model to enhance scientific creativity: study in static fluid physics learning. *Berkala Ilmiah Pendidikan Fisika*, *12*(1), 21. https://doi.org/10.20527/bipf.v12i1.17668

Dunn, T. J., Baguley, T., & Brunsden, V. (2014). From alpha to omega: A practical solution to the pervasive problem of internal consistency estimation. *British Journal of Psychology*, *105*(3), 399–412. https://doi.org/10.1111/bjop.12046

Eroglu, S., & Bektas, O. (2022). The Effect of STEM applications on the scientific creativity of 9th-grade students. *Journal of Education in Science, Environment and Health*, *8*(1), 17-36. https://doi.org/10.21891/jeseh.1059124

Fadllan, A., Hartono, S., & Saptono, S. (2019). Analysis of students' scientific creativity and science process skills at UIN Walisongo Semarang. In *Journal of Physics: Conference Series* (Vol. 1321). Institute of Physics Publishing. https://doi.org/10.1088/1742-6596/1321/3/032099

Farag, K. A., Mohamed, M. A., Abobaker, Z. M., Binsaud, B. M., & Jabe, A. M.

(2025). The impact of sample size on exploratory and confirmatory factor analysis: a simulation study. *International Journal of Environmental Sciences*, *11*(6s).

Fortus, D., Krajcik, J., Dershimer, R. C., Marx, R. W., & Mamlok Naaman, R. (2005). Design based science and real world problem solving. *International Journal of Science Education*, *27*(7), 855–879. https://doi.org/10.1080/09500690500038165

Guinovart-Pedescoll, M., & Palau, R. (2025). Design and validation of a self-perception instrument on the use of scientific knowledge in teaching practice. *Journal of New Approaches in Educational Research*, *14*(1), 3. https://doi.org/10.1007/s44322-024-00026-5

Hayes, A. F., & Coutts, J. J. (2020). Use omega rather than cronbach's alpha for estimating reliability. but…. *Communication Methods and Measures*, *14*(1), 1–24. https://doi.org/10.1080/19312458.2020.1718629

Hebebci, M. T., & Usta, E. (2022). The effects of integrated STEM education practices on problem solving skills, scientific creativity, and critical thinking dispositions. *Participatory Educational Research*, *9*(6), 358-379. https://doi.org/10.17275/per.22.143.9.6

Henriksen, D., Mishra, P., & Fisser, P. (2016). Infusing creativity and technology in 21st century education: a systemic view for change. *Educational Technology & Society*, *19*(23), 27–37.

Hong, O., Park, M. H., & Song, J. (2022). The assessment of science classroom creativity: scale development. *International Journal of Science Education*, *44*(8), 1356–1377. https://doi.org/10.1080/09500693.2022.2077466

Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education*, *24*(4), 389–403. https://doi.org/10.1080/09500690110098912

Hu, W., Wu, B., Jia, X., Yi, X., Duan, C., Meyer, W., & Kaufman, J. C. (2013). Increasing students' scientific creativity: the "learn to think" intervention program. *The Journal of Creative Behavior*, *47*(1), 3–21. https://doi.org/10.1002/jocb.20

Isnaini, I., Atmazaki, A., Ahda, Y., Lufri, L., Elizar, E., Amran, A., … Hasan, A. (2023). Analysis of critical thinking, creativity, communication, and collaboration skills (4c) for junior high school students, 191–197. https://doi.org/10.2991/978-94-6463-166-1_27

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika*, *39*(1), 31–36. https://doi.org/10.1007/BF02291575

Kirana, T. (2020). Development of OCIPSE learning model to increase students' scientific creativity in natural science learning. *International Journal of Recent Educational Education*, *1*(1).

Murti, B. (2011). *Validitas dan reliabilitas pengukuran*. Semarang: Uns.

Nogueira, S. I., Almeida, L. S., & Lima, T. S. (2017). Two tracks of thought: a structural model of the test for creative thinking-drawing production (TCT-DP). *Creativity Research Journal*, *29*(2), 206–211. https://doi.org/10.1080/10400419.2017.1303312

Osborne, J. W., & Costello, A. B. (2004). Sample size and subject to item ratio in principal components analysis. *Practical Assessment, Research, and Evaluation*, *9*, 11. https://doi.org/10.7275/ktzq-jq66

Prahani, B. K., Suprapto, N., Rachmadiarti, F., Sholahuddin, A., Mahtari, S., Suyidno, & Siswanto, J. (2021). Online scientific creativity learning (OSCL) in science education to improve students' scientific creativity in covid-19 pandemic. *Journal of Turkish Science Education*, *18*(Special Issue), 77–90. https://doi.org/10.36681/tused.2021.73

Rababah, L. (2018). An adapted version of torrance test of creative thinking (TTCT) In EFL/ESL writing: a rubric scoring and a review of studies. *International Journal of English and Education*, *7*(2).

Retnawati, H. (2016). *Analisis kuantitatif instrumen penelitian (panduan peneliti, mahasiswa, dan psikometrian)*. Yogyakarta: Paramu Publishing.

Ritter, S. M., Gu, X., Crijns, M., & Biekens, P. (2020). Fostering students' creative thinking skills by means of a one-year creativity training program. *PLOS ONE*, *15*(3), e0229773. https://doi.org/10.1371/journal.pone.0229773

Rosidin, U., Herliani, D., & Viyanti. (2023). Development of assessment instruments in project-based learning to measure students' scientific literacy and creative thinking skills on work and energy materials. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4484–4494. https://doi.org/10.29303/jppipa.v9i6.2421

Runco, M. A., & Acar, S. (2012). Divergent thinking as an indicator of creative potential. *Creativity Research Journal*, *24*(1), 66–75. https://doi.org/10.1080/10400419.2012.652929

Schoen, J. L., Bowler, J. L., & Schilpzand, M. C. (2018). Conditional reasoning test for creative personality: rationale, theoretical development, and validation. *Journal of Management*, *44*(4), 1651–1677. https://doi.org/10.1177/0149206315618012

Siew, N. M., Chong, C. L., & Chin, K. O. (2014). Developing a scientific creativity test for fifth graders. *Problems of Education in the 21st Century*, *62*.

Silvia, P. J., Winterstein, B. P., Willse, J. T., Barona, C. M., Cram, J. T., Hess, K. I., … Richard, C. A. (2008). Assessing creativity with divergent thinking tasks: Exploring the reliability and validity of new subjective scoring methods. *Psychology of Aesthetics, Creativity, and the Arts*, *2*(2), 68–85. https://doi.org/10.1037/1931-3896.2.2.68

Sisman, H. E., Aydogan, N., & Cankaya, O. (2024). A scientific creativity scale development process for science teacher candidates. *International Journal on Social and Education Sciences*, *6*(1), 37-63. https://doi.org/10.46328/ijonses.587

Smith, G. J. W., & Carlsson, I. (1983). Creativity in early and middle school years. *International Journal of Behavioral Development*, *6*(2), 167–195. https://doi.org/10.1177/016502548300600204

Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional development for training teachers of exceptional children: a sourcebook*. Indiana: Indiana University Bloomington.

Torrance, E. P. (1966, July 9). Torrance tests of creative thinking. *PsycTESTS Dataset*. https://doi.org/10.1037/t05532-000

Torrance, E. P. (1968). A longitudinal examination of the fourth grade slump in creativity. *Gifted Child Quarterly*, *12*(4), 195–199. https://doi.org/10.1177/001698626801200401

Vlachopoulos, D., & Makri, A. (2024). A systematic literature review on authentic assessment in higher education: Best practices for the development of 21st century skills, and policy considerations. *Studies in Educational Evaluation*, *83*, 101425. https://doi.org/10.1016/j.stueduc.2024.101425

Wahid, Z., Latiff, A. I., & Ahmad, K. (2017).

Application of one-way ANOVA in completely randomized experiments. *Journal of Physics: Conference Series*, *949*, 012017. https://doi.org/10.1088/1742-6596/949/1/012017

Watkins, M. W. (2018). Exploratory factor analysis: a guide to best practice. *Journal of Black Psychology*, *44*(3), 219–246. https://doi.org/10.1177/0095798418771807

Winter, J. C. F., Dodou, D., & Wieringa, P. A. (2009). Exploratory factor analysis with small sample sizes. *Multivariate Behavioral Research*, *44*(2), 147–181. https://doi.org/10.1080/00273170902794206

Wiyanto, S., S., & Hidayah, I. (2020). Scientific creativity: A literature review. In *Journal of Physics: Conference Series* (Vol. 1567). Institute of Physics Publishing. https://doi.org/10.1088/1742-6596/1567/2/022044

Wiyanto, W., & Hidayah, I. (2021). Review of a scientific creativity test of the three-dimensional model. *Journal of Physics: Conference Series*, *1918 (2021)* (052088).

Zalya, A. P., Zulirfan, A., & Feniwati. (2025). STEM at home improves students' creative thinking skills on the topic of simple machines. *Journal of Indonesian Science Teachers*, *3(1)*, 1-10.