

Development and Validation of a Creative Thinking Skills Test Instrument Based on the 4D Model (Define-Design-Develop) for High School Students on Static Fluid Material

Dya Atul Fahmi¹, Parno^{1*}, Khusaini¹, and Marlina Ali²

Department of Physics, Universitas Negeri Malang, Malang, Indonesia
School of Education, University Teknologi Malaysia, Johor Bahru, Malaysia
*parno.fmipa@um.ac.id

Article Info	Abstract
Article history: Received: December 28, 2025 Accepted: May 13, 2026 Published: June 30, 2026 Keywords: Creative thinking skills High school students Instrument test Static fluid material This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License © 2026 Berkala ilmiah Pendidikan Fisika	Creative thinking skills are an important 21st-century competency in physics learning, but currently, the availability of test instruments specifically measuring these skills in static fluids is still limited and has not fully met the criteria for validity and reliability. This study aims to develop a valid, reliable, and suitable instrument for testing creative thinking skills in static fluids for high school students. The study uses a 4D development model through the define, design, and develop stages. The implementation stage has just reached 3D. This instrument was designed based on indicators of fluency, flexibility, originality, and elaboration. Internal validation was conducted by two expert lecturers, while external validation was conducted through a trial on 70 high school students who had previously studied static fluids. The results of the internal analysis showed that all test items were categorized as very valid with an average validity percentage of 88.67% and a range of 81.25%–93.75%. Meanwhile, the results of the external analysis showed that the instrument was empirically valid with an item-total correlation coefficient ranging from 0.498 to 0.762; reliable with a Cronbach's Alpha value of 0.797; had a dominant difficulty level in the medium category with a difficulty index ranging from 0.35 to 0.79; and had moderate-to-very-high discrimination power with a discrimination index ranging from 0.336 to 0.617. Thus, the developed instrument is suitable for use as an assessment tool to measure creative thinking skills in static fluids in high school students. The implication of this research is the availability of instruments that can support improving the quality of physics learning evaluation and become a reference for teachers and researchers in developing assessments of high-level thinking skills.
To cite this article: Fahmi, D. A., Parno, P., Khusaini, K., & Ali, M. (2026). Development and validation of a creative thinking skills test instrument based on the 4d model (define-design-develop) for high school students on static fluid material. <i>Berkala Ilmiah Pendidikan Fisika</i>, 14(2), 209-217.	

INTRODUCTION

Creative thinking is a key skill in 21st-century learning, crucial for facing the challenges of modern life ([Adeoye & Jimoh, 2023](#); [Chusna et al., 2024](#); [Parno et al., 2019](#); [Ramos & Araya, 2025](#); [Wulansari & Sunarya, 2023](#)). Creative thinking enables students to generate diverse ideas, view problems from multiple perspectives, and develop original and meaningful solutions. In the context of science and physics education, this skill is generally measured through indicators of fluency, flexibility, originality, and elaboration ([Ratna et al., 2021](#); [Riberio, 2023](#)). Physics learning, which emphasizes the relationship between concepts and everyday phenomena, requires students not only to understand formulas but

also to think creatively in applying these concepts to real-life situations ([Hidayah et al., 2024](#); [Ilmi et al., 2020](#); [Nisa et al., 2024](#); [Susilowati et al., 2025](#)).

One high school physics topic with significant potential for developing creative thinking skills is static fluids. This topic has numerous applications in everyday life, such as hydrostatic pressure in diving, Pascal's law in hydraulic systems, and Archimedes' force in the phenomena of floating and sinking. The characteristics of static fluids require students to connect theoretical concepts with contextual phenomena, thus encouraging the use of creative ideas in problem-solving ([Adipan & Asrizal, 2024](#); [Rahayu & Asrizal, 2024](#)). However, this potential has not been optimally utilized due to the limited availability of test instruments specifically designed to measure students' creative thinking skills in the context of static fluids ([Susilowati et al., 2025](#)).

Assessment practices in high schools are still dominated by multiple-choice questions and routine calculation questions that focus on a single answer. This type of assessment tends to only measure lower- to mid-level cognitive aspects and fails to comprehensively reflect students' creative thinking abilities ([Gumilang et al., 2021](#); [Utama et al., 2021](#)). Evaluation instruments used by teachers generally do not accommodate creativity indicators because students are not given the opportunity to express diverse ideas, alternative solutions, or develop ideas openly ([Rohmatika et al., 2025](#)).

Several previous studies have shown that creative thinking development instruments still have several limitations. From a material perspective, the instrument developed by [Istiyono et al. \(2018\)](#) is still general and does not focus on a specific physics topic, so it is unable to capture the characteristics of the specific context in physics learning. From an indicator perspective, the study by [Tiadarma et al. \(2022\)](#) did use creativity indicators such as fluency, flexibility, and originality, but did not fully accommodate the elaboration indicator, so the measurement of creativity was not fully comprehensive. Meanwhile, from an instrument perspective, several studies still use semi-structured or limited question formats, which tend to direct students' answers and do not fully provide space for exploring diverse ideas ([Purba et al., 2022](#)). Based on these limitations, this study developed an instrument that specifically integrates the context of statistical fluid material, uses a complete set of creativity indicators, and applies an open-ended question format that gives students the freedom to generate various alternative solutions.

Thus, the developed instrument is expected to provide a more comprehensive and contextual measurement of creative thinking abilities. Based on the description above, this study aims to develop a valid, reliable, and appropriate creative thinking ability test instrument for high school students in the subject of statistical fluids. The resulting instrument is expected to meet the validity and reliability criteria ([Barbot & Kaufman, 2025](#); [Sudarmin et al., 2020](#); [Suherman & Vidakovich, 2024](#)). The development of a quality instrument through an internal validation process by experts or lecturers who have competence in the field of learning evaluation and physics materials, followed by empirical validation through trials on students ([Gumilang et al., 2021](#); [Utama et al., 2021](#)). This process is important to ensure that each item truly represents the indicators of creative thinking and is able to measure student abilities consistently ([Nurlita et al., 2025](#)). Therefore, this instrument can serve as a more representative evaluation alternative to measure students' creative thinking abilities and support improving the quality of physics learning and assessment in the high school ([Adipan & Asrizal, 2024](#); [Susilowati et al., 2025](#)).

METHODS

This study used the Research and Development (R&D) method, which aims to develop and produce a product in the form of a test instrument for high school students' creative thinking skills on static fluid material. The development model used is the 4D model (Four-D Model) ([Thiagarajan et al., 1974](#)). The development of the test instrument is based on

indicators of creative thinking skills, which include fluency, flexibility, originality, and elaboration. These indicators are integrated into test items tailored to the characteristics of the static fluid material. Creative thinking ability indicators and operational descriptions are presented in Table 1.

Table 1 Creative thinking ability indicators and operational descriptions

Creative Thinking Indicators	Operational Description in Test Instruments
Fluency	Students' ability to produce many relevant ideas, answers, or solutions in solving static fluid problems, such as putting forward more than one possible answer based on the concept of hydrostatic pressure, Pascal's law, or Archimedes' law, is a key indicator of their understanding.
Flexibility	Students' ability to use various strategies, approaches, or different perspectives in solving static fluid problems, for example, changing mathematical representations into conceptual or contextual forms.
Originality	Students' ability to produce ideas or solutions that are unique, uncommon, and rarely used by other students in answering static fluid problems.
Elaboration	Students' ability to develop, detail, and clarify ideas or solutions proposed logically and systematically with in-depth and coherent explanations of physics concepts.

The research process in the 4D model conceptually includes four stages: define, design, develop, and disseminate ([Thiagarajan et al., 1974](#)). The 4D model in this study is shown in Figure 1.

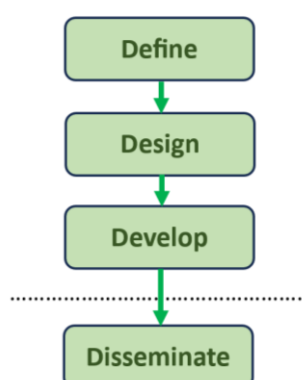


Figure 1 4D Model

However, in practice, this research was only conducted up to the third stage, namely the define, design, and develop stages. This is because the main objective of the research focuses on developing and testing the feasibility of the test instrument, so the dissemination stage has not been widely implemented. The define stage is carried out to analyze the needs, characteristics of students, and concepts of static fluid material. The design stage includes the preparation of instrument grids, the design of test items, and the preparation of scoring rubrics. Next, the develop stage includes expert validation, instrument revision, and limited trials on students.

Instrument validation was conducted through two types of validation: internal validation and external validation. Internal validation was conducted by two expert lecturers with expertise in physics education and learning evaluation. This validation aimed to assess the suitability of the content, question construction, language, and the relationship between the items and indicators of creative thinking skills. Meanwhile, external validation was conducted through a pilot test of the instrument on 70 high school students who had studied

static fluids. External validation aimed to obtain empirical data regarding the quality of the items based on student responses.

The data from internal validation by two lecturers was analyzed using percentage analysis techniques. The percentage of eligibility was calculated based on the scores given by the validators for each assessment aspect. The percentage of the eligibility analysis formula is as follows:

$$P = \frac{\sum X}{\sum X_{maks}} \times 100\% \quad \dots (1)$$

An instrument is deemed suitable for use if it falls within the minimum valid category. Internal validity criteria are determined by referring to the percentage ranges in Table 2.

Table 2 Percentage criteria for internal validity eligibility

Presentation Score (%)	Category
81-100	Very valid
61-80	Valid
41-60	Quit valid
21-40	Less valid
0-20	Invalid

The external validity of the instrument was analyzed based on the results of the trial with students using statistical analysis of the test items. The criteria used included empirical validity, reliability, difficulty level, and discriminatory power. The test items were declared empirically valid if they met the specified validity coefficient value and reliable if they had a reliability coefficient in the high or very high category. The difficulty level and discriminatory power were used to ensure that the instrument was able to measure students' creative thinking skills accurately and proportionally. Instruments that met all of these criteria were declared suitable for use as a measuring tool for students' creative thinking skills in static fluid material. The external validity analysis was conducted using IBM SPSS 27. The value criteria for determining the external validity category are in Table 3.

Table 3 External validation criteria

Test Aspect	Category	Value Criteria
Empirical Validity	Valid	$r \text{ value} > r \text{ table}$
	Invalid	$r \text{ value} < r \text{ table}$
Reliability Test	Unreliable	$0.00 \leq r < 0.20$
	Less reliable	$0.20 \leq r < 0.40$
	Fairly reliable	$0.40 \leq r < 0.60$
	Reliable	$0.60 \leq r < 0.80$
	Very reliable	$0.80 \leq r \leq 1.00$
Difficulty Level	Difficult	$0.00 \leq D \leq 0.30$
	Medium	$0.30 < D \leq 0.70$
	Easy	$0.70 < D \leq 1.00$
Discrimination Index	Very low	$D \leq 0.00$
	Low	$0.00 < D \leq 0.20$
	Medium	$0.20 < D \leq 0.40$
	High	$0.40 < D \leq 0.70$
	Very high	$0.70 < D \leq 1.00$

RESULT AND DISCUSSION

The creative thinking ability test instrument for static fluid material was developed based on creative thinking skill indicators, including fluency, flexibility, originality, and elaboration. These four indicators were integrated into the context of static fluid concepts, such as hydrostatic pressure, Pascal's law, Archimedes' law, and their application in everyday life. The instrument development was carried out through the 4D model stages, specifically at the define, design, and develop stages, emphasizing the suitability between

the creative thinking skill indicators and the competency demands of high school physics material. The instrument that had been developed was then validated internally by two expert lecturers in physics education at the State University of Malang to assess aspects of material substance, question construction, and readability. In addition, external validation was carried out through a limited trial on 70 high school students to obtain empirical data regarding the quality of the question items. The results of the internal validity of the creative thinking test instrument are listed in Table 4.

Table 4 Internal validity of creative thinking test instrument

Assessed Aspect	Validity (%)	Category
Alignment with learning objectives	81.25	Very valid
Alignment with creative thinking indicators	87.50	Very valid
Accuracy of answer keys	92.19	Very valid
Clarity of test items	93.75	Very valid
Overall average	88.67	Very valid

The internal validity results presented in Table 4 indicate that all test items achieved a very valid percentage. Expert assessments indicated that the instrument met the creative thinking indicators, static fluid material, and the principles of good test item construction. Internal validation by experts plays a crucial role in ensuring that the instrument accurately measures the intended construct and is free from conceptual errors before being administered to students. This finding aligns with previous research, which emphasized that expert involvement in instrument validation is crucial for ensuring content validity and the appropriateness of measurement indicators. High internal validity indicates that the test instrument is theoretically and conceptually feasible for use in the empirical testing phase (Fernandez-Gomez et al., 2020; Simbolon & Simbolon, 2025). The results of the external validity of the creative thinking test items are listed in Table 5.

Table 5 External validity of creative thinking test items

Item No.	Validity	Reliability	Difficulty Index	Discrimination Index
1	0.498 = valid	0.797 = reliable	0.79 = easy	0.336 = medium
2	0.590 = valid		0.35 = medium	0.425 = medium
3	0.628 = valid		0.59 = medium	0.514 = high
4	0.735 = valid		0.60 = medium	0.617 = very high
5	0.588 = valid		0.67 = medium	0.445 = medium
6	0.731 = valid		0.58 = medium	0.592 = high
7	0.762 = valid		0.54 = medium	0.610 = very high
8	0.645 = valid		0.58 = medium	0.528 = high

In line with the internal validity results, which indicate that the instrument meets the construct suitability, creative thinking indicators, and item development principles, the external validity analysis in Table 5 strengthens these findings through empirical testing of item quality. The external validity of the instrument is presented in Table 5, which includes item validity, test reliability, difficulty level, and discrimination power. Quantitatively, the item validity coefficient (r-count) ranged from 0.498 to 0.762, indicating that all items were valid. The instrument's reliability value of 0.797 indicated reliability. The difficulty level index (p) ranged from 0.35 to 0.79, with one item categorized as easy ($p = 0.79$) and the rest in the moderate category. Meanwhile, the discrimination index (D) ranged from 0.336 to 0.617, categorizing it as moderate to very high. These results indicate that all test items are not only theoretically valid but also consistent and able to measure students' creative thinking abilities stably in an empirical context.

These results align with various studies showing that item characteristic analysis is a crucial foundation for developing high-quality and empirically reliable assessment instruments (Akbarini & Anggrawal, 2024; Jumini et al., 2024). Together with previous research, these results reinforce and complement previous findings. Research by Sari and

[Istiyono \(2021\)](#) emphasized that good instrument development must meet validity and empirical testing requirements, but did not explicitly address the overall balance in the distribution of item characteristics, such as difficulty and discriminatory power. Meanwhile, [Kurniawan et al., \(2024\)](#) analyzed the Rasch model, revealing that although items met validity and reliability criteria, variations in item difficulty and quality remained a challenge in ensuring the instrument optimally differentiated student abilities. In contrast to these findings, the instrument in this study demonstrated a balance between validity, reliability, difficulty, and discriminatory power, thus providing a more comprehensive measurement. The uniqueness of this research lies in the consistent integration between conceptual (internal) validity and empirical (external) validity in the specific context of static fluid material based on creative thinking indicators, which are still limited in previous research. Thus, the developed test instrument is declared suitable for use as a tool to assess high school students' creative thinking abilities in static fluid material.

CONCLUSION

This study successfully developed a creative thinking ability test instrument on static fluid material for high school students that is valid, reliable, and suitable for use as an assessment tool. The validity of the instrument was proven through internal validation by two expert lecturers who showed that all items were in the very valid category so that conceptually and constructively the instrument was in accordance with the indicators of creative thinking and static fluid material. In addition, external validation through empirical testing on 70 high school students showed that all items were declared valid, the overall instrument was reliable, the difficulty level was predominantly in the medium category, and the discrimination power was in the medium to very high category. These results confirm that the instrument is able to measure creative thinking skills consistently and differentiate students' abilities effectively. However, this study has limitations in the number and scope of samples, which are still limited to one group of students, and has not tested the use of instruments in different learning contexts. Thus, the research objective to develop a creative thinking skill test instrument on static fluid material that is valid, reliable, and suitable for use has been achieved. The implication of this research is the availability of instruments that can support improving the quality of learning evaluation and become a reference in developing high-level thinking skills assessments in schools. Further research is recommended to test this instrument on a wider and more diverse sample, such as various grade levels and school district backgrounds, as well as integrating it into various innovative learning models to determine the sensitivity of the instrument in measuring the improvement of students' creative thinking skills.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest in the publication of this article.

AUTHOR CONTRIBUTION

All authors contributed jointly to the study design, instrument development, data collection and analysis, and manuscript writing. All authors approved the final version of the manuscript.

AI DISCLOSURE STATEMENT

All aspects of the research design, data collection, data analysis, and conclusion drawing were conducted entirely by the author without the assistance of artificial intelligence (AI).

REFERENCES

Adeoye, M. A., & Jimoh, H. A. (2023). Problem-solving skills among 21st-century learners toward creativity and innovation ideas. *Thinking Skills and Creativity Journal*, 6(1), 52–

58. <https://doi.org/https://doi.org/10.23887/tscj.v6i1.62708> Problem-Solving
- Adipan, J. P., & Asrizal, A. (2024). Pengaruh e-modul fluida statis terintegrasi stem terhadap keterampilan proses sains dan keterampilan berpikir kreatif siswa. *Jurnal Pendidikan Tambusai* 3862, 8(1), 3862–3869.
- Akbarini, N. R., & Anggrawal, A. (2024). Validity and reliability of test questions to measure the information literacy skills of prospective teacher students. *Jurnal Eduscience (JES)*, 11(1), 163–177. <https://doi.org/https://doi.org/10.36987/jes.v11i1.5640>
- Barbot, B., & Kaufman, J. C. (2025). PISA 2022 creative thinking assessment: opportunities, challenges, and cautions. *The Journal of Creative Behavior*, 59(1), 1–8. <https://doi.org/10.1002/jocb.70003>
- Chusna, I. F., Aini, I. N., Putri, K. A., & Elisa, M. C. (2024). Literatur review: Urgensi keterampilan abad 21 pada peserta didik. *Jurnal Pembelajaran, Bimbingan, dan Pengelolaan Pendidikan*, 4(4). <https://doi.org/10.17977/um065.v4.i4.2024.1>
- Fernandez-Gomez, E., Martin-Salvador, A., Luque-Vera, T., Sánchez-Ojeda, M. A., Navarro-Prado, S., & Enrique-Mirón, C. (2020). Content validation through expert judgement of an and habits of pregnant women. *Nutrients*, 12. <https://doi.org/doi:10.3390/nu12041136>
- Gumilang, N. S. R., Wahidin, & Tsurayya, A. (2021). Development of mathematics ' critical and creative thinking instruments for grade vii on secondary school. *Jurnal Pendidikan Matematika dan Sains*, 9(2), 89–98. <https://doi.org/http://dx.doi.org/10.21831/jpms.v9i1.27349>
- Hidayah, N., Sari, R., Handoko, A., & Firmansah, D. (2024). The effect of cps model with brainstorming method on creative thinking skills and creative attitudes : A study on high school students. *E3S Web of Conferences*. <https://doi.org/https://doi.org/10.1051/e3sconf/202448204011>
- Ilmi, A. M., Sukarmin, S., & Sunarno, W. (2020). Development of tpack based-physics learning media to improve hots and scientific attitude. *Journal of Physics: Conference Series*. <https://doi.org/10.1088/1742-6596/1440/1/012049>
- Istoyono, E., Dwandaru, W. B., & Rahayu, F. (2018). Pengembangan tes creative thinking skills fisika sma (physcrethots) berdasarkan teori tes modern. *Cakrawala Pendidikan*, 2, 190–200.
- Jumini, S., Madnasri, S., Cahyono, E., Nadrah, Y., Hamzah, H., & Fatiatun, F. (2024). Analysis of Items for measuring technological literacy using the rasch model. *Jurnal Pendidikan IPA Indonesia*, 13(2), 209–218. <https://doi.org/10.15294/04k5q459>
- Kurniawan, A., Istiyono, E., & Naba, S. D. (2024). Item quality analysis of physics concept understanding test with rasch model. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, 9(3), 474–486. <https://doi.org/10.26737/jipf.v9i3.5692>
- Nisa, N. Z., Prahani, B. K., Marianus, M., Irwanto, I., Kurtulus, M. A., & Hudha, M. N. (2024). Profile of Students creative thinking skills and implementation of inquiry-based learning assisted by physics 3d module. *Jurnal Pedagogi dan Pembelajaran*, 7(2), 223–230. <https://doi.org/https://doi.org/10.23887/jp2.v7i2.68112> Profile
- Nurlita, A. D., Suwarma, I. R., & Aminudin, A. (2025). Analysis of students creative thinking skills in solving problems on global warming material using the rasch model. *Journal la edusci*, 06(03), 475–487. <https://doi.org/10.37899/journallaedusci.v6i3.2460>
- Parno, P., Supriana, E., Yuliati, L., Widarti, A. N., Ali, M., & Azizah, U. (2019). The influence of stem-based 7e learning cycle on students critical and creative thinking skills in physics. *International Journal of Recent Technology and Engineering (IJRTE)*, 8(2), 761–769. <https://doi.org/10.35940/ijrte.B1158.0982S919>
- Purba, D. M., Tampubolon, T., & Rajagukguk, J. (2022). Development of creative thinking skills test instruments momentum and impulse. *AISTEEL*. <https://doi.org/10.4108/eai.20-9-2022.2324582>

- Rahayu, P., & Asrizal. (2024). Analisis kebutuhan pengembangan bahan ajar digital fluida statis terintegrasi stem untuk membangun penguasaan konsep dan keterampilan berpikir kreatif siswa. *Jurnal Pendidikan Tambusai*, 8(3), 42347–42353.
- Ramos, J. H., & Araya, R. (2025). Do school activities foster creative thinking ? an analysis of pisa results. *Education Sciences*, 15(133), 1–27. <https://doi.org/https://doi.org/10.3390/educsci15020133>
- Ratna, S. D., Simanjuntak, M. P., & Sahyar, S. (2021). Analysis of critical and creative thinking skills on the topic of static fluid physics with guided inquiry learning assisted by computer simulation. *Journal of Physics: Conference Series*. <https://doi.org/10.1088/1742-6596/1811/1/012004>
- Riberio, A. S. F. (2023). A systematic review for creative thinking skills in physics subjects. *Edufisika: Jurnal Pendidikan Fisika*, 8(2), 154–163. <https://doi.org/10.59052/edufisika.v8i2.25281>
- Rohmatika, R., Asie, Y. P., Fatmawati, S., & Suhartono, S. (2025). Profil keterampilan berpikir kreatif peserta didik pada pelajaran fisika materi besaran dan satuan. *Jurnal Pena Edukasi*, 12(1), 43–50.
- Sari, L. P., & Istiyono, E. (2021). Developing assessment instrument to measure senior high school student 's mathematical representation ability in physics learning. *Proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences*, 521–530.
- Simbolon, H., & Simbolon, I. (2025). Validasi isi pengembangan instrumen evaluasi kualitas program preceptorship keperawatan dengan menggunakan content validity ratio. *Nutrix Journal*, 9(2), 323–332.
- Sudarmin, S., Sumarni, W., Mursiti, S., & Sumarti, S. S. (2020). Students ' innovative and creative thinking skill profile in designing chemical batik after experiencing ethnoscience integrated science technology engineering mathematic integrated ethnoscience (ethno-stem) learnings. *Journal of Physics: Conference Series*, 0–7. <https://doi.org/10.1088/1742-6596/1567/2/022037>
- Suherman, S., & Vidakovich, T. (2024). Role of creative self-efficacy and perceived creativity as predictors of mathematical creative thinking: Mediating role of computational thinking. *Thinking Skills and Creativity journal*, 53, 1–14. <https://doi.org/10.1016/j.tsc.2024.101591>
- Susilowati, N. E., Al-akbari, S., Irwandani, I., Arifiyanti, F., Saputra, M. R. D., & Fratiwi, N. J. (2025). Measuring students ' creative thinking skills with SCI-Fi (Science Creative Instrument in Fluids): How Suitable Is It? *Tarbiyah: Jurnal Ilmiah Kependidikan*, 14(2), 247–263. <https://doi.org/http://dx.doi.org/10.16085/tarbiyah.v12i1> Key
- Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional development for training teachers of exceptional children: A sourcebook*. Indiana University, Center for Innovation in Teaching the Handicapped.
- Tiadarma, M. A., Sahyar, & Bunawan, W. (2022). Development of creative thinking skills test instruments on kinematics materials for sma/ma students in medan. *AIP Conference Proceedings*, 1–8. <https://doi.org/https://doi.org/10.1063/5.0113166>
- Utama, A. S., Rosidin, U., & Suyatna, A. (2021). Instrument of creative thinking skills in project based learning physics. *indonesian Journal of Science and Mathematics Education*, 04(1), 58–68. <https://doi.org/10.24042/ij sme.v4i1.8572>
- Wulansari, K., & Sunarya, Y. (2023). Keterampilan 4c (critical thinking, creativity, communication, dan collaborative) guru bahasa indonesia sma dalam pembelajaran abad 21 di era industri 4.0. *Jurnal basicedu*, 7(3), 1667–1674. <https://doi.org/https://doi.org/10.31004/basicedu.v7i3.5360> ISSN

AUTHOR PROFILES



Dya Atul Fahmi, S.Pd
dya461538@gmail.com

Departemen of Physics, Universitas Negeri Malang, Indonesia



Prof. Dr. Parno, M.Si
parno.fmipa@um.ac.id

Expertise : Physics Education

Departemen of Physics, Universitas Negeri Malang, Indonesia



Khusaini, S.Pd., M.Pd., Ph.D
khusaini.fmipa@um.ac.id

Expertise : Physics Education

Departemen of Physics, Universitas Negeri Malang, Indonesia



Marlina Ali, M.Ed, Ph.D
p-marlina@utm.my

Expertise : Physics Education

School of Education, University Teknologi Malaysia, Malaysia