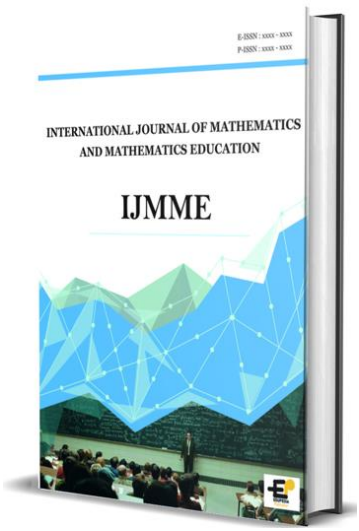

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Analysis of Students' Mathematical Creative Thinking Ability in Solving Open-Ended Questions Based on Their Self-Concept

Nopita Palwa
Universitas Suryakancana, Indonesia

Sarah Inayah*
Universitas Suryakancana, Indonesia

Ari Septian
Universitas Suryakancana, Indonesia

Vahid Norouzi Larsari
Charles University, Czech Republic

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Nopita Palwa, Sarah Inayah*, Ari Septian, Vahid Norouzi Larsari

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Abstract

Students' mathematical creative thinking abilities can be determined by giving students open-ended problems. This research aims to describe students' mathematical creative thinking abilities in solving open-ended problems when viewed from their self-concept. This type of research is qualitative descriptive research. The subject selection technique used in this research was purposive sampling. The subjects of this research consisted of one student with a high self-concept category, one with a medium self-concept category, and one with a low self-concept. Data collection methods in this research include questionnaire methods and tests. Moreover, the data analysis techniques used include analysis of mathematical self-concept questionnaires and open-ended mathematics questions. The research results show that students with a high self-concept category can fulfill all aspects of creative thinking abilities, including fluency, flexibility, and originality, so their mathematical creative thinking abilities are also high. In contrast to students with moderate self-concept, it was found that their creative thinking abilities were low, and students with low self-concept had moderate mathematical creative thinking abilities. So, it can be concluded that based on this research, students' self-concept does not always describe their mathematical creative thinking abilities in solving open-ended problems.

Introduction

Mathematics is an important subject. By studying mathematics, a person is accustomed to thinking systematically and scientifically, using logic critically, and can increase creativity (Hanipah, 2018). Mathematics is the basis of knowledge in every branch of science (Setyaningsih & Kustiana, 2023). Therefore, mathematics is essential in education (Khaerunnisa et al., 2017).

Modern progress requires educators to adapt to improve teaching quality (Sanusi et al., 2020). 21st-century education emphasizes mastery of thinking skills, including critical thinking and problem-solving, communication, collaboration, creativity, and innovation (Agustina, 2023). Based on this, to

face the challenges of the 21st century, the ability to think creatively is one of the thinking abilities that students must have in facing the challenges of the 21st century (Faradilla, 2022).

With creative thinking skills, students can create something unique to expand their basic mathematical knowledge. Based on the characteristics of mathematics, studying mathematics requires creativity (Dwi et al., 2018). Utami et al. (2020) stated that creative thinking ability has four indicators, namely fluency, flexibility, originality, and elaboration. Fluency is associated with continuity between ideas, flow of associations, and use of knowledge. Flexibility refers to changing ideas in various ways to produce various solutions to solve problems. Originality is characterized by the ability to think unusually and uniquely to produce something original. Elaboration is associated with the ability to detail and generalize an idea.

The lack of creative thinking abilities has also been shown by several previous studies, such as research conducted by (Ramdani & Apriansyah, 2018), stating that the mathematical creative thinking abilities of junior high school students at one of the schools in Cimahi on flat-sided shapes are in the low category. Researchers currently know that focus and attention on efforts to improve creative thinking abilities in mathematics are rarely developed. A person's creativity is given less attention in mathematics learning. Teachers only prioritize logic and arithmetic, so students are less creative, and activity is considered unimportant in the learning process (Hanipah, 2018). Based on these conditions, another factor causes students' weak creative thinking abilities to solve mathematical problems, especially open-ended problems, namely mathematical problems with many solving techniques or solutions. Based on these problems, applying different learning patterns, namely learning that can improve creative thinking skills in problem-based learning and especially open-ended mathematical problems, is necessary. One of them is learning through open-ended problems.

Apart from the ability to think creatively, psychological aspects also contribute to a person's success in completing tasks well. One of the psychological aspects is self-concept. Many experts have put forward the limitations of self-concept, even though the contents of the meaning are almost the same or have various similarities. However, various limitations can complement each other. In every boundary regarding the definition of self-concept, there is always an element of similarity, which shows that in the self-concept, there is an individual's view of himself (Takaria & Talakua, 2019).

Individual self-concept has a direct and indirect effect on academic achievement; an increase in self-concept causes an increase in academic achievement and vice versa; a high academic self-concept directly influences better academic achievement because the positive self-concept that students have can trigger them to be actively involved in constructing creative ideas in learning (Takaria, 2018).

According to (2018), there is a positive relationship between creative mathematical thinking abilities and students' self-concept. This means that the better the students' self-concept, the better their creative thinking abilities will be. Aisyah, Nurul Siti, and Zanti's (2018) research results stated that students with low self-concept will also have low creative thinking abilities.

Previous researchers discussed the analysis of mathematical creative thinking abilities in terms of junior high school students' mathematical self-concept using rectangular material. This research found that creative thinking abilities in the high category had a high self-concept, medium creative thinking abilities had a medium self-concept, and low creative thinking abilities had a low self-concept (Rahma, 2022). It can be concluded that students' self-concept influences their' creative thinking abilities. To support the ability to think creatively in mathematics, a form of problem with various solutions to a problem is needed, namely an open-ended problem. The research results (Sari, 2022)show that giving open-ended questions can develop students' mathematical representation abilities regarding self-concept. It can be interpreted that ability can be related or influential to other aspects, one of which is the self-concept each student has and is aware of. Therefore, this research aims to discover students' self-concepts and describe their mathematical creative thinking abilities in solving open-ended problems when viewed from their self-concept.

Method

This research is a qualitative descriptive analysis that describes information collected qualitatively in the form of written text. Subject selection was carried out using the purposive sampling method. Purposive sampling is a technique for determining samples with certain considerations (Sugiono, 2019). Subject selection was done by selecting three students based on the mathematical creative thinking ability test and self-concept questionnaire results. The subject selection was based on several considerations, namely: (1) students with high self-concept, medium self-concept, and low self-concept, (2) students who have good communication based on recommendations from teachers at the research site in class VIIA ATS-TSUUR Cianjur Islamic Junior High School for the 2022-2023 academic year. The main instrument is the researcher. The supporting instruments include non-test instruments in the form of self-concept questionnaires and test instruments in open-ended problems to measure students' mathematical creative thinking abilities.

The self-concept questionnaire instrument was adapted from indicators according to Rahma (2022), namely a) students' opinions regarding their mathematical abilities, b) students' opinions regarding the ideal mathematical abilities they would like to have, c) students' opinions regarding the relationship between the abilities they have and the ideal mathematical abilities they have, d) the student's opinion regarding how other people view him, e) the student's assessment of whether he is a person who has succeeded or failed in learning mathematics. The self-concept instrument given is a questionnaire totaling twenty-five statements with four answer choices: Very Unsuitable, Unsuitable, Suitable, and Very Suitable. Analysis of answers from the questionnaire is then used to categorize students with low, medium, or high self-concepts.

Next, students are given a creative mathematical thinking ability test in the form of an open-ended problem to see how students' mathematical creative thinking abilities are. The questions are in the form of rectangular flat shapes containing three description questions. In the test instrument, the first

question contains an indicator of fluency, the second one contains an indicator of flexibility, and the third is originality. The open-ended question instrument used to determine students' mathematical creative thinking abilities has gone through a validation process by the Mathematics Education Lecturer at Suryakancana University with the following stages: consulting with the supervisor regarding the design of three open-ended mathematics questions, then continuing with product creation The beginning is a question. Then, make revisions according to input from the supervisor, and the questions are ready to be tested.

The next step is conducting interviews using a semi-structured interview method with more flexible guidelines than other interview methods, where researchers can ask questions outside the guidelines but not outside the topic being researched. The researcher asks questions to the subject according to the interview guide that has been created to obtain additional information or data that is needed if the results of the mathematical creative thinking ability test in the form of open-ended questions are deemed not to answer the questions and indicators in the research and are used to verify the students' answers. Previously obtained.

Results

Data Analysis of Students Self-Concept Questionnaire Results

The mathematical self-concept questionnaire was one of the instruments used in this research to determine the level of students' mathematical self-concept. The categorization of the self-concept questionnaire results, tested on twenty-five class VII students, is presented in Table 1 below. After that, they were grouped into three categories: high, medium, and low self-concept. Table 1 below shows the categorization of students based on the student's self-concept questionnaire scoring.

Table 1. Categorization of self-concept questionnaire results

No	Score Range	*self-concept* Category
1.	$Score \geq \bar{X} + SD$	High
2.	$\bar{X} - SD \leq Score < \bar{X} + SD$	Medium
3.	$Score < \bar{X} - SD$	Low

From this categorization of 25 students. There are three students in the high category, 20 in the medium category, and 1 in the low category. Based on the results of the student's mathematical self-concept questionnaire, it was found that most students were at a moderate level of mathematical self-concept. Next, students are given a creative mathematical thinking ability test with three questions: fluency, flexibility, and originality.

The study intentionally selected subjects to ensure representation from each self-concept group, including only one subject from each category. Three subjects were selected to meet this requirement, as shown in Table 2. The selection method ensures a diverse sample accurately representing the many self-concept categories studied. Researchers aimed to understand how individuals perceive themselves

within specific conceptual frameworks by picking one subject from each category. This method enables a detailed examination of the connections between self-concept and research variables, revealing possible trends or distinctions among the selected individuals.

Table 2. Selected subject

Subject Code	Score	Self-concept category
HSH	78	High
SM	67	Medium
FS	46	Low

Data on Creative Thinking Ability Test Results

The mathematical creative thinking ability test given by researchers to the three selected subjects is in Table 2. The test results were grouped into three categories: high, medium, and low. The creative thinking ability test level categories are in Table 3 (Rahma, 2022).

Table 3. Category of Creative Thinking Ability Level

Interval (%)	Creative Thinking Ability Level Category
≥ 77	High
$58 - 76$	Medium
< 57	Low

Table 4 shows the results of the creative thinking ability assessments on the three selected subjects. This table offers vital information about their ability to think imaginatively and originally. Examining these results can provide valuable insights into their capacity for problem-solving, adaptability, and creativity across different situations. The data in Table 4 provides a quantifiable measure of their creative talents, facilitating the assessment and comparison of their unique strengths.

Table 4. Creative Thinking Ability Test Results

No	Subject Code	Score	Creative Thinking Ability Level Category
1	HSH	83	High
2	FS	67	Medium
3	SM	33	Low

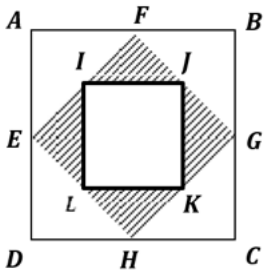
Based on Table 2 and Table 4, it was found that subjects with high self-concept also had high mathematical creative thinking abilities. Meanwhile, students with medium and low self-concepts have mathematical creative thinking abilities that differ from their self-concept categories. Students in the medium self-concept category have low mathematical creative thinking ability. In contrast, students in the low self-concept category have a medium mathematical creative thinking ability level.

Figure 1 below is an open-ended problem used in research to measure students' mathematical creative

thinking abilities. The test consists of three questions: Question number one measures fluency, question number two measures flexibility, and question number three measures originality.

1. Tentukan jenis segi empat beserta ukuran-ukuran (sisi, alas, atau tinggi) dari segi empat tersebut sehingga memiliki luas 80 cm². Boleh menuliskan lebih dari satu jawaban.

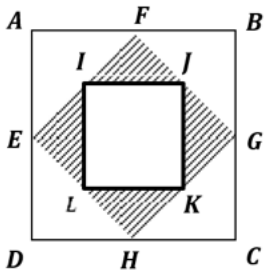
2. Pada gambar di bawah diketahui persegi $ABCD$ dan belah ketupat $EFGH$, persegi $IJKL$ dengan $AD = 4cm$. Tentukan luas daerah yang diarsir sesuai gambar di bawah ini! Jawablah pertanyaan tersebut dengan cara-cara yangberbeda dan jawablah dengan caramu sendiri!



3. Nisa dan Dea ingin membuat bangun layang-layang dalam sebuah karton persegi panjang dengan ukuran karton 14 cm x 16 cm. Berapa ukuran layang-layang yang dapat dibuat dari karton tersebut. Kemudian tentukan juga sisa karton yang tidak terpakai. Diharapkan sisa karton tersebut sekecil mungkin!

1. Determine the type of quadrilateral along with the dimensions (side, base, or height) of the quadrilateral so that it has an area of 80 cm². You can write more than one answer.

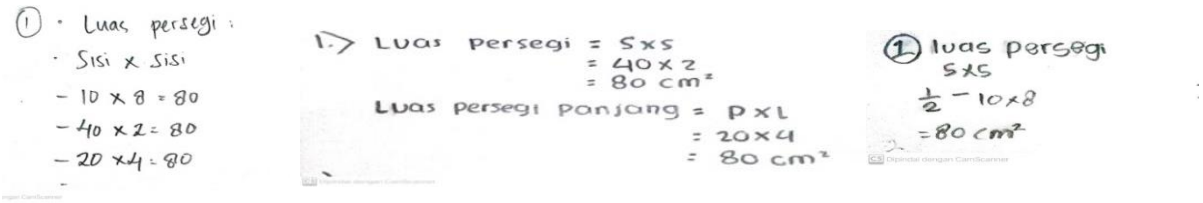
2. In the image below we know square $ABCD$ and rhombus $EFGH$, square $IJKL$ with $AD = 4cm$. Determine the area of the shaded area according to the image below! Answer the question in different ways and answer it in your own way!



3. Nisa and Dea want to make a kite in a rectangular cardboard with a cardboard size of 14 cm x 16 cm. What size kite can be made from cardboard? Then also install the remaining unused cardboard. Promising that the remaining cartons are as small as possible!

Figure 1. Open-ended problem to measure Mathematical Creative Thinking Ability

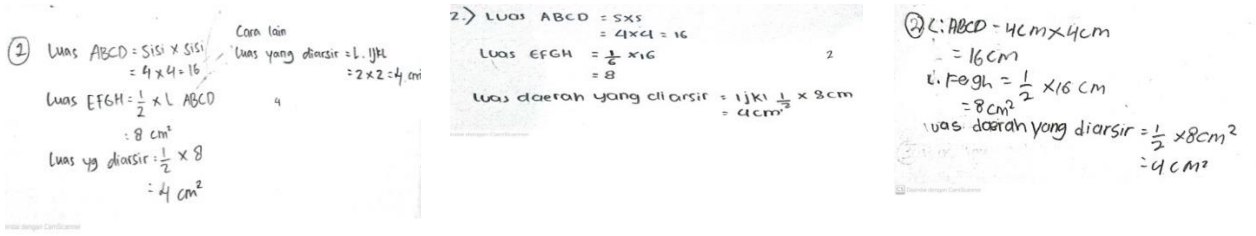
The following presents the answers to the mathematical creative thinking ability test with open-ended problems from three selected subjects: HSH, FS, and SM. Figure 2 shows the selected subject's answer to question number 1.



(a) (b) (c)

Figure 2. (a) HSH's answer (b) FS's answer (c) SM's answer to question number 1

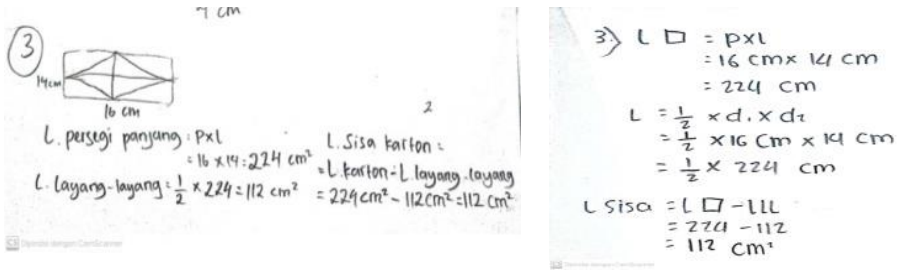
Based on the selected subject's answers in Figure 2, HNH and FS can provide more than one correct and fluent answer. Meanwhile, SM only gives one correct and fluent answer.



(a) (b) (c)

Figure 3. (a) HSH's answer (b) FS's answer (c) SM's answer to question number 2

Based on the selected subject's answers in Figure 3, in the second question, HNH provides various ways of the correct calculation process. Meanwhile, FS and SM can only provide one correct solution.



(a) (b)

Figure 4. (a) HSH's answer (b) FS's answer to question number 3

Based on the selected subject's answers in Figure 4, in the third question, HNH can provide various methods of the correct calculation process. FS gave the correct usual answer to the question, while SM did not answer.

Discussion

The creative mathematical thinking ability of students with high mathematical self-concept in solving open-ended mathematics problems in the fluency component is demonstrated by students being able to write down several building areas of various shapes. Thus, this is in line with research (Rohman et al.; Utami et al.; Indiati, 2021), which states that students with high self-concept can write various answers correctly, so it can be said that they meet the fluency indicators and can solve problems with various ideas or alternative solutions so that it can be said to meet the flexibility indicators. This is also by research by Susilawati, S. and Pujiastuti, H. (2020), who said that students with a high self-concept category can answer questions fluently and use the correct formula to get final results that have the correct value. Moreover, in line with research by Muniroh, Badriyatul, and Hartono (2019), students with a high level are included in the very creative category because these students fulfill all aspects of the self-concept of creative thinking abilities, including fluency, flexibility, and novelty.

The relationship between students' mathematical creative thinking abilities and their self-concept is complex and multifaceted. Several studies have explored this relationship and found evidence

supporting a positive correlation between these two constructs. Higher self-concept is associated with increased students' mathematical creative thinking ability (Yaniawati et al., 2020). Similarly, it aimed to describe the characteristics of students' mathematical creative thinking skills based on self-confidence, indicating a link between self-confidence and creative thinking in mathematics (Gunawan et al., 2022). Furthermore, the research demonstrated a positive influence between self-efficacy and creative thinking ability, suggesting that higher self-efficacy leads to more persistent efforts when faced with difficulties or problems (Faradillah & Purwitasari, 2022).

Moreover, a study was conducted to determine the effectiveness of a learning model on students' mathematical creative thinking abilities in self-regulated learning, indicating the interconnectedness of these factors (Novegitasari et al., 2023). Additionally, it highlighted the significant influence of self-efficacy, mathematical achievement, and metacognition on students' creative thinking abilities (Munahefi et al., 2022). These findings collectively suggest that self-concept, self-efficacy, and self-regulated learning play crucial roles in shaping students' mathematical creative thinking abilities.

Furthermore, the study found a strong relationship between mathematical creativity and problem-solving, emphasizing the interconnected nature of these cognitive processes (Hidayat & Evendi, 2022). She additionally reported increased students' mathematical creative thinking ability by implementing an open-ended approach, further supporting the link between pedagogical methods and creative thinking skills (Parinduri et al., 2018).

The relationship between students' mathematical creative thinking abilities and their self-concept is intricate and influenced by various interconnected factors such as self-efficacy, self-regulated learning, problem-solving, and pedagogical approaches. These findings underscore the importance of considering multiple dimensions to understand and enhance students' mathematical creative thinking abilities.

Based on the available references, students with low self-concept may have better mathematical creative thinking abilities than students with higher self-concept. Yaniawati et al. (2020) found that students' mathematical creative thinking ability is higher with higher self-concepts. However, Fatah et al. (2016) and Yuliani et al. (2018) indicated that the potential of students with low self-concept regarding mathematical creative thinking ability is less explored. Additionally, Gunawan et al. (2022) and Rahayuningsih et al. (2022) suggested that students with high self-efficacy are likelier to possess high mathematical creative thinking ability and vice versa. Furthermore, Jatisunda et al. (2020) highlighted that the higher the mathematical creative thinking ability, the higher the self-efficacy, and vice versa.

Moreover, Buchori and Cintang (2018) and Ibrahim and Widodo (2020) demonstrated that specific teaching models and approaches, such as the Powtoon-assisted group-to-group exchange model and the advocacy approach with open-ended problems, can improve students' mathematical creative thinking abilities. Rahman et al. (2020) also emphasized that students with low creative thinking skills may have difficulty solving complex mathematical problems. Furthermore, Qadri and Ikhsan (2019)

suggested that students still encounter problems in resolving math questions related to mathematical creative thinking ability, which impacts their overall ability in this area.

The available references provide mixed evidence regarding the relationship between self-concept and mathematical creative thinking abilities. While some studies suggest a positive correlation between self-concept and mathematical creative thinking abilities, others indicate that students with low self-concept may have untapped potential in this area. The effectiveness of teaching models and approaches in improving mathematical creative thinking abilities is also highlighted. However, it is essential to consider the diverse factors and contexts that may influence students' mathematical creative thinking abilities.

The synthesis of these references supports the idea that open-ended problems can help students further explore creative mathematical thinking abilities, considering various levels of their self-concept. The evidence suggests that open-ended approaches positively impact students' mathematical creative thinking ability and self-esteem in mathematics, emphasizing the importance of considering self-concept in mathematical learning.

Open-ended problems have been shown to positively impact students' mathematical creative thinking ability and self-esteem in mathematics (Fatah et al., 2016). The use of open-ended learning methods has been found to interact positively with students' mathematical-analytical thinking skills, indicating that it can contribute to developing creative mathematical thinking abilities (Anggoro et al., 2021). Additionally, open-ended problems based on analytic-synthetic learning have been recommended to enhance mathematical creative thinking (Yuniarti et al., 2017). Furthermore, the influence of an open-ended approach on elementary school student's mathematical creative thinking ability has been highlighted, emphasizing the optimal development of students' mathematical thinking abilities through creative activities (Sabrina et al., 2018).

Moreover, literature review studies have indicated that using an open-ended approach in mathematics learning can increase students' creative thinking skills and self-regulated learning (Ali et al., 2021). These findings suggest that open-ended problems can help students further explore creative mathematical thinking abilities. Additionally, open-ended approaches have positively impacted students' critical thinking skills in solving mathematical problems (Basri et al., 2019). Furthermore, the effectiveness of mathematics in context learning models with an open-ended approach has been shown to enhance students' mathematical creative thinking ability (Dwidayati et al., 2020).

Furthermore, mathematical self-concept has been identified as pivotal in students' appraisal of mathematics (Beek et al., 2017). This suggests that students' self-concept in mathematics is an essential factor to consider when exploring the impact of open-ended problems on their mathematical thinking abilities. The relationship between students' self-concept and mathematical critical thinking skills has been explored, indicating variations in critical thinking skills based on self-esteem levels (Kuncoro et al., 2021). Moreover, elementary school students' mathematics self-concept levels have been found to

vary based on their grade levels, highlighting the importance of considering self-concept in mathematical learning (Erdoğan & Şengül, 2014).

Conclusion

Based on the results of the analysis and discussion, it was concluded that the creative thinking abilities of Islamic Junior High School students in solving open-ended mathematics problems were viewed from the mathematical self-concept as follows:

1. Students' mathematical creative thinking abilities with high self-concept in solving open-ended problems can fulfill all aspects of creative thinking abilities, including fluency, flexibility, and originality.
2. Students' mathematical creative thinking abilities with moderate self-concept in solving open-ended problems are low. The results of students' answers on the fluency and flexibility aspects only provide one solution method or one standard answer. The novelty aspect was also not fulfilled because students did not provide answers.
3. The creative thinking ability of students with low self-concept in solving open-ended questions is included in the medium level. In terms of fluency, students can provide more than one solution. The results of the students' answers did not meet the flexibility aspect because the students could not show different types of flat shapes other than the flat shapes given in the question, and the novelty aspect was also not fulfilled because the students' answers were the same as other students.

Recommendations

For other researchers who wish to continue this research, it is best to create open-ended mathematics questions to bring out the components of creative thinking, including fluency, flexibility, and novelty. The open-ended mathematics questions used in this research are still limited, so the solution methods used by students are still limited, which results in the student's creative thinking ability test answers being less varied.

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Author Information

Nopita Palwa
Universitas Suryakancana
Jl Dr. Muwardi Komplek Pasir Gede Raya
Cianjur
Indonesia
Contact e-mail: *nopitapalwa@gmail.com*

Sarah Inayah
https://orcid.org/0000-0002-6700-4597
Universitas Suryakancana
Jl Dr. Muwardi Komplek Pasir Gede Raya
Cianjur
Indonesia
Contact e-mail: *inayahsarah@unsur.ac.id*

Ari Septian
https://orcid.org/0000-0003-0496-4416
Universitas Suryakancana
Jl Dr. Muwardi Komplek Pasir Gede Raya
Cianjur
Indonesia
Contact e-mail: *ariseptian@unsur.ac.id*

Vahid Norouzi Larsari
https://orcid.org/0000-0002-3359-2677
PhD in Education, Charles University
Prague
Czech Republic
Contact e-mail: *vahid.norouzi@pedf.cuni.cz*