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Contribution of spatial intelligence, adversity intelligence, to the creativity of vocational school students

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ABSTRACT

Today's industry requires graduates of mechanical engineering expertise programs who have high creativity. The purpose of this study is to describe how the influence of spatial intelligence, adversity intelligence, on the creativity of vocational students of the mechanical engineering expertise program. The urgency of this research is as a basis for consideration of talent interest search, selection of student admissions in vocational schools, which has been general. This research is a type of ex post facto involved 206 students of the mechanical engineering expertise program in Surabaya city in Indonesia. The data collection techniques used are tests and questionnaires. Data analysis using structural equation modeling (SEM) with SmartPLS application. The results of the analysis showed that: i) spatial intelligence and adversity intelligence had a positive and significant effect on student creativity with scores of 7.3% and 87.5%, respectively and ii) simultaneously spatial intelligence and adversity intelligence contributed to increasing student creativity by 81.4%. Implications this study can help in the development of a selection system for new student admissions tailored to the needs of mechanical engineering expertise programs. In addition to the development of a more diverse curriculum to integrate learning approaches that allow students with various types of intelligence to develop optimally.

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1. INTRODUCTION

In general in Indonesia, there are three types of vocational education systems, namely school-based vocational education, dual system education, and informal training [1]. School-based vocational education or known as vocational high schools (VHS) has the aim of producing graduates who are ready for work [2], The problem that occurs is still the high open unemployment rate of vocational graduates. Based on data from the national statistics agency, VHS graduates ranked second in open unemployment rate after high school, which was 2,111,338 in August 2021. Open unemployment rate for VHS graduates in East Java Province occupies the top position, namely 11.89% in 2020 [3]. This can happen because of the gap between schools and industry in the 21st century.

There are several terms used to describe the 21st century, including the industrial revolution 4.0, globalization, the century of knowledge, and the century of information technology [4]. In this century, there have been very rapid and unpredictable changes in all aspects of life including education [5]. This rapid change can provide opportunities if it can be utilized properly, but it can also be disastrous if not anticipated systematically, structured, and measurable [6]. This change triggers changes in the field of skills needed by the world of work [7], [8]. To predict the skills needed will be very difficult because it depends on the field and sub-job that is the focus of the skill. The 21st century is the era of the industrial revolution 4.0 which raises the need for new types of skills that previously did not exist, as well as eliminating skills that are no longer relevant [9], [10].

Industry 4.0 pushes world civilization into a global, automated, virtual, and flexible environment, resulting in global competition for jobs that demand specific skills for the digital economy [11]. These changes result in new job requirements for mastering unique and specialized skills. The industrial revolution 4.0 no longer requires a workforce that is only skilled in operating machines (machine operators), more than that it is certainly required to better understand artificial intelligence (AI) which has been included in the latest machines [12]. In addition, i) the production process no longer uses pure mechanisms, ii) manual production machines have been abandoned and no longer reproduced, iii) all manufacturing technologies began to use numerical control, and iv) numerical control was adopted from the design [13], [14]. One of the competencies that must be possessed by vocational school students of the machining engineering expertise program (manufacturing) is student design skills, this is because design is the initial stage of the manufacturing process before the production process. So that this design skill must be possessed by everyone (workforce) in the business world and the industrial world who concentrate in the field of production (manufacturing) [15]. The workforce used in the industry certainly has diverse characteristics and diverse intelligence [16].

Every workforce (person) has their own intelligence in accordance with passion, there are eight types of intelligence possessed by humans, namely: i) linguistic intelligence, ii) logical-mathematical intelligence, iii) spatial intelligence, iv) musical intelligence, v) body kinesthetic intelligence, vi) interpersonal intelligence, vii) intrapersonal intelligence (intrapersonal intelligence), and viii) naturalistic intelligence [17]. The competence of mechanical engineering expertise is closely related to drawing/design, based on several theories and initial observations that have been carried out the intelligence that most supports students to produce good drawing skills are: i) spatial intelligence and ii) adversity intelligence [18], besides that in certain situations students are required to bring out creativity in completing tasks and a project. The measurement of spatial intelligence in this study focused on the individual student. Bennett *et al.* [19], explained that the visual ability test generally aims to measure the power of visual logic, the power of spatial imagination, accuracy and accuracy of a person presented in abstract forms or symbols. There are three dimensional aspects in spatial intelligence, namely spatial relations, spatial orientation, and spatial visualization [20]. In addition, Lohman [21] also proposed the dimension of spatial intelligence with three aspects, namely spatial orientation, spatial relations, and spatial visualization. Explanation of the dimensions of spatial intelligence, which is as follows: i) image orientation (spatial orientation), ii) image relation (spatial relation), and iii) image visualization (spatial visualization).

The ability to adapt, process, and transform a problem or difficulty into a challenge that must be overcome in order to prevent it from impeding the goals and accomplishments that need to be attained is known as the adversity quotient [22]. Or in other words, someone who has high adversity intelligence will be better able to realize his goals than people who have low adversity intelligence [22]. Adversity intelligence has four dimensions commonly abbreviated as CO2RE, namely [23]: i) control (C): this dimension aims to determine how much or how much control is felt by individuals over a difficult event; ii) origin and ownership (O2): this dimension questions two things, namely what or who is the cause of a difficulty and to what extent a person is able to deal with the consequences caused by the difficult situation; ownership: This dimension questions the extent to which individuals are willing to acknowledge the consequences of difficult situations; iii) reach (R): this dimension is a part of adversity intelligence that asks questions to what extent the difficulties encountered will affect other parts or sides of the individual's life; and iv) endurance (E): endurance is a dimension that questions how long a difficult situation will last.

In addition to the basic intelligence possessed by educators today is also required to be creative, creativity can be interpreted as inventiveness, and creative is interpreted as having inventiveness, while creation is interpreted as creation, and creator means creator [24]. Creativity can also be defined from a personality point of view i.e. as the tendency to self-actualize, realize potential, the drive to develop to be more mature, the tendency to express and activate all its abilities [25]. However, the creative personality will not develop when there is no environment that values imagination, fantasy, and innovation, because it can be an obstacle to creativity [26]. Creativity is a cognitive process by combining several components that exist

before so that it can produce a new work, has not existed before or renews existing so that it can be useful for the environment. Indicators to measure creativity consist of: fluency, flexibility, elaboration, originality [27], [28].

Objects that need to be considered to support the future development of students are required to be more creative, so in this case the researcher will describe how the influence of spatial intelligence, adversity intelligence, on the creativity of vocational students who are specialized in the competence of mechanical engineering expertise [29]. Various studies show that a person's creativity is very diverse and influencing factors can be grouped in several main categories, namely: individual, environmental, social, and psychological factors [30]. But from several studies that have been conducted from these factors that contribute the most to creativity are individual factors, this individual factor is identical to a person's intelligence level, people who have high intelligence (IQ) can help in the creative thought process [31]. The basic intelligence possessed by a person consists of 8 basic intelligences: i) linguistic intelligence, ii) logical-mathematical intelligence, iii) spatial intelligence, iv) musical intelligence, v) body kinesthetic intelligence, vi) interpersonal intelligence, vii) intrapersonal intelligence, and viii) naturalistic intelligence [17]. However, existing research has not explained specifically what basic intelligence can trigger one's creativity, so research needs to be done to analyze it. The advantage and uniqueness of this study is that there has been no previous research that examines basic intelligence for vocational students, especially the mechanical engineering expertise program, besides that the results of this research can be used as a benchmark or basis for determining the basic intelligence of students who will take these skills, making it easier for students and teachers to achieve competencies that must be possessed in the mechanical engineering expertise program.

2. METHOD

2.1. Research design

In this study, *an ex post facto* quantitative approach was used with a survey method [32]. Furthermore, the data and facts collected from the constructs of spatial intelligence, adversity intelligence, and creativity will be tested according to the research framework in Figure 1.

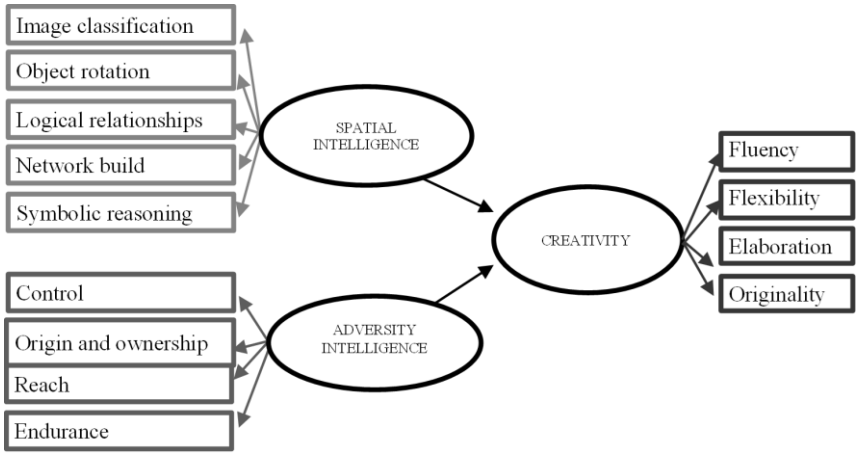

Figure 1. Research framework

2.2. Population and sample

The population in this study is all state vocational school students in the city of Surabaya class XI competence in mechanical engineering expertise for the 2022/2023 academic year total 425 student, the sampling technique used is simple random sampling using the Slovin's formula [33], so that the number of students who are the subject of research is 206 students consisting of 4 public schools in the city of Surabaya in Table 1.

Table 1. Research respondent data

Number	School	Sum
1	State Vocational Schools 2 Surabaya	50
2	State Vocational Schools 3 Surabaya	50
3	State Vocational Schools 5 Surabaya	56
4	State Vocational Schools 7 Surabaya	50

2.3. Instrument research

To obtain data on the construct to be tested, data collection instruments in the form of questionnaires and tests were compiled. For efficiency, questionnaires and tests are deployed with the help of applications such as google forms. The test is used to measure the construct of spatial intelligence and drawing skills of students while the questionnaire is used to measure the construct of creativity, design interest, and spatial intelligence of students. The instrument to be used will be prepared first according to the rules of instrument preparation, namely: construct validity, content validity, face validity, and continued with item validity to see the validity and reliability of the instrument to be prepared. For more details about the description of instruments in each construct can be seen in the following Table 2.

Table 2. Instrument grille

Variable	Indicator	Data collection
Spatial intelligence	1. Image classification	Test
	2. Object rotation	
	3. Relationship and logical consistency	
	4. Test arbitrary build	
	5. Symbolic reasoning	
Adversity intelligence	1. Control	Questionnaire
	2. Origin and ownership	
	3. Reach	
	4. Endurance	
Creativity	1. Fluency	Questionnaire
	2. Flexibility	
	3. Elaboration	
	4. Originality	

2.4. Data analysis

Structural equation modeling (SEM), is the analytical method utilized in this quantitative study and is appropriate for multivariate statistical analysis. Measurement models and structural models are the foundation of SEM data processing. Three activities occur concurrently in SEM: path analysis, which tests models of relationships between variables, confirmatory factor analysis, which verifies the validity and reliability of instruments, and structural model analysis and regression analysis, which produce models appropriate for prediction. A measurement model and a structural model, also known as a causal model, make up a full model. While structural models, or modeling that specifies proposed relationships, are used to generate judgments regarding the validity and validity of discriminants, measurement models.

This analysis is used to determine the effect of spatial intelligence, adversity intelligence, on creativity in students of the mechanical engineering expertise program. In testing the hypothesis of the construct above, it will be analyzed how the influence of each construct directly or indirectly influences each construct. Analysis test tools used to use the help of the SmartPLS application with a degree of trust 95%.

3. RESULTS AND DISCUSSION

3.1. Measurement model analysis

The results of descriptive data processing showed that all research respondents were 100% male. Their age range is between 16-18 years. The instruments used in this study were tested for validity first. Analysis of test results was carried out using Aiken' [34]. After the validity of the instrument, the next stage is to take research data on the samples that have been determined. The test results show average variance extracted (AVE) data as shown in Table 3. Based on the Table 3, the AVE of each construct/variable has a value above >0.5. The results explain that the contruct is able to account for more than half of the indicator variants of each construct. The results of the loading factor test of each indicator are presented in Table 4.

Table 3. Results of discriminant validity AVE

Variable	AVE
Spatial intelligence	0.649
Adversity intelligence	0.594
Creativity	0.605

Table 4's loading factor test results demonstrate that every indicator for every construct has a loading factor value greater than 0.7. According to the findings, the indicator is capable of representing

distinct structures. It is possible to determine the veracity of the data by looking at the loading factors and AVE determinants. After checking the validity, the next step is to check the data for reliability. The reliability test in this study used the reliability of Cronbach Alpa. The data is said to be reliable if the value of Cronbach Alpha ≥0.5.

Table 1. Results of discriminant loading factor validity

	Spatial intelligence	Adversity intelligence	Creativity
X1.1	0.732		
X1.2	0.844		
X1.3	0.798		
X1.4	0.728		
X1.5	0.780		
X2.1		0.811	
X2.2		0.877	
X2.3		0.756	
X2.4		0.772	
Y1.1			0.793
Y1.2			0.799
Y1.3			0.781
Y1.4			0.707

Note: X1 is spatial intelligence, X2 is adversity intelligence, and Y is creativity.

Table 5 shows value of each construct of Cronbach Alpha value is above 0.5. Spatial intelligence has a value of 0.820, adversity intelligence 0.773, and Creativity 0.836 this shows that the instrument in all research constructs is Reliable. After the data has been said to be valid and reliable, the data is analyzed to determine the influence of each research construct, namely: spatial intelligence, adversity intelligence, and creativity. The test results obtained data as shown in the following Figure 2.

Table 2. Cronbach Alpha reliability results

Variable	Cronbach's Alpha
Spatial intelligence	0.820
Adversity intelligence	0.773
Creativity	0.836

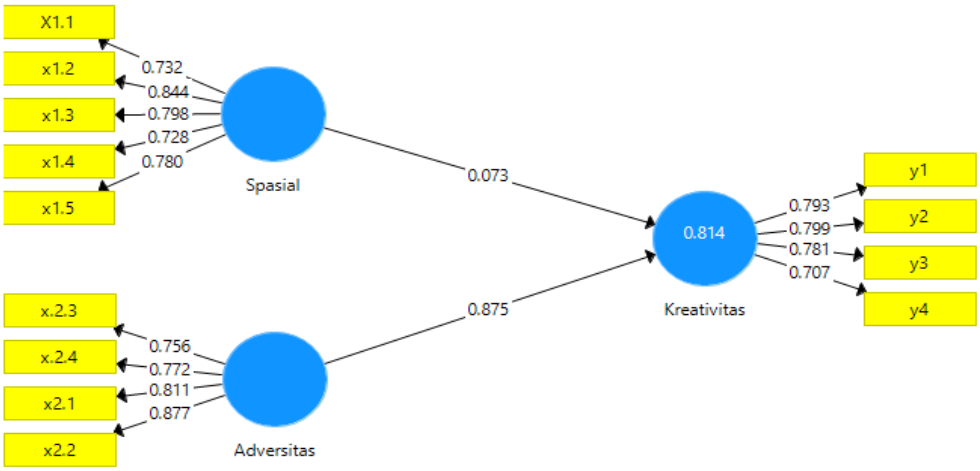

Figure 2. Model the relationship between variables with each loading factor

The results of the data analysis obtained the influence between spatial intelligence variables and adversity intelligence, on creativity and the joint influence of two independent variables on the dependent variable. The results of the path analysis can be seen in Table 3 and the R square value in Table 4.

Based on Table 6, P value shows less 0.05 then the influence between variables is significant. Each influence has a positive value. Here is an explanation of each variable. Based on Table 3, it is found that

spatial intelligence (X1) has a positive influence of 0.073 on creativity (Y). P values of 0.030<0.05 mean significant. So, it can be concluded that there is a positive and significant influence of spatial intelligence on the creativity of vocational students in Surabaya competence of mechanical engineering expertise.

Table 6. The value of influence between variables

Variable testing	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Adversity -> creativity	0.875	0.875	0.019	45.191	0.000
Spatial -> creativity	0.073	0.073	0.033	2.174	0.030

Based on Table 3, it is found that adversity intelligence (X2) has a positive influence of 0.875 on job readiness (Y). P values of 0.000<0.05 mean significant. So, it can be concluded that there is a positive and significant influence of adversity intelligence on the creativity of VHS students in Surabaya mechanical engineering expertise competence. Based on Table 7, the R Square value is 0.814 or 81.4%. So that the variable models X1 and X2 can explain Y by 81.4% and 18.6% influenced by other variables. But the biggest influence is the intelligence of adversity. So, it can be concluded that good student creativity is possessed by students who have good adversity intelligence and spatial intelligence. The conclusions drawn from your study are detailed in the results section. Provide suitable tables and figures to clearly display your findings. Tables are especially helpful when exact quantities are crucial, whereas figures are used to show data trends or other visual information.

Table 7. R square value

Variable	R square	R square adjusted
Creativity	0.814	0.812

3.2. The influence of spatial intelligence on creativity

Intelligence and creativity can be considered the most important, and perhaps most important, components that characterize human success in terms of learning, acquiring knowledge, and knowledge-based behavior [35], [36]. In other words, intelligence and creativity are two fundamental constructs, which largely determine human existence. Both have been the subject of extensive study and research, given the importance of intelligence and creativity in all human endeavors, and particularly in educational and professional environments, it will be essential to have a clear understanding of the relationship between the two. Based on the results of the research conducted, it was found that X1 has a positive influence of 0.073 on Y. P values of 0.030<0.05 mean significant. So, it can be concluded that there is a positive and significant influence of spatial intelligence on the creativity of vocational school students in Surabaya mechanical engineering expertise competence.

From these results, it can be explained that spatial intelligence contributes to increasing student creativity, if partially reviewed the influence of spatial intelligence on creativity is very small, which is 7.3%, this is because the creativity indicators used as data collection in this study are through students' self-perceptions of their creative thinking. In addition, the indicator that assesses student creativity is creativity in general, not creativity in certain competencies. Other studies that examine the contribution of spatial intelligence to creativity in general have not been done much until now that has been done a lot is related to design creativity and creativity in solving mathematical problems, so that the results of this research can be used as material or reference for further development related to spatial intelligence with creativity in general. Spatial intelligence can be defined as the capacity to recognize and describe objects or patterns received by the brain [37], while creativity is a cognitive process by combining several pre-existing components so as to produce a new work, not before [38].

The relationship between spatial intelligence and creativity is more appropriate if used to explore certain competencies that have a high relationship with the basic intelligence possessed by students, for example. In drawing competence, if students have good spatial intelligence, creativity for solving image problems will be better than students who have low spatial intelligence. This is supported by previous research that revealed an increase in representational image creativity, object rotation, arrangement drawings, and design art if you have good basic intelligence, then spatial intelligence also supports creative thinking skills, psychomotor skills (images) by 54% [38]. Furthermore, the results of Suh's research show that spatial intelligence related to spatial visualization and mental rotation is positively correlated with creativity in producing three-dimensional volumetric designs [29].

If reviewed more deeply about the construct of spatial intelligence represented by 5 indicators, namely: i) image classification, ii) object rotation, iii) logical relationships and consistency, iv) arbitrary building networks, and v) symbolic reasoning the results showed that the loading factor of all indicators has a value above 7 This means that all indicators used as research data really reflect a good level of relationship to spatial intelligence. So, it can be concluded that all existing indicators can affect creativity, the creativity referred to in this case is self-perception in creative thinking in vocational students.

3.3. The Influence of adversity intelligence on creativity

Adversity intelligence is an important factor in the ability to overcome student problems during the learning process [38]. Someone who has good adversity intelligence, will be able to identify a problem as an opportunity and challenges are not obstacles [39]. Adversity intelligence is an assessment that measures how a person's response to problems and challenges can be empowered into opportunities [23]. In addition, the adversity intelligence that exists in students can support the fighting power of students in facing various difficulties that may arise during the teaching and learning process experienced by students themselves [40]. So that the intelligence of adversity in students plays a role in learning, especially in students majoring in mechanical engineering. In the mechanical engineering expertise program, students' reasoning skills are needed for mathematical solutions for modeling mechanisms in the production process, besides that they are also required to be able to design with high accuracy. So good creativity is needed for VHS students of the mechanical engineering expertise program.

Creativity is one of the supporting factors in the ability to solve problems faced by students in the learning process. Through creativity, a person is able to generate new ideas or ideas in finding solutions to a problem [41]. Fundamentally, creativity is the universal capacity to produce something novel, to generate fresh concepts for problem-solving, or to recognize novel connections between previously existing pieces [42].

The intelligence of adversity and creativity of students plays an important role for students in overcoming problems experienced in the learning process, but if we explore more deeply related to the basic intelligence possessed by students, we can see from the results of research that has been done that X2 has a positive influence of 0.875 on Y. P value of 0.000<0.05 which means significant. So, it can be concluded that there is a positive and significant influence of Adversity intelligence on the creativity of VHS students mechanical engineering expertise competence. The influence of adversity intelligence on creativity is quite large, which is 87.5%.

The magnitude of the influence of adversity intelligence on student creativity shows that there is a very close relationship between the two, students who have high adversity intelligence then these students tend to be creative [43], [44], and it is easier to solve or deal with problems experienced. When the learning process, this is supported by previous research adversity intelligence affects the achievement of abilities students' creative thinking on mathematics learning [40] . Then students who have adversity intelligence at the climber level have good creative thinking skills, especially in the aspects of being able to meet fluency, flexibility, and novelty [45].

Indicators of adversity intelligence consist of: i) control, ii) origin and ownership, iii) reach, and iv) endurance. When viewed from each indicator that has the highest value is the origin and ownership indicator which is marked with a loading factor value of 0.877 so that the indicator is the most important indicator to foster creativity from students.

3.4. The effect of spatial intelligence and adversity intelligence on creativity

Based on Table 7, the R Square value is 0.814 or 81.4%. So that the variable models X1 and X2 can explain Y by 81.4% and 18.6% influenced by other variables. So, it can be concluded that good student creativity is possessed by students who have good adversity intelligence and spatial intelligence. From these results it can be explained that spatial intelligence and adversity intelligence contribute to increasing student creativity, partially the effect is very small, this is because the creativity indicator used as data collection in this study is the indicator that assesses student creativity is the ability to think creative is not creativity in certain competencies, as well as data retrieval carried out through students' self-perception. While the intelligence of adversity partially has a very large influence on creativity. The magnitude of the influence of adversity intelligence on student creativity shows that there is a very close relationship between the two, students who have high adversity intelligence then these students tend to be creative [46].

When referring to the basic intelligence possessed by humans that the aspects of intelligence that most influence creativity (creative thinking) are adversity intelligence and spatial intelligence, while the rest are influenced by conditions or other basic intelligence that has an influence of 18.6%. Spatial intelligence contributes greatly to visualization and problem-solving abilities that require high creativity, creativity is meant to be creativity in visualizing 2D and 3D Space, while adversity intelligence supports mental resilience and adaptation necessary to continue innovating despite facing challenges that can spur one's creativity [23],

[47]. These two types of intelligence complement each other in developing students' creative potential and helping them become more innovative in various fields.

4. CONCLUSION

From the results of the research that has been carried out related to several variables tested, 3 conclusions are obtained as follows: Spatial intelligence has an impact on creativity by 7.3%. Our findings provide conclusive evidence that high spatial intelligence has an impact on high student creativity. There was a positive and significant influence of adversitas intelligence on student creativity, the magnitude of the influence was 87.5%. Students who have high adversity intelligence tend to be easier to solve or face problems experienced during the learning process. Spatial intelligence and adversity Intelligence simultaneously affected students' creativity by 81.4%. If referring to the basic intelligence possessed by humans, the aspects of intelligence that most affect creativity (creative thinking) are adversity intelligence and spatial intelligence, while the rest are influenced by conditions or other basic intelligence that have an influence of 18.6%.

The implications of the results of this study can help in the development of a new student admission selection system that is adjusted to the competencies needed, especially for the Mechanical Engineering expertise program, in addition to the development of a more diverse curriculum to integrate a suitable learning approach by looking at the basic intelligence possessed by students so that graduates can easily achieve the planned/expected competencies. This study comprehensively explores the impact of spatial intelligence and adversity intelligence on students' creativity. However, further and in-depth studies may be needed to confirm the basic intelligence and creativity related to the skill competencies that students focus on in vocational schools.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
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Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

The authors state that there are no conflicts of interest (financial, personal, or professional) that could affect the results of the research reported in this article.

DATA AVAILABILITY

Statement of data availability in this study the authors confirm that the data supporting the findings of this study are available within the article [and/or its supplementary materials].

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