



Publication and methodological trends in creative thinking research in Indonesian biology education

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ARTICLE INFO

Article history

Received: 08 November 2025

Revised: 02 January 2026

Accepted: 24 February 2026

Keywords:

Content analysis

Journal analysis

Instructional design

Research methodology

ABSTRACT

Creative thinking skills have become a central focus in biology education research in Indonesia, reflecting the growing demand for innovative and student-centered learning approaches. However, comprehensive evidence regarding research design and data analysis trends in this field remains limited. This study aims to analyze publication and methodological trends in creative thinking research published in SINTA-accredited biology education journals in Indonesia between 2012 and 2024. A content analysis was conducted on 121 peer-reviewed articles published between 2012 and 2024, focusing on research design, instruments, data analysis techniques, and biological content domains. The results indicate that quantitative and quasi-experimental designs dominate the field, with tests and questionnaires as the most frequently used instruments, while descriptive and inferential statistics remain the primary analytical approaches. These findings suggest the need for greater methodological diversity and deeper integration of biological content contexts, and this study recommends future researchers to adopt mixed-method approaches and advanced analytical techniques to strengthen the rigor and impact of creative thinking research in biology education.

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INTRODUCTION

Creative thinking has been widely recognized as a core competency for 21st-century learners, particularly in science and biology education, as it enables students to generate original ideas, solve complex problems, and adapt to rapidly evolving scientific and technological contexts (Beghetto & Kaufman, 2014; Plucker, 2023; OECD, 2019; Henriksen, Mishra, & Fisser, 2016). International research published in reputable journals further emphasizes that learning environments, instructional strategies, and assessment practices play a central role in fostering students' creative capacities and preparing them for transdisciplinary challenges in academic and professional contexts (Fauzi, Wuri, and Supartinah, 2025; Hansen & Bertel, 2023; Li & Yu, 2025; DeHaan, 2017; Durnali, Orakci, & Khalili, 2023). In the Indonesian context, integrating 21st-century skills into the education system has become a key priority to strengthen students' creativity and innovation in response to global competition and curriculum transformation (Nur & Dwi, 2024; Griffin & Care, 2015).

Recent studies in biology and science education have primarily focused on classroom-level interventions, including inquiry-based learning, problem-based learning, and project-oriented instructional designs aimed at enhancing creative and critical thinking skills (Ernawati et al. 2023; Irwanto, 2023; Gülap & Karakoc-topal, 2025; Siew, Chong, & Lee, 2015). Large-scale reviews and international trend studies have demonstrated that the diversity of research designs strongly influences the quality and impact of educational research, the rigor of data analysis techniques, and the transparency of methodological reporting (Dağhan & Gündüz, 2022; Sjölund et al. 2022; Kimmons and Rosenberg, 2022). Despite the growing number of publications on creative thinking in Indonesian biology education journals, systematic evidence that maps methodological patterns, dominant analytical approaches, and biological content domains across studies remains limited and fragmented. This indicates a gap in the state of the art regarding how creative thinking research in this field has been methodologically developed over time.

In the Indonesian context, the rapid growth of SINTA-accredited biology education journals has increased the volume of publications addressing creative thinking skills across diverse biological topics and educational levels. Nevertheless, the methodological quality of these studies varies considerably in terms of research design selection, treatment implementation, and analytical rigor, a pattern that has also been reported in recent international science and education research emphasizing methodological transparency, analytical validity, and coherence across study designs (Creswell & Clark, 2018; Tosun, 2022). Recent review and meta-research studies further indicate that publication trend analyses often remain descriptive and under-theorized, with limited attention to the alignment between research purposes, methodological frameworks, and analytical strategies in education research (Zawacki-Richter et al. 2020; Gough, Oliver, & Thomas, 2017). This condition underscores the need for a comprehensive content-based analysis that not only maps publication patterns but also evaluates the methodological coherence and analytical depth of creative thinking research in biology education.

Addressing this gap is urgent, given the increasing demand for internationally competitive and methodologically robust studies in biology education. Therefore, this study offers a novel contribution by conducting a content-based trend analysis of 119 peer-reviewed articles published between 2012 and 2024 in SINTA-accredited biology education journals, focusing on research design, treatment types, measurement instruments, data analysis techniques, and biological content areas. Specifically, this research seeks to answer the following questions: (1) What is the trend in the number of studies on creative thinking skills over time? (2) What research designs are most frequently used? (3) What biological topics are most investigated? (4) What types of treatments are applied to enhance students' creative thinking skills? (5) What instruments are used to measure creative thinking skills? (6) What data analysis techniques are employed to evaluate creative thinking skills? and (7) What overall methodological patterns characterize the body of creative thinking research in Indonesian biology education journals?

METHODS

Research Design

This study employed a qualitative-dominant content analysis design combined with descriptive quantitative techniques to systematically examine trends and methodological patterns in creative thinking research published in Indonesian biology education journals. Content analysis enables the replicable, transparent, and valid interpretation of textual and documentary data through structured

coding and categorization, making it suitable for synthesizing large bodies of published literature (Susetyarini & Fauzi, 2020; Krippendorff, 2019; Neuendorf, 2017).

A trend analysis approach was applied to map the distribution of studies over time, research designs, biological content domains, treatment types, measurement instruments, and data analysis techniques. This design is widely adopted in education research reviews to evaluate the development and methodological rigor of a specific research field (Zawacki-Richter et al. 2020).

Although this study does not adopt a full systematic literature review protocol such as PRISMA, it applies a structured and transparent review procedure to ensure methodological rigor. Explicit inclusion and exclusion criteria were defined, articles were systematically screened from accredited journals indexed in SINTA, and categorical coding was conducted using a predefined analytical framework adapted from Susetyarini & Fauzi (2020). This approach aligns with trend-mapping and research pattern analysis methodologies that focus on identifying publication characteristics and methodological patterns rather than synthesizing empirical effect sizes.

Data Collection Techniques

Data were collected from biology education journals accredited by the Science and Technology Index (SINTA), a national web-based system that indexes and evaluates the performance of Indonesian scholarly journals. Article retrieval was conducted in February 2025. A total of 25 SINTA-accredited biology education journals were identified as the population of this study. All articles addressing creative thinking skills published between 2012 and 2024 were initially retrieved. From several thousand published articles, 121 articles were identified as relevant to creative thinking research. After a full-text screening process, two articles were excluded due to unreadable file formats, resulting in a final sample of 119 articles analyzed in this study.

Population and Sample

The population consisted of all articles published in SINTA-accredited biology education journals in Indonesia between 2012 and 2024. The sample comprised 119 peer-reviewed articles that met the inclusion criteria: (1) the focus of the study was creative thinking skills, (2) the article was published in a SINTA-accredited biology education journal, and (3) the full text was accessible and readable. Articles not meeting these criteria were excluded.

Instrument

The primary research instrument was a structured content analysis coding sheet adapted from Susetyarini & Fauzi (2020). The coding scheme consisted of seven main aspects: (1) number of publications per year; (2) type of research; (3) research subject; (4) biological topic; (5) treatment; (6) data collection instruments; and (7) data analysis techniques. Aspects (1), (4), and (5) were identified through inductive categorization during the coding process, while aspects (2), (3), (6), and (7) were deductively defined before data collection based on established methodological classifications in education research. The finalized coding framework is presented in Table 1.

Table 1
Aspects and Categories Used in the Content Analysis Framework

Aspect	Category	
Research Type 2(a)	A.1 - R and D	A.4 - Quantitative Research
	A.2 - C A R	A.5 - Literature Review
	A.3 - Qualitative Research	A.6 - Mixed Method
Quantitative research 2(b)	B.1 - Observational Research (OR)	B.6-True-Experiment Design (TED)
	B.2 - Correlational Research (CR)	B.7-Quasi-Experiment Design (QED)
	B.3 - Survey Research (SR)	B.8 -Ex Post Facto Design (EPFD)
	B.4 - Quantitative Descriptive (QD)	
	B.5 - Pre-Experiment Design (PED)	
Research Subject	C.1 - Elementary Students	C.7 - XII Grade SHS Students
	C.2 - VII Grade JHS Students	C.8 - Undergraduate Students
	C.3 - VIII Grade JHS Students	C.9 - Postgraduate Students
	C.4 - IX Grade JHS Students	C.10 - JHS Teacher
	C.5 - X Grade SHS Students	C.11 - SHS Teacher
	C.6 - XI Grade SHS Students	C.12 - Lecturer
		C.13 - Unidentified

Aspect	Category		
Data Collection Instruments		D.1 - Questionnaire Sheet	D.4 - Interview Sheet
		D.2 - Observation Sheet	D.5 - Combination
		D.3 - Test Sheet	D.6 - Unidentified
Data Analysis Techniques		E.1 - Percentage	E.6 - Qualitative Descriptive
		E.2 - N-Gain	E.7 - Quantitative Descriptive
		E.3 - T-Test	E.8 - Correlation
		E.4 - Anova	E.9 - Combination
		E.5 - Anacova	E.10 - Unidentified
			E.11 - Others

Source: Adapted from Susetyarini and Fauzi (2020).

Table 1 presents the coding framework used to classify the reviewed articles into seven analytical aspects, including research design, quantitative research types, research subjects, data collection instruments, and data analysis techniques. This framework provides operational definitions and categorical boundaries that guide the systematic extraction and classification of information from each article, thereby ensuring consistency and transparency throughout the content analysis process.

To enhance stability and consistency, the researcher conducted a test-retest coding procedure on a subset of the articles at two different time points, allowing for the identification and refinement of unclear or overlapping categories. An audit trail documenting coding decisions, category refinements, and data extraction procedures was maintained throughout the analysis to support transparency and replicability. Content validity of the coding instrument was established through expert judgment involving two senior scholars in biology education and educational research methodology, who evaluated the relevance, clarity, and representativeness of each coding category (Lynn, 1986). Furthermore, the complete coding scheme and category definitions are presented in Table 1, enabling other researchers to apply the same framework in future studies and thereby supporting methodological consistency across similar reviews (Neuendorf, 2017; Krippendorff, 2019).

Data Analysis Techniques

Each article was coded according to the predefined categories and subsequently analyzed using descriptive statistics and trend analysis. The frequency and percentage for each category were calculated and presented in tables and bar charts to illustrate publication trends, dominant research designs, treatment types, instruments, and data analysis techniques across the reviewed studies.

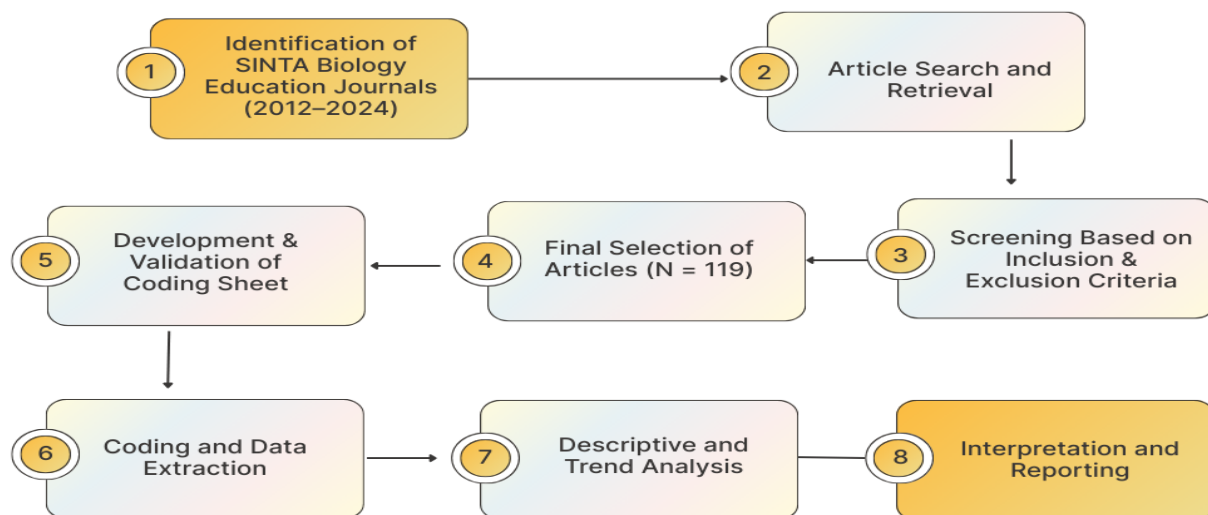


Figure 1. Procedure of Research.

RESULTS AND DISCUSSION

Number of Publications

Scientific publications are an important indicator in assessing academic productivity and the development of a field of science. The number of publications produced each year can reflect various factors, such as the availability of research resources, academic policies, scientific trends, as well as the

motivation of researchers to produce work. Based on Figure 2, the number of publications per year reviewed, there is a significant growth trend in publication activity over the past decade.

Scientific publications serve not only as indicators of academic productivity but also as reflections of epistemic priorities and policy-driven research agendas within a discipline. Trends in annual publication output can therefore be interpreted as manifestations of broader systemic factors, including shifts in curriculum frameworks, funding schemes, and the global discourse on 21st-century skills in education. As shown in Figure 2, the publication trend over the past twelve years demonstrates a pronounced and non-linear growth pattern, indicating a gradual institutionalization of creative thinking as a core research theme in Indonesian biology education.

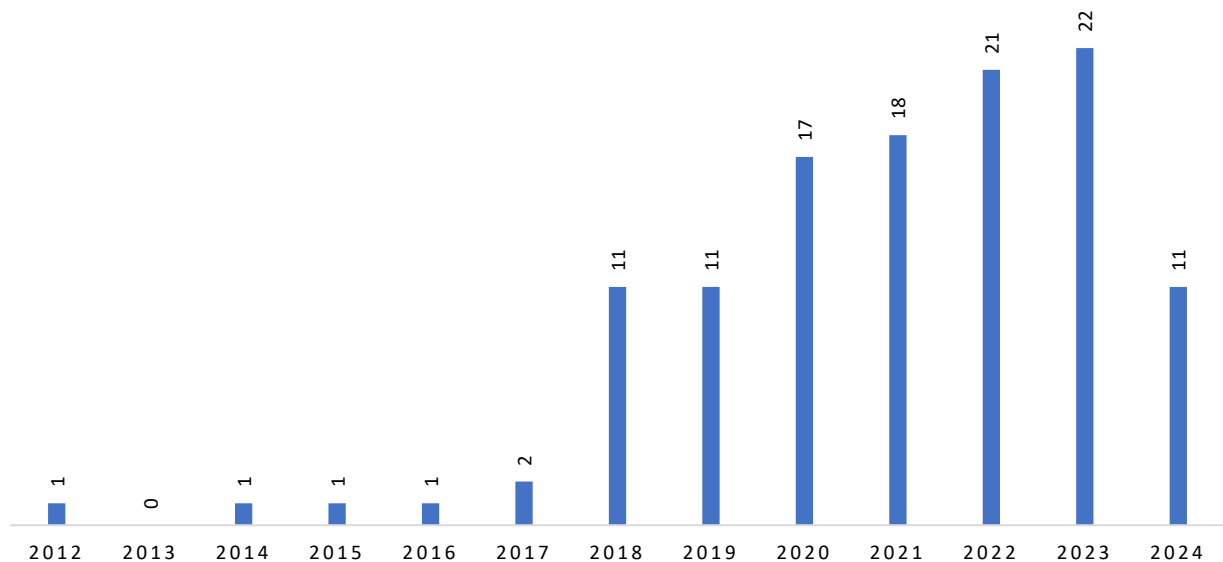


Figure 2. Number of Published Education Research with Creative Thinking as the Main Concern in Indonesia in 12 Years

In the early period (2012–2017), publication output remained minimal and largely stagnant, with an average of one article per year. This limited productivity suggests that creative thinking had not yet been widely conceptualized as a central learning outcome in biology education research. Similar patterns of delayed thematic adoption have been reported in other national contexts, where higher-order thinking skills only gained prominence following global policy alignment with competence-based education frameworks (Voogt & Roblin, 2012).

A marked increase emerged in 2018, when publication output rose sharply to 11 articles, signaling a structural shift in research orientation. This inflection point aligns with the growing international emphasis on creativity as a key educational outcome for sustainable development and workforce readiness (Henriksen et al. 2016). The sustained growth observed from 2020 to 2023 further reflects the consolidation of creative thinking research within Indonesian academic discourse (Siregar, Lubis, and Batubara, 2021). This pattern may be interpreted as a response to both internal academic incentives, such as performance-based journal accreditation systems, and external pressures to align educational research with global learning competencies frameworks (Darling-Hammond et al. 2020).

Rather than merely indicating increased productivity, this upward trend suggests a paradigmatic shift in how biology education research positions creative thinking not only as a pedagogical outcome but as a critical dimension of scientific literacy and problem-solving capacity in complex socio-ecological contexts.

Type of Research

Broadly speaking, research types are divided into two, namely quantitative research and qualitative research. However, there are also mixed-method types of research that combine these two types of research to get a more comprehensive picture. Based on Figure 2, quantitative research shows dominance with 64 publications, then qualitative research with 8 publications. This significant difference is because often researchers using quantitative methods provide numerical data that can prove or disprove a theory and easily share these quantitative findings with other researchers

(Siripipatthanakul et al., 2023). Qualitative research also requires a lot of time in terms of in-depth observations for more comprehensive results (Waruwu, 2024). For this reason, the lack of qualitative research is a good opportunity to continue this research using a qualitative design and focusing the research on creative thinking skills.

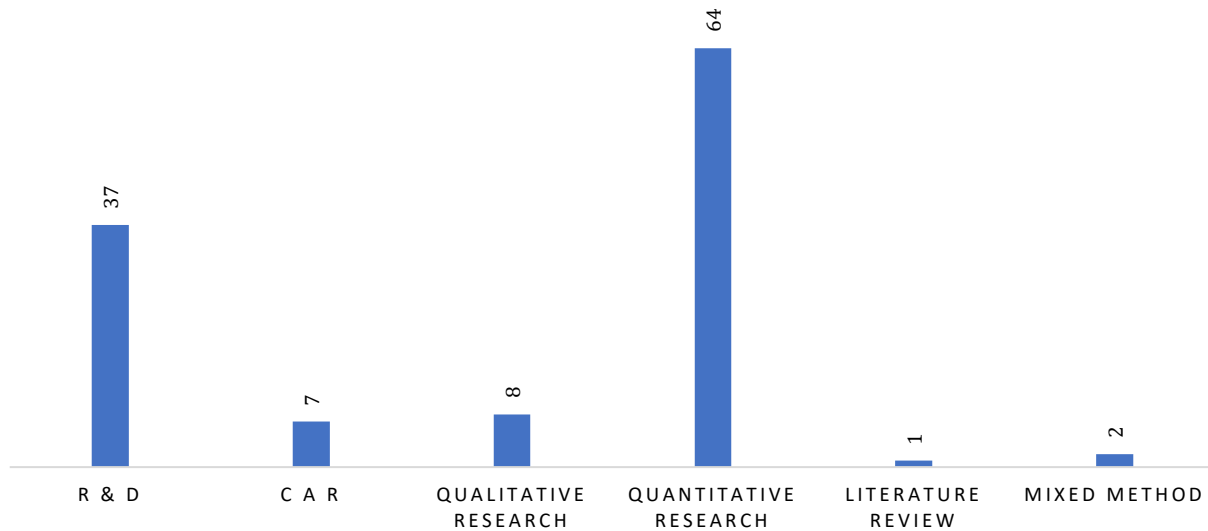


Figure 3. Types of Research in Publications where Creative Thinking is the Main Concern

It was found that out of the 25 journals that the author used as the source of article data, there was 1 journal where all the publicized articles were R&D research types with 17 articles. This contributes greatly with 45.9% of R & D research types obtained from only one journal. In recent years, R&D has been widely used in education along with technological developments. Development research products are not only available in the form of books, movies, or other learning materials, but also in the form of processes, learning models, or teaching methods Okpatrioka, 2023).

Research designs in education function as methodological lenses that shape how learning phenomena are conceptualized, measured, and interpreted. As illustrated in Figure 3, quantitative research designs dominate the analyzed corpus, accounting for more than half of the total publications. This dominance reflects a broader global trend in education research, where experimental and quasi-experimental methods are often prioritized due to their perceived capacity to establish causal inferences and generate generalizable findings (Creswell & Clark, 2018).

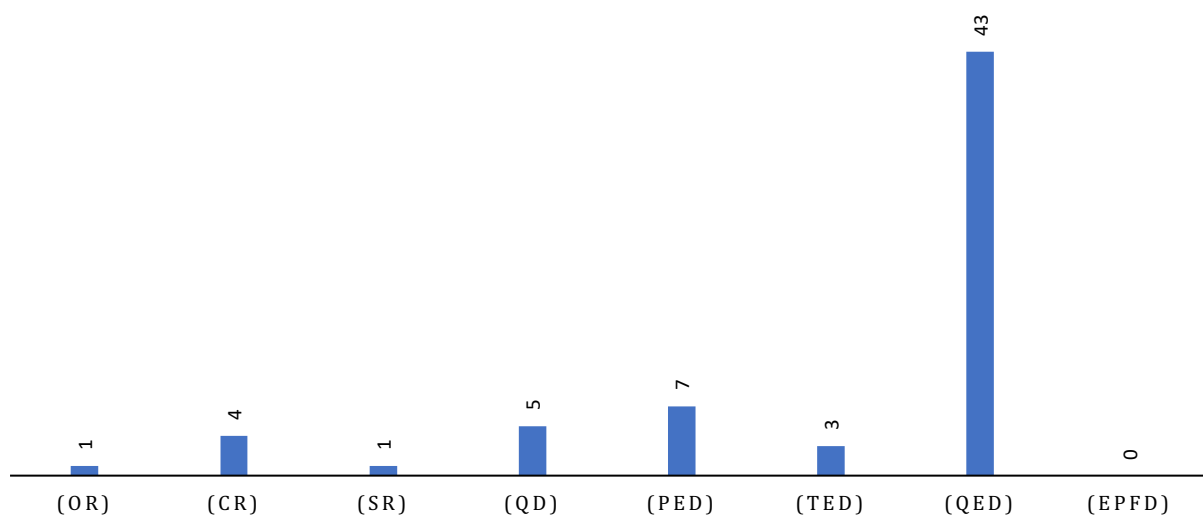


Figure 4. Types of Quantitative Research in Publications where Creative Thinking is the Main Concern in Indonesia

Figure 4 reveals a strong predominance of quasi-experimental designs (QED), which account for the largest proportion of quantitative studies. This preference reflects structural constraints commonly

encountered in school-based research, where random assignment is often impractical due to administrative, ethical, and curricular limitations. Similar trends have been documented internationally, positioning quasi-experimental designs as pragmatic compromises between methodological rigor and ecological validity (Creswell & Guetterman, 2024). The limited use of true experimental, correlational, and observational designs suggests a narrow operationalization of creative thinking research, primarily framed around intervention effectiveness rather than explanatory or predictive modeling. Contemporary educational research increasingly calls for the integration of correlational and longitudinal approaches to examine how creative thinking interacts with motivational, socio-economic, and contextual variables over time (Beghetto, 2021). The absence of ex post facto designs further indicates that retrospective and secondary-data-based analyses remain underutilized. This methodological gap restricts the field's ability to explore large-scale patterns and policy-level influences on creative thinking development. Expanding the range of quantitative designs could therefore enhance both the analytical depth and the theoretical scope of future studies.

Compared to other research designs, the only one that stands out is the quasi-experimental research design. The characteristic of this type of research is that researchers are allowed to involve all students in the class as a control group and designate another class as the experimental class. Quasi-Experiment was born because of the difficulty of controlling other variables in a study (Abraham & Supriyati, 2022). Researchers can apply different treatments and then conclude which treatment has a better effect in improving students' creative thinking skills. In addition, it is difficult to apply the True Experiment Design, considering that some variables will be difficult for us to implement, for example, classes that have been determined by the school.

Research Subject

Education research is very diverse, covering various levels of education and different subject groups. The selection of research subjects is usually based on the relevance of the topic studied, the educational challenges faced, and the need for innovation in learning. The following graph shows the distribution of educational research subjects by level, including students from various school levels, university students, and educators. By looking at this data, it is possible to analyze patterns of research trends and identify groups that are more likely to be the focus of study. Understanding the distribution of research subjects can provide insight into aspects of education that have been extensively researched and areas that still require further attention.

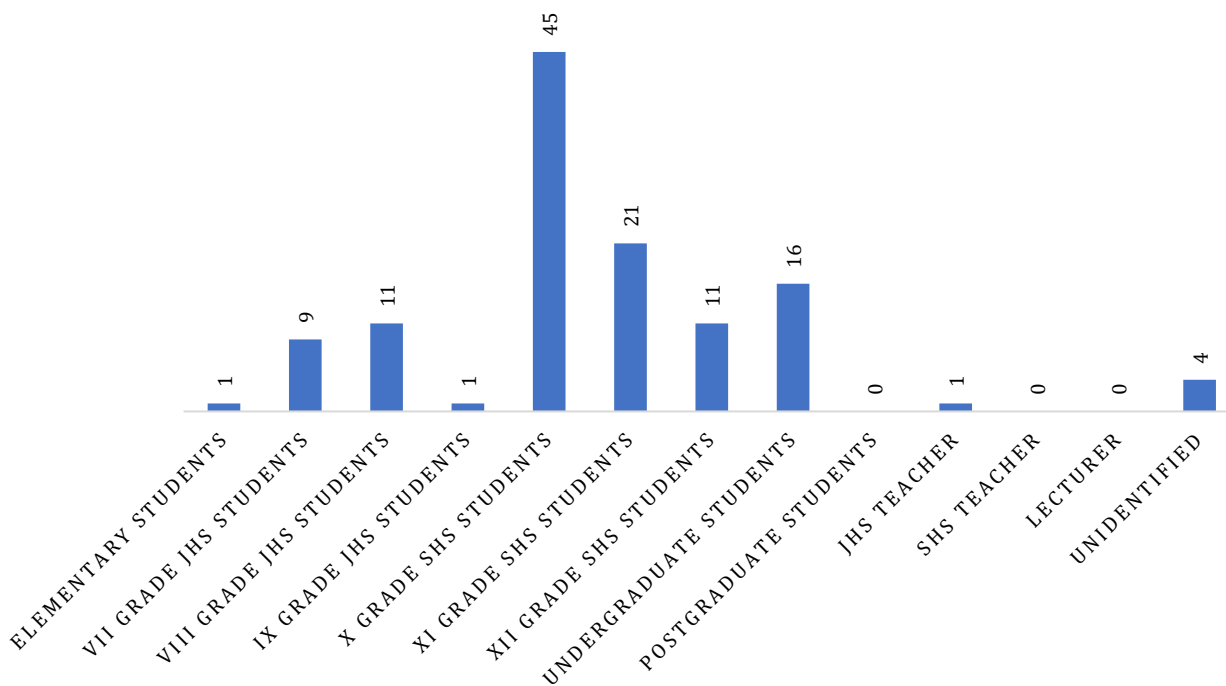


Figure 5. Research Subjects in Publications where Creative Thinking is a Key Concern in Indonesia

Figure 5 demonstrates a clear concentration of research subjects at the senior high school level, particularly Grade X students. This pattern suggests that early upper-secondary

education is perceived as a critical developmental stage for fostering creative thinking in biology learning. International research supports this focus, indicating that adolescence represents a key period for the maturation of higher-order cognitive and metacognitive skills, including creative problem-solving and scientific reasoning (Sawyer, 2022; Long et al., 2022).

However, the declining representation of higher grade levels, particularly Grade XII, reveals a structural limitation linked to institutional policies that prioritize examination preparation and curriculum completion. This constraint mirrors global challenges in conducting classroom-based research in high-stakes academic environments (Darling-Hammond et al. 2020).

The underrepresentation of teachers, lecturers, and postgraduate students also highlights a conceptual gap in the literature. Creativity research increasingly emphasizes the role of instructional design, teacher beliefs, and professional competencies in shaping classroom creativity (Kettler, Lamb, & Mullet, 2019; Beghetto, 2021). Expanding subject categories beyond students could therefore strengthen the systemic and theoretical contributions of future studies.

Biology Topics in Research

In the world of biology education research, various topics have become the focus of researchers. Several factors make it difficult for students to learn, one of which is the topic of the lesson (Harahap, 2022). Each topic reflects an area of study that is considered important in improving students' understanding of biology concepts and their relevance in everyday life. As shown in Table 2, ecosystems and biotechnology emerge as the most frequently selected topics in creative thinking research. These themes are inherently interdisciplinary and conceptually complex, requiring learners to integrate ecological, technological, and ethical perspectives. International studies have identified such domains as particularly conducive to the development of creative and systems thinking due to their open-ended problem structures and real-world relevance (Hmelo-Silver & DeSimone, 2013).

Table 2

Five most frequently selected Biology Topics in Publications where Creative Thinking is a Key Concern in Indonesia

Topic	Number of Articles
Ecosystems	11
Biotechnology	9
Excretory System	5
Digestive System	5
Waste Recycling	4

Similar to articles that chose ecosystems as a topic, articles that chose biotechnology, excretory systems, digestive systems and waste recycling also did not explain the reasons for choosing the material clearly. However, if we discuss more deeply, waste recycling material is still included in the scope of environmental material, but some researchers choose more specifically. In research conducted (Ryza Aqilla, 2024) that recycling waste is an effort to protect the environment, meaning that there are certain reasons researchers choose more specific material to see students' creative thinking skills but do not state clearly in their articles.

Despite this potential, most analyzed articles do not explicitly articulate a theoretical or pedagogical rationale for topic selection. This omission weakens the analytical coherence of the studies, as the alignment between content characteristics and creative thinking processes remains implicit rather than theoretically grounded. Contemporary curriculum theory emphasizes the importance of constructive alignment between learning objectives, content domains, and cognitive outcomes to ensure conceptual validity (Akker et al. 2013).

Contradictory findings regarding the effectiveness of learning models across similar topics, as reported in ecosystem-based studies, further underscore the need for explicit theoretical framing. Rather than attributing learning gains solely to instructional models or media, recent research suggests

that creativity outcomes are mediated by task structure, epistemic openness, and learner autonomy embedded within the content itself (Zhao 2022).

Treatment

Biology is a complex subject that makes it difficult for students in some learning processes on the subject (Farahani et al., 2023). This has led researchers to use a variety of treatments to determine students' creative thinking skills. Table 3 indicates a strong preference for Project-Based Learning (PjBL) and Problem-Based Learning (PBL) as dominant instructional treatments. This trend reflects a global pedagogical shift toward constructivist and inquiry-oriented learning environments that emphasize authenticity, collaboration, and learner agency as drivers of creative cognition (Henriksen et al. 2016); (Hmelo-Silver and DeSimone, 2013).

These approaches align with theoretical models of creativity that conceptualize creative thinking as emerging from engagement with ill-structured problems and iterative knowledge construction processes. However, the relatively limited adoption of STEM-integrated and inquiry-based models suggests that interdisciplinary and epistemic integration remains underexplored in Indonesian biology education research.

Table 3

Five Most Frequently Selected Treatments in Publications Focusing on Creative Thinking in Indonesia

Treatment	Number of Articles
Project-Based Learning	25
Problem-Based Learning	19
Inquiry-Based Learning	11
STEM (Science, Technology, Engineering, and Mathematics)	6
Mind Mapping Based	4

Furthermore, the scarcity of studies examining demographic and contextual moderators indicates a narrow focus on instructional design as the primary explanatory variable. Recent international meta-analyses highlight that socio-cultural factors, classroom climate, and learner motivation significantly mediate the impact of pedagogical interventions on creative outcomes (Akker et al. 2013). Addressing these dimensions could enhance the explanatory power and generalizability of future research.

This data reflects a trend in student creative thinking research, where project-based and problem-solving learning methods are more widely studied for their ability to enhance critical and creative thinking skills, collaboration, and real-life application of concepts. On the other hand, Inquiry-based and STEM approaches are still growing, while Mind Mapping has a smaller number of studies, possibly because it is more often used as a supporting technique rather than the main method in learning. Literature study conducted (Lestari & Ilhami, 2022), creative thinking skills can be improved with a project-based learning model. Creative thinking is a very important potential for students in terms of finding solutions to every problem to understand a subject matter.

Data Collection Instruments

In research on creative thinking, the selection of data collection instruments plays an important role in determining the validity and reliability of the research results. Various methods can be used to measure creative thinking ability, ranging from tests to observations, depending on the research objectives to be achieved. In Indonesia, research focusing on creative thinking has used various data collection instruments to measure and understand the factors that influence students' creativity.

Based on Figure 6, the most widely used instrument is the test sheet (55 publications), which shows that most studies on creative thinking tend to use the test method to measure students' creative abilities. This can be understood because tests allow for more objective and systematic measurements in evaluating creative thinking skills. Test instruments are basically used to measure the psychological side of test takers, including creativity (Kurniawan, 2021). In the second position, there is a combination of instruments (35 publications), which indicates that some studies combine various methods, such as tests with questionnaires, observations, or interviews. This approach shows that researchers are trying to get richer and more holistic data in understanding aspects of students' creative thinking.

Meanwhile, there were two articles where the research instruments were not clearly mentioned, so they were categorized as unidentified. Interview sheets are actually found in many of the articles we analyzed, but this interview sheet is not the only instrument used in the study, so we categorize it into

a combination where there is more than one instrument, including triangulation, which is known in qualitative research that researchers use interviews, observations, and surveys (Susanto et al., 2023).

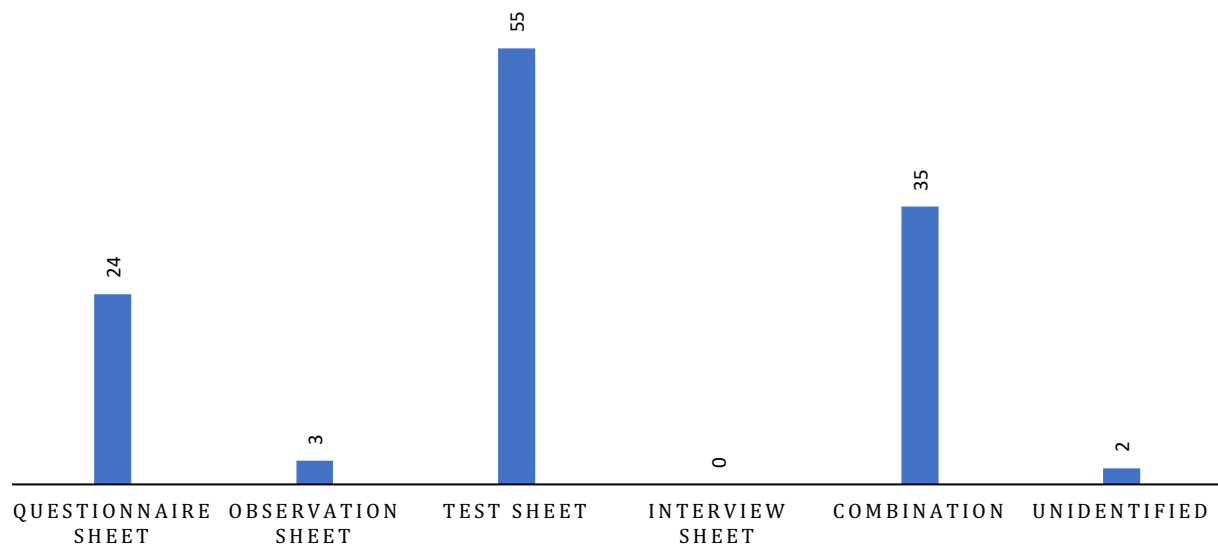


Figure 6. Data Collection Instruments on Publications that make Creative Thinking a Key Concern in Indonesia

Figure 6 shows that test-based instruments dominate the measurement of creative thinking. While standardized tests offer advantages in terms of reliability and comparability, they often privilege convergent responses and may inadequately capture the divergent, process-oriented, and context-sensitive nature of creativity. Contemporary creativity assessment literature advocates for multi-method approaches that integrate performance tasks, portfolios, and observational protocols to enhance construct validity (Beghetto, 2021; Cabedo-Mas et al., 2025).

The substantial use of combined instruments reflects an emerging recognition of the need for methodological triangulation. This aligns with international best practices, which emphasize that mixed assessment strategies provide more robust and ecologically valid representations of learners' creative capacities in authentic learning environments (Akker et al. 2013).

Data Analysis Technique

The data analysis technique used determines how the research results are interpreted. The chosen analysis technique must be in accordance with the type of data collected and the research objectives to be achieved. In general, data analysis methods can be categorized into quantitative, qualitative, or a combination of both approaches. In the context of research in Indonesia that focuses on creative thinking, a variety of data analysis techniques have been used to process and draw conclusions from the data obtained. Techniques such as T-test, ANOVA, ANCOVA, and correlation analysis are more commonly used in experimental research, while quantitative and qualitative descriptive analysis are more commonly found in exploratory research. In addition, combination techniques that consist of several techniques to process the data obtained are also quite often used by researchers to gain a deeper understanding of the phenomenon under study.

If we look at Figure 7, in addition to the combination technique which consists of a combination of several techniques, the T-test is the most frequently used in educational research in Indonesia to measure the effectiveness of various learning models on improving students' creative thinking skills. The T-test is often used in experimental and quasi-experimental research designs to analyze differences before and after a treatment, such as the application of certain learning methods to students' creative thinking skills (Muroiroh, 2022). In line with research conducted (Wahyudi et al., 2023) which states that many other studies use the t-test, then to process research data can use various tools such as SPSS.

There is also the use of quantitative descriptive techniques with 17 research articles, this technique aims to describe phenomena systematically using numerical data that can be analyzed statistically. The descriptive analysis technique in question can be in the form of Mean, Median, Frequency, Mode, Range, Standard Deviation, and Skewness (Sofwatillah et al., 2024).

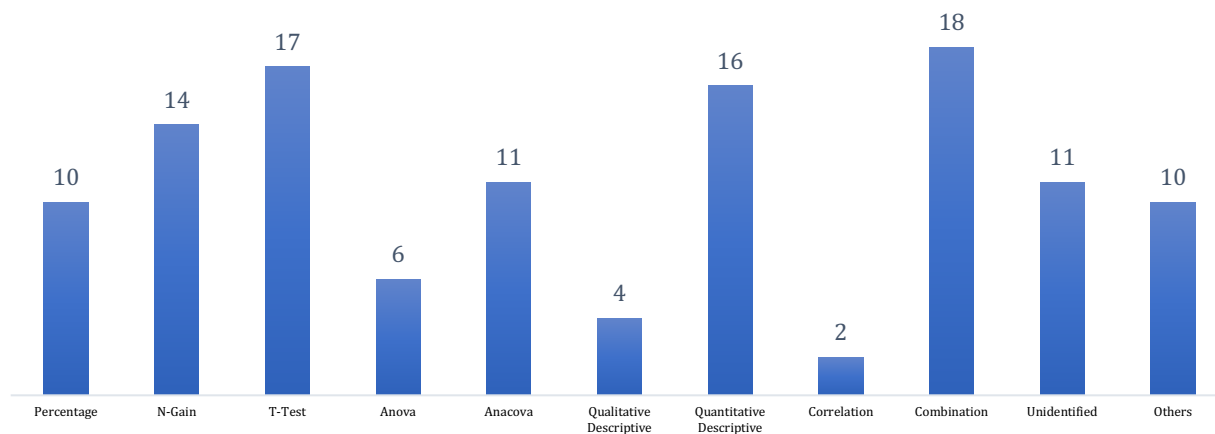


Figure 7. Data Analysis Techniques in Publications where Creative Thinking is a Key Concern in Indonesia

While inferential statistics are essential for establishing statistical significance, recent methodological discourse in education research calls for a stronger integration of explanatory and modeling approaches, such as multilevel analysis and structural equation modeling, to account for nested data structures and complex variable interactions (Creswell & Guetterman, 2024). The continued reliance on descriptive statistics also suggests that many studies remain at an exploratory stage, focusing on pattern identification rather than theory testing. Strengthening the alignment between analytical techniques and theoretical frameworks would enhance the interpretive depth and scientific contribution of creative thinking research in biology education.

CONCLUSION

This literature-based analysis of 119 biology education articles indexed in SINTA from 2012 to 2024 reveals a substantial growth in research focusing on students' creative thinking skills, particularly after 2018. The findings indicate a strong dominance of quantitative and quasi-experimental research designs, with upper secondary school students, especially Grade X, as the most frequently studied subjects. Ecosystems and biotechnology emerged as the most selected biology topics, while project-based and problem-based learning were the most widely applied instructional treatments to enhance creative thinking. Test-based instruments and combined data collection methods were predominantly used, supported mainly by inferential and descriptive statistical analyses. Overall, the results highlight a research landscape that prioritizes instructional effectiveness through experimental approaches, while suggesting the need for broader methodological diversity and deeper theoretical integration in future studies on creative thinking in biology education.

ACKNOWLEDGMENT

The authors would like to thank colleagues from the Biology Education Department, Faculty of Teacher Training and Education, Universitas Pattimura, Indonesia, for their direct assistance in article screening, data classification, and methodological discussions during the content analysis process. The authors also appreciate the editors and reviewers of the SINTA-accredited journals whose published works formed the primary data source of this study.

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