Assimilation: Indonesian Journal of Biology Education
ISSN 2621-7260 (Online)
Journal homepage: https://ejournal.upi.edu/index.php/asimilasi

The profile of pre-service biology teacher students' ability to design digital learning media and its correlation with creative thinking skills

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OPEN ACCESS

ARTICLE HISTORY
Received: 10 June 2025
First Revised: 20 June 2025
Accepted: 29 June 2025
First Available Online: 29 June 2025
Publication Date: 29 June 2025

KEYWORDS
Creativity thinking skills
Digital biology learning media
Pre-service biology teacher
Project-based learning

ABSTRACT

In the era of technological advancement, integrating innovative learning models is crucial to developing skills for the twenty-first century. This study explores how project-based learning (PjBL) is applied in a Digital Biology course and its contribution to fostering student creativity. The research involved 36 biology education students at Universitas Pendidikan Indonesia, using a quantitative descriptive approach. Data were gathered through assessments of student-created digital projects such as Instagram carousels, digital modules, interactive worksheets, and a creative thinking questionnaire. The creative thinking indicators based on Guilford (fluency, flexibility, originality, and elaboration) were used to evaluate student performance. The results showed that 31 out of 36 students (81.58%) achieved a "Creative" level (Level 3), indicating that PjBL effectively stimulated creative thinking in digital contexts. Descriptive statistics revealed that project task scores were high, with strong positive correlations between flexibility (r = 0.68), fluency (r = 0.61), and originality (r = 0.61) with the final scores. This study highlights the importance of integrating PjBL with digital pedagogy to design creative competencies in pre-service biology teacher students and suggests further strategies to promote elaborative thinking. The research provides empirical evidence that multi-format digital projects can effectively stimulate creativity in teacher education.

INTRODUCTION

The advancement of digital technology has brought significant transformation to the world of education, including biology learning. This change aligns with Sustainable Development Goal (SDG) 4, which aims to ensure inclusive, equitable quality education and promote lifelong learning for all (UNESCO, 2020). Accordingly, higher education institutions are expected to cultivate 21st-century competencies, such as creativity, collaboration, digital literacy, and problem-solving skills among students.

The Digital Biology Learning course is designed to equip pre-service teachers with technological and pedagogical competencies to meet these evolving demands. A key framework supporting this is Technological Pedagogical Content Knowledge (TPCK), which enables educators to meaningfully integrate technology into subject-specific teaching strategies (Dogan et al., 2020). This integration is increasingly essential, particularly considering the current student learning preferences that lean toward microlearning compact, modular, and digital-based learning resources such as videos, infographics, and interactive content (Yunianti et al., 2025).

Technological Pedagogical Content Knowledge (TPCK) also needs to be provided to prospective teachers as a primary preparation to face the challenges of 21st-century learning. One of them is through project-based courses or Project-Based Learning (PjBL). TPCK integrates an understanding of content, pedagogy, and technology, enabling teachers to design innovative, meaningful, and relevant learning experiences for students in the digital era (Tondeur et al., 2020). The application of TPCK in courses such as Digital Biology Learning encourages pre-service teacher students to combine technological skills with a scientific approach, including in designing digital and interactive products. One of the learning models that supports the development of TPCK competencies as well as creative thinking abilities is Project-Based Learning (PjBL). In this approach, students are involved in solving real-life projects related to everyday life, while also honing high-level thinking skills, collaboration, and innovation.

Project-based learning (PjBL) involves students in real projects that are relevant to everyday life. PjBL not only aims to enhance content mastery but also to develop creative thinking skills such as original thinking, discovery, and idea exploration (Biazus & Mahtari, 2022). Creative thinking is the capacity to actively engage in the generation, assessment, and enhancement of options that result in innovative and effective solutions (Orbe et al., 2025). In PjBL, students actively work together and collaborate to create a product or solution that reflects their understanding of a specific topic. In this case, students have the freedom to express ideas, create products, and explore creative solutions. Students can be classified as possessing creative thinking skills if they can generate diverse ideas, present unconventional concepts, and elaborate on their thoughts (Aini et al, 2020). When students are asked to design a project to solve a problem, their mindset influences the solutions created, resulting in diversity in problem-solving, so that students' potential for creative thinking can develop, they must be skilled in seeing problems from various perspectives and being skilled in understanding the topics of the existing problems (Rupalestari and Prabawanto, 2020). This is influenced by self-efficacy, which is an affective component that affects the way students think, motivate themselves, and build their own self-confidence during the learning process (Dinther et al., 2011, Morin & Herman, 2022).

Various perspectives from experts in education and psychology suggest that PjBL can provide an environment where students can stimulate their creative thinking, supporting the emergence of new ideas, solving complex problems, and enhancing critical thinking skills. PjBL markedly enhances the development of creative thinking, particularly when students engage in collaborative design oriented project that address intricate real world issue (Chen et al, 2020). In the context of challenging projects, students are encouraged to think outside the box and generate unique solutions (Fadhil et al, 2021). PjBL places students at the center of the learning process, thereby increasing their active participation, creativity, and innovation (Viswambaran & Shafeek, 2019). PjBL has proven effective in supporting the enhancement of students' creative thinking

DOI: https://doi.org/10.17509/aijbe.v8i2.85722
e-ISSN 2621-7260

skills in the context of science learning through authentic projects and reflection (Sucilestari et al, 2023).

In the study of the use of the project-based learning model in biology education, the development of PjBL is necessary for students to enhance their life skills, especially in understanding the material and finding solutions. Some research indicates positive findings that the PjBL model can enhance not only students' creative thinking abilities but also their critical thinking and problem-solving skills (Illahi, Fitri, and Arsih, 2022). This is in line with the research by Hasan et al. that PjBL can enhance creative thinking skills because it provides great flexibility in finding solutions and allows students to develop their knowledge and creativity with confidence (Hasan et al., 2022). The enhancement of student creativity plays an important role in the context of a dynamic and competitive education system. The importance of creativity can help students face challenges, develop innovative solutions, and achieve success in the real world.

In the context of digital biology learning, PjBL can be optimally utilized through the use of interactive media, digital simulations, and collaborative platforms that support active student engagement. Digital biology learning is an educational approach that utilizes digital technology to enhance the effectiveness and efficiency of the learning process. The technologies used can include simulations, animations, interactive videos, virtual laboratories, e-modules, and learning management systems (LMS). Digital integration in biology education enables the visualization of complex concepts, improved access to information, and virtual collaboration among students. Additionally, blended learning can also facilitate PjBL and encourage creativity and collaboration among students, ultimately resulting in more active learning (Hizqiyah et al., 2023). The study proved that the PjBL model is still not sufficient to enhance students' collaboration and creativity skills, thus an appropriate learning approach and the use of suitable technology are highly necessary. Thus, PjBL can provide a challenging learning experience and expand the boundaries of students' thinking, especially in digital biology learning classes.

Although PjBL offers various benefits and potential in enhancing students' creativity, its implementation is not easy. Support and guidance from lecturers, the use of relevant technology, and a learning design that stimulates creativity are needed. Through this research, it is hoped that empirical evidence can be found to support the effectiveness of PjBL in stimulating students' creativity and to broaden the understanding of how the application of PjBL can be optimized to enhance students' creativity. However, limited research has explicitly explored the simultaneous implementation of multiple digital product formats such as digital modules, Instagram carousels, and interactive worksheets within PjBL and its correlation with creative thinking skills in biology education. Most earlier studies focused only on one format of digital learning product, such as e-modules (Hasan et al., 2022) or visual-based media like PowerPoint (Illahi et al., 2022), which may not fully reflect students' creative potential in diverse digital environments

This study lies in its integrated use of various digital project types that combine narrative, visual, and interactive elements. This integrated approach provides a broader perspective on how PjBL can stimulate creativity in the context of digital biology learning and respond to current pedagogical challenges in 21st-century higher education (Sucilestari et al, 2023). The purpose of this study is to delineate the profile qualities of pre-service biology teachers' creative thinking abilities as evidenced in their digital project designs (e.g., digital modules, Instagram carousels, and interactive worksheets) within the context of project-based learning. In addition, this study aims to analyze the correlation and regression between indicators of students' creative thinking and their ability to construct digital biology learning media, providing insight into which components most significantly contribute to students' creativity development.

METHODS

This research uses a descriptive quantitative approach. This approach was chosen because the researcher wants to gain an in-depth understanding of how Project Based Learning is applied in

DOI: https://doi.org/10.17509/aijbe.v8i2.85722
e-ISSN 2621-7260

the Digital Biology Learning course and how it impacts students' creativity skills. The research was conducted in the Biology Education Study Program, Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia. It was conducted over one semester (2024/2025 academic year), coinciding with the Digital Biology Learning course.

The subjects of this research are first-semester students' cohort who are taking the Digital Biology Learning course using the PjBL model in the learning activities, totaling 36 people. The number of participants was selected through purposive sampling with criteria including being actively enrolled in the Digital Biology Learning course, being actively involved during classroom learning, being able to complete the project to the final stage, and being willing to participate in data completion or filling. The focus of the research is directed towards the learning process, interaction or activity during the project, as well as the final results of the students' digital projects as a representation of their creative process.

PjBL learning is conducted through six stages, namely: project or task determination, project planning, project scheduling, project execution, presentation or presentation of results, and project evaluation. Data was collected using the following instruments:

a. Student Questionnaire sheet, used to measure students' creative thinking abilities. It is intended to assess the extent to which students demonstrate indicators of creative thinking based on Guilford's theory
b. Documentation of student digital project products, such as digital modules, Instagram Carousel content, and interactive worksheet, to be analyzed based on creativity indicators.

The value of each project is entered and analyzed using Microsoft Excel to obtain descriptive statistical data such as the mean, standard deviation, maximum, and minimum values. Additionally, the Pearson formula is used to determine the correlation between the total project value and the final value. Drawing conclusions is based on categories of creativity indicators such as originality, flexibility, elaboration, and fluency of ideas, referring to Guilford's theory (Guilford, 1973). Each indicator has a score range of 1-5. The respective Guilford indicators can be seen in the following Table 1.

Table 1. Indicator of creative thinking skills adapted from Guilford

No	Aspect	Indicator
1	Fluency	The ability to generate various alternative ideas in a short time.
2	Flexibility	Ability to generate ideas from various media and technology
3	Originality	The ability to generate unique ideas in digital projects
4	Elaboration	Ability to develop ideas in detail and complexity in digital products

Based on the obtained data and the fulfillment of Guilford's creative thinking skills indicators, the results will subsequently be classified according to the levels of creative thinking. The levels can be seen in the following Table 2. (adapted from Widiansyah, 2019 in Wahyuni and Palupi, 2022).

Table 2. Levels of creative thinking skills

Levels of Creativity	Criteria
Level 4 (very creative)	Students are able to meet all aspects of creative thinking abilities, namely fluency, flexibility, originality, and elaboration.
Level 3 (creative)	Students are able to meet 3 out of 4 aspects of creative thinking skills in generating ideas/products.
Level 2 (quite creative)	Students are able to meet 2 out of 4 aspects of creative thinking skills in generating ideas/products.
Level 1 (less creative)	Students are able to meet 1 out of 4 aspects of creative thinking skills in creating ideas/products.
Level 0 (not creative)	Students are unable to meet all aspects of creative thinking skills in generating ideas/products.

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e-ISSN 2621-7260

In the table above, there are five different levels of creativity. Students at level 4 (Very Creative) have the ability to meet all four components of creative thinking. They demonstrate exceptional ability in creating, developing, and delivering unique and complexly structured concepts. Students at level 3 (Creative) can meet three of the four aspects of creative thinking. Although they are not yet very creative, they have shown the ability to create creative concepts for digital projects. At level 2 (Somewhat Creative), students must meet two of the four aspects of creative thinking. They have the potential for creative thinking, but they can only meet some of the criteria. Level 1 (Less Creative), students only meet one of the four aspects of creative thinking. This indicates that they are less creative and need further assistance to develop ideas. Level 0 students (not creative) do not meet any of the aspects of creative thinking. This shows that they are unable to develop and create ideas. The score obtained from the average value of each Instagram carousel project, digital module, and interactive worksheet, is converted to a scale of 1-5 based on the interpretation scale of student creativity levels using the following conversion formula:

$$\text{Scale Score 1-5} = \frac{Score\ of\ Percentase}{100}\ X\ 5$$

Then, the obtained interpretation scale is analyzed based on the score range in the following table 3.

Table 3. Range of categories based on a 1-5 scale

Average Score Range	Category	Level
4.21 – 5.00	Very Good	Level 4 (Very Creative)
3.41 – 4.20	Good	Level 3 (Creative)
2.61 – 3.40	Enough	Level 2 (Quite Creative)
1.81 – 2.60	Less Creative	Level 1 (Less Creative)
1.00 – 1.80	Very Low	Level 0 (Not Creative)

This classification helps researchers interpret questionnaire results in a more structured manner and provides a clear picture of how creativity is distributed among students. This method also allows for the mapping of students' creative thinking abilities, which can be used as a basis for developing more targeted learning strategies.

To further explore the relationship between students' creative thinking indicators and their digital project performance, this study included additional statistical analyses in the form of simple linear regression and one-way correlation analysis. The purpose was to determine the strength and direction of the relationship, and identify which creative thinking component (fluency, flexibility, originality, elaboration) contributes most significantly to students' final scores. The one-way correlation analysis was conducted using Pearson's product-moment correlation coefficient (r), while simple linear regression was applied to assess the predictive effect of each creative thinking skill on the students' final project score. Regression and correlation were analyzed using SPSS Statistics, with a significance level (α) of 0.05. An effect is considered statistically significant if $p < 0.05$. It's can be seen in the following Table 4 (adapted from Evans, 1996).

Table 4. Interpretation of Pearson's correlation coefficient (r)

Correlation Coefficient (r)	Interpretation
0.00 – 0.19	Very weak
0.20 – 0.39	Weak
0.40 – 0.59	Moderate
0.60 – 0.79	Strong
0.80 – 1.00	Very strong

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e-ISSN 2621-7260

To analyze how differences in one variable can be explained by another variabel is using the coefficient of determination, R^2, it can be seen in the following Tabel 5 (adapted from Creswell & Creswell, 2021)

Table 5. Interpretation criteria for coefficient of determination (R^2)

R^2 Value	Interpretation
< 0.20	Very weak contribution
0.21–0.40	Weak contribution
0.41–0.60	Moderate contribution
0.61–0.80	Strong contribution
> 0.80	Very strong contribution

This analysis allows for identifying which aspect of creative thinking most strongly contributes to the students' overall performance and helps refine project-based learning strategies in digital biology learning.

RESULTS AND DISCUSSION

The findings of this research indicate that the implementation of Project-Based Learning (PjBL) in the Digital Biology Learning course significantly improves students' creative thinking skills. This is evidenced by the high grades obtained by students in various digital-based projects. Active involvement in designing each project allows students to explore new ideas, develop creativity, and integrate technology into the context of biology learning. The average score and other statistical analyses are summarized in Table 6 below.

Table 6. Descriptive statistical data

Data	Instagram Carousel	Digital Module	Interactive Worksheet	Average Project Score	Average Final Score
Average	94.72	95.13	87.69	92.51	90.56
Median	95	95	87.5		
Deviation St.	4.4	5.3	2.05		
Minimum	90	75	85		
Maximum	100	100	95		

Based on the table above, overall, the scores for the Instagram Carousel project and the Digital Module received high marks (> 94), indicating that the quality or work of the students on this digital product is very good. The interactive worksheets score is lower (87.69) but still falls within the good category. For the median, the score is almost the same as the average, the data distribution tends to be symmetrical and not too biased to the left or right. The standard deviation value of interactive worksheets has the smallest variation among individuals (more homogeneous), and the digital module has the highest value variation, indicating differences in students' abilities in completing the digital module projects.

Creative Thinking Skills in Project-Based Learning

In addition to achieving high scores on every product worked on by students, the increase in student creativity is demonstrated by high scores in all aspects of creative thinking according to Guilford's indicators, namely Fluency, Flexibility, Originality, Elaboration. The assessment of students' creativity, based in Guilford's four indicators such as fluency, flexibility, originality, and elaboration, demonstrated increased average scores through all aspects (Table 7).

DOI: https://doi.org/10.17509/aijbe.v8i2.85722
e-ISSN 2621-7260

Table 7. The results of students' creativity skills

Aspect	Source of Value	Average Score	Scale Score 1-5	Category
Fluency	Instagram Carousel	94.72	4.74	very creative
Flexibility	Digital Module	95.13	4.76	very creative
Originality	Instagram Carousel	94.72	4.74	very creative
Elaboration	Interactive Worksheet	87.69	4.38	very creative

Various digital formats used, such as Instagram Carousel, Digital Modules, and interactive worksheet, provide space for students to showcase their creative abilities from various aspects. From the table, the aspect of flexibility received the highest score among the four aspects of creativity, which are categorized as "very good" and evaluated through digital module products with an average score of 95.13 or equivalent to 4.76 on a scale of 1-5. This illustrates the students' ability to prepare learning materials adaptively, according to different contexts and audiences. Students are able to present learning information using various approaches and delivery styles, and are capable of adjusting the materials to the context and needs of the users. These findings are in line with previous research that emphasizes the importance of flexibility in digital project-based learning (Hamsar, 2023). Other findings reveal that the high score for the flexibility indicator is due to students being accustomed to learning methods that train them to think flexibly (Hanni et al, 2018). The Digital Module that was developed is not only information-dense but also presents content in a flexible, engaging, and easy-to-understand structure. Compared to the aspects of Fluency (4.74) and Elaboration (4.38), this score indicates that flexibility is the main advantage of students in designing learning media. This reflects adaptive and creative abilities in organizing and delivering material. Here are examples of the Digital Modul results from the Biology Education Study Program students in the Digital Biology Learning course, presented in Figure 1.

Figure 1. The examples of digital module project of students

The aspect of Fluency, or the smoothness of creative thinking that refers to students' ability to generate many ideas in a short time, is analyzed through Instagram Carousel products that require the arrangement of several visual contents in a single learning narrative. The assessment shows an average score of 94.72, which, when converted to a scale of 1–5, becomes 4.74. This score falls into the "Very Good" category, indicating that students have a high ability to generate numerous ideas or solutions to communicate learning messages visually and informatively. The Instagram Carousel products created demonstrate fluency in developing relevant and varied content. Based on the assessment conducted by the lecturer team, the average score of students

DOI: https://doi.org/10.17509/aijbe.v8i2.85722
e-ISSN 2621-7260

in the Instagram Carousel project is 94.72. Here are examples of the Carousel results from the Biology Education Study Program students in the Digital Biology Learning course, presented in Figure 2.

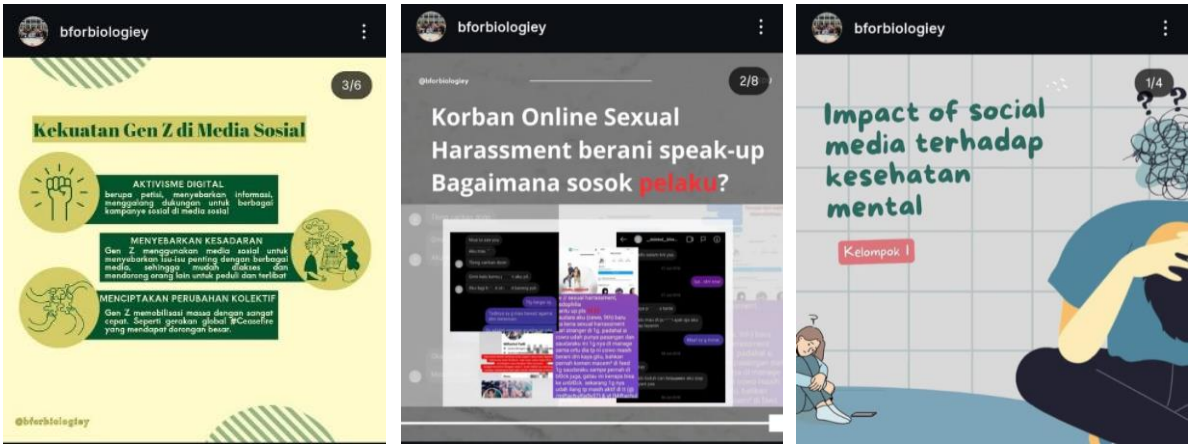

Figure 2. The examples of Instagram carousel project of students

The high fluency score indicates that students not only understand the material but are also able to communicate it in various interesting visual and narrative forms. As stated by Qomariyah and Subekti (2021), fluency in creative thinking is often evident in students' ability to formulate numerous questions, re-explain information, and systematically and gradually organize ideas in the products they create. Students are able to generate several ideas or solutions based on personal experiences or information obtained from the media (Trisnawati et al, 2020). Fluency also reflects the ability to think divergently early in the creative process, which is crucial in the ideation stage of PjBL (Guilford & Fruchter, 1973). Instagram Carousel has become an effective medium for stimulating fluency, as students are required to consistently create engaging multi-slide content.

The Originality aspect refers to the ability to generate new, unique, and unconventional ideas, analyzed based on works in the form of Instagram Carousels that reflect a distinctive and innovative style in content presentation, with an average score of 94.72% or 4.74 on a scale of 1–5. Based on the assessment criteria, this score falls into the "Very Good" category. This result indicates that the students have a high ability to produce unique, innovative ideas that differ from the commonly used approaches. The content created is not repetitive or imitative, but rather shows distinctive characteristics and uniqueness in the presentation of information. When compared to Flexibility (4.76) and Elaboration (4.38), the aspect of Originality occupies a very competitive position, showing that besides being able to think flexibly and fluently, students are also capable of bringing important novelty values in the creative process of developing digital learning media. This is in line with previous findings that show the PjBL model can encourage originality when students are given the freedom to determine the method, media, and communication style of the products being sold (Biazus & Mahtari, 2022). In the digital era, the use of social media as a learning platform has also become an innovation that supports originality, as evidenced in this research.

The Elaboration aspect refers to the students' ability to develop ideas in detail, depth, and complexity. This aspect is analyzed through the interactive worksheets (Student Worksheet) products prepared by the students. The average score obtained is 87.64%, which, when converted to a scale of 1–5, becomes 4.38 (very good category). Although it is the lowest score among the four aspects, it still indicates that the students are quite capable of developing products rich in content and supporting elements. Students have been quite good at developing detailed ideas, adding further explanations, and organizing instructional components completely and systematically in the interactive worksheets. However, there is still room for improvement, especially in expanding task explorations and presenting visual or interactive elements and more

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e-ISSN 2621-7260

in-depth instructional designs. Compared to Flexibility (4.76) and Originality (4.74), the Elaboration score indicates that the aspect of detail development is a unique challenge that needs to be improved in the project-based learning process. In line with previous research that elaboration is the most difficult aspect to achieve (Qomariyah and Subekti, 2021), students who are not accustomed to systematic thinking often face difficulties in elaborating ideas in a structured manner (Anggraini and Zulkardi, 2020). Therefore, faculty guidance during the project design phase is crucial to directing students in developing complex content elements. This research shows that these aspects can still be improved through visual support, interactive formats, and systematic preparation of interactive worksheets. Here are examples of the interactive worksheets created by students in digital biology learning in Figure 3.

Figure 3. The examples of interactive worksheets project of student

The Level of Student Creativity in Project-Based Learning

The research results show that 36 students enrolled in the project-based digital biology learning course, where 80.56% of the students are in Level 3 (Creative), and 16.67% are in Level 4 (Very Creative). Only one student (2.77%) is in Level 2 (Somewhat Creative), and there are no students in the lower levels (Level 1 or Level 0). This distribution illustrates that a large majority of students have optimally developed their creative thinking skills, meeting at least three out of the four main indicators of creativity according to Guilford (1973), namely fluency, flexibility, originality, and elaboration (Apriansyah et al, 2024). These findings are also in line with the study by Anggraini & Zulkardi (2020), which found that project-based learning encourages students to meet most of the creativity indicators, especially when given the freedom to explore and present ideas in the form of concrete products. Students were also more active and focused in preparing the projects or materials to be worked on (Mutiasari, Mustaji, and Susarno, 2023).

The dominance of students at Levels 3 and 4 indicates that the project-based learning design implemented in this study successfully encouraged students not only to understand the content but also to construct knowledge creatively. This is reinforced by the students' works in the form of digital modules, interactive worksheets, and Instagram carousels, all of which demonstrate the integration of ideas, aesthetics, and high exploratory power.

These findings surpass several previous studies that recorded the proportion of creative students at only around 50–70% in the implementation of traditional PjBL (Hizqiyah et al., 2023; Trisnayanti et al., 2020). This advantage is suspected to be influenced by the integration of a digital approach in project design, which provides students with opportunities to access learning resources, process information, and design products in a more open and dynamic environment.

DOI: https://doi.org/10.17509/aijbe.v8i2.85722
e-ISSN 2621-7260

To see how creative the students are in working on projects within PjBL learning, it can be seen in table 8.

Table 8. Percentage of student creativity levels

Level of Creativity	Number of Students	Persentase (%)
Level 4 (Very Creative)	6	16.67
Level 3 (Creative)	29	80.56
Level 2 (Quite Creative)	1	2.77
Level 1 (Less Creative)	0	0
Level 0 (Not Creative)	0	0
Total	36	100

Based on Table 8 above, figure 4 presents visual distribution students with their creativity levels from 3 of 5 categories. It is known that 80.56% of students fall into the creative and 16.67% for very creative categories, indicating that project-based learning in the context of digital biology education has effectively enhanced students' creative thinking abilities. Similar to other studies, the implementation of PjBL in elementary science education significantly contributes to the improvement of creativity indicators, such as flexibility and originality (Putri et al, 2019).

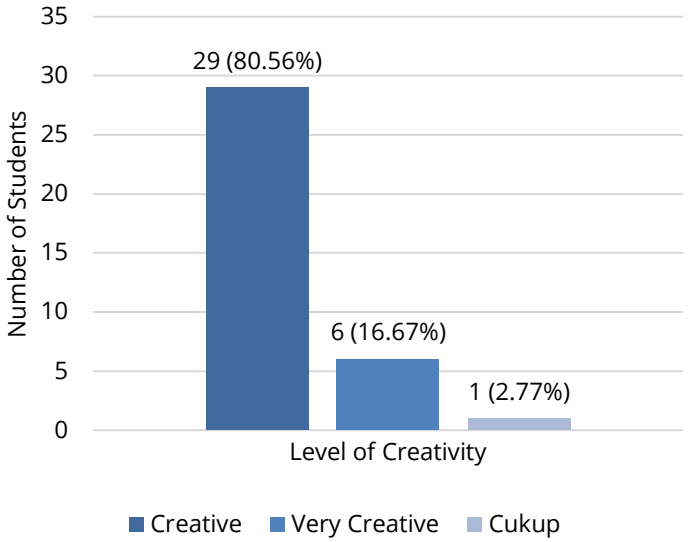

Figure 4. Graph of distribution of student creativity levels

The dominance of students at Level 3 and Level 4 indicates that the majority of learners are able to meet at least three out of the four indicators of creative thinking according to Guilford, namely fluency, flexibility, originality, and elaboration (Guilford & Fruchter, 1973, Wijayanti et al, 2019). These results are consistent with previous findings by Anggraini and Zulkardi (2020) which state that project-based learning can enhance students' creative thinking abilities, especially when presented in the form of structured real products. This increase in creativity is also significantly greater compared to the use of conventional learning methods (Juniarmi, 2024). In addition, PjBL can enhance students' creativity and innovation. Students become more active in the learning process, able to collaborate with their peers, and develop innovative ideas in the projects they work on (Nupus et al., 2025).

The figure 4 also shows that the project approach conducted systematically and based on digital technology is able to reach almost all students to achieve a medium to high level of creativity. In the context of this research, the use of digital media such as Instagram carousels, interactive modules, and integrated interactive worksheets has proven to expand the space for

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e-ISSN 2621-7260

students' idea exploration, ultimately increasing the distribution of creativity towards higher levels. Additionally, the proportion of students at Level 4 (Highly Creative) at 16.67% indicates that some students have a high capacity to develop ideas in an original, adaptive, and complex manner. This success is likely influenced by the freedom given in determining the theme, format, and presentation style in the digital project, which contributes to the increased self-efficacy of the students (Dinther et al., 2011).

Thus, this distribution graph not only reflects the success of Project-Based Learning (PjBL) in enhancing creativity but also highlights the importance of combining project-based learning strategies with the use of digital technology in supporting higher-order thinking skills in a more inclusive and comprehensive manner. As previous research has shown, the project-based learning model combined with technology and a hybrid approach can significantly improve creative and critical thinking abilities, in line with the results of this study (Trisnowati, 2022).

Correlation and Regression of Creative Thinking Indicators Toward Final Score

To examine the strength and direction of the relationship between each indicator of creative thinking and students' final project score, Pearson's one-way correlation analysis was conducted. The following table summarizes the correlation coefficient (r), coefficient of determination (R^2), and significance (p-value) for each indicator. The result of analysis can be seen in Table 9.

Table 9. Pearson correlation and regression summary

Indicator	Source	r (Correlation)	R^2	Sig. (p-value)	Interpretation
Fluency	Instagram Carousel	0.61	0.38	0.003	Strong
Flexibility	Digital Module	0.68	0.46	0.001	Strong
Originality	Instagram Carousel	0.61	0.38	0.003	Strong
Elaboration	Interactive Worksheet	0.47	0.22	0.021	Moderate

The analysis between creative thinking indicators and students' final scores revealed that flexibility demonstrated the highest positive correlation. Flexibility, the ability to adapt ideas and shift approaches, was measured via students' digital modules. It showed the strongest positive correlation with the final score ($r = 0.68$, $p = 0.001$) and was the most influential predictor in regression analysis ($R^2 = 0.46$), indicating a strong contribution. This suggests that students who can present ideas from different perspectives and apply varied strategies in designing their digital media tend to perform better. The flexibility demonstrated in the modules, through layout design, user experience (UX), and content navigation, reflects their ability to meet diverse learner needs, a skill vital in 21st-century education. These results resonate with Hamsar (2023) and Hasan et al. (2022) who found that flexibility is a key component in creative PjBL tasks, especially when students are granted autonomy in designing meaningful and user-oriented digital outputs.

Fluency, the ability to generate multiple ideas quickly, was assessed through students' Instagram Carousel projects. The correlation analysis indicated a strong and significant relationship between fluency and final scores ($r = 0.61$, $p = 0.003$). Regression results showed that fluency contributed 38% of the variance in students' final scores ($R^2 = 0.38$), indicating a moderate contribution. These findings are in line with Qomariyah & Subekti (2021) and Trisnawati et al. (2020) who emphasized that fluency is closely tied to divergent thinking and is often reflected in students' ability to express multiple visual, verbal, and conceptual ideas. In digital media tasks, fluency allows students to organize and sequence content dynamically, enhancing their digital storytelling and communication skills.

DOI: https://doi.org/10.17509/aijbe.v8i2.85722
e-ISSN 2621-7260

Originality, the ability to generate novel and unique ideas, was also assessed from the Instagram Carousel projects. The indicator showed a strong correlation with the final score ($r = 0.61$, $p = 0.003$) and contributed 38% to final score variance ($R^2 = 0.38$), the same as fluency. This finding indicates that the more original and novel a student's digital product such as creating unique infographic styles or thematic narratives, the more impactful it is in terms of project evaluation. Students who stood out in originality showed a capacity to break from conventional formats and introduce new creative directions, which aligns with the goals of project-based digital pedagogy. This supports prior findings from Biazus & Mahtari (2022) and Chen et al. (2019), which highlight that originality increases when students are involved in open-ended, real-life problem-solving tasks.

The last indicator, elaboration, the ability to expand and detail ideas systematically, was measured using students' interactive worksheets. Although still positively correlated, the relationship was moderate compared to the other indicators ($r = 0.47$, $p = 0.021$) with a lower predictive power ($R^2 = 0.22$), signifying a weak–moderate contribution. This result suggests that while students can include details and enrich their project components, elaboration is the most challenging skill to develop. Many students struggled with instructional sequencing, in-depth explanation, and visual structuring, which limited the complexity of their worksheets. This aligns with the findings of Anggraini & Zulkardi (2020) and Qomariyah & Subekti (2021), who stated that elaboration often develops at a slower pace and requires systematic guidance and frequent practice.

The analysis demonstrates that all four indicators of creative thinking positively affect student performance, with flexibility being the most influential. This highlights the need for learning environments that promote adaptive design thinking, divergent idea generation, and supportive project scaffolding, all central to project-based learning. Moreover, the integration of multiple digital media formats (e.g., Instagram carousel, e-module, and interactive worksheet) offers students the space to express different dimensions of creativity. These findings strengthen the theoretical underpinnings of TPACK (Technological Pedagogical Content Knowledge) and support broader educational goals such as SDG-4 (UNESCO, 2020) by fostering digital competency and creative innovation in teacher education.

CONCLUSION

Based on the research conducted on students of the biology education program at Universitas Pendidikan Indonesia, it shows that the creativity skills of students using the Project-Based Learning approach have a high level of creativity. This can be seen from the observation results of creativity, which obtained a percentage exceeding 80%. Project-Based Learning (PjBL) in the Digital Biology Learning course effectively promote students' creative thinking skills, which are significantly correlated with their academic achievement. Among the four indicators of creative thinking assessed such as fluency, flexibility, originality, and elaboration, flexibility emerged as the most influential predictor of students' final project scores. This suggests that students' ability to adapt and design learning content in a varied and responsive manner plays a pivotal role in successful digital media creation. Fluency and originality also showed strong positive correlations with students' performance, highlighting the importance of idea generation and novelty in digital project work. While elaboration had a moderate correlation, it remains a crucial aspect of developing detailed and structured learning materials.

These results underline the importance of integrating creative thinking skill development, particularly flexibility and originality, within digital learning environments. Furthermore, the use of varied digital products such as Instagram carousels, digital modules, and interactive worksheets provides meaningful opportunities for pre-service teachers to express, refine, and apply their creative competencies. This study supports the integration of PjBL and digital pedagogy in higher

DOI: https://doi.org/10.17509/aijbe.v8i2.85722
e-ISSN 2621-7260

education, especially in preparing future educators with the skills needed for 21st-century learning challenges.

The research conducted by the researchers is far from perfect, and it is hoped that future researchers will delve deeper into aspects that can help students develop their creativity, thereby building support and awareness from all parties. So that there is feedback on the evaluation of the implementation of PjBL regularly from both the perspective of lecturers and students. Different experiences from many researchers allow for numerous improvements in the education sector, particularly in the issue of promote students' skills (creativity), information obtained from various parties can be used as a reference to improve and develop the PjBL approach in the campus world.

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DOI: https://doi.org/10.17509/aijbe.v8i2.85722
e-ISSN 2621-7260

Acknowledgment

The researcher would like to express sincere gratitude to Universitas Pendidikan Indonesia for the financial support and funding provided for this research. Special thanks are also extended to the participants, particularly the 36 students from the Biology Education Study Program, whose valuable involvement and contributions made this study possible.

Authors' Note

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

How to Cite this Article

Widianingsih., A. A., Supriatno, B., Suwandi, T. (2025). The profile of pre-service biology teacher students' ability to design digital learning media and its correlation with creative thinking skills. *Assimilation: Indonesian Journal of Biology Education, 8*(2), 121-135. https://doi.org/10.17509/aijbe.v8i2.85722

DOI: https://doi.org/10.17509/aijbe.v8i2.85722
e-ISSN 2621-7260