

Theoretical construction of the microteaching model-based PjBL and blended learning for prospective biology teachers

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Abstract

Microteaching as a learning model must be updated for the future, especially in preparing prospective biology teachers with the 4C skills required in the 21st century. This study aims to develop a microteaching model-based Project-based Learning (PjBL) and blended learning to enhance the 4C skills of prospective biology teachers. The research method uses a Research & Development approach with the ADDIE framework. The research subjects are the Biology Education Study Program students who take the microteaching course. This model integrates PjBL and blended learning, including the following stages: (1) Project orientation (synchronous), (2) Module development (asynchronous), (3) Peer review (asynchronous), (4) Presentation of peer review results (synchronous), (5) First teaching practice and peer review (asynchronous), (6) Presentation of first teaching practice results (synchronous), (7) Second teaching practice and peer review (asynchronous), (8) Presentation of second teaching practice results (synchronous), (9) Collection of project videos (synchronous), and (10) Project evaluation (synchronous). Data collection techniques include questionnaires, validation sheets, observation sheets, and tests, with data analysis using a t-test. The results show that model enhances the 4C skills of prospective biology teachers. In conclusion, this model effectively improves 4C skills with the guidance of a logbook and LMS. Still, lecturers must encourage and facilitate student learning activities through direct communication or instant messaging. This research impacts the quality of education for prospective biology teachers in the future.

Abstrak. Microteaching sebagai model pembelajaran perlu diperbaharui untuk masa depan, khususnya dalam menyiapkan calon guru biologi dengan keterampilan 4C yang dibutuhkan pada abad 21. Penelitian ini bertujuan mengembangkan model microteaching berbasis project-based learning (PjBL) dan blended learning bagi calon guru biologi. Metode penelitian ini menggunakan pendekatan Research & Development dengan kerangka ADDIE. Subjek penelitian adalah mahasiswa Program Studi Pendidikan Biologi yang mengambil mata kuliah microteaching. Model microteaching yang dikembangkan mengintegrasikan PjBL dan blended learning, meliputi tahapan: (1) Orientasi proyek (sinkronus), (2) Pengembangan modul (asinkronus), (3) Peer review (asinkronus), (4) Presentasi hasil peer review (sinkronus), (5) Praktik mengajar pertama dan peer review (asinkronus), (6) Presentasi hasil praktik mengajar pertama (sinkronus), (7) Praktik mengajar kedua dan peer review (asinkronus), (8) Presentasi hasil praktik mengajar kedua (sinkronus), (9) Pengumpulan video proyek pembelajaran (sinkronus), dan (10) Evaluasi dan penilaian proyek (sinkronus). Teknik pengumpulan data menggunakan angket, lembar validasi, lembar observasi, dan tes. Teknik analisis data menggunakan t-test. Hasil menunjukkan bahwa model ini meningkatkan keterampilan 4C pada calon guru biologi. Kesimpulannya, model ini efektif meningkatkan keterampilan 4C dengan panduan logbook dan LMS. Namun, dosen perlu mendorong dan memfasilitasi kegiatan belajar mahasiswa melalui komunikasi langsung atau pesan instan. Penelitian ini berdampak pada peningkatan kualitas pendidikan calon guru biologi di masa depan.

A. Introduction

Preparing prospective biology teachers for effective and efficient teaching is a top institution priority. Research related to the most appropriate pedagogical approaches for educating prospective teachers continues to attract academic attention, highlighting the need for innovation in teaching methods (Nye et al., 2004; Cochran-smith & Villegas, 2015). Furthermore, efforts to enrich the knowledge and pedagogical approaches of prospective teachers are continually evolving, demonstrating progress in the field of teacher education (Knight et al., 2014). This awareness paves the way for developing more profound and comprehensive teaching strategies.

However, there is a gap in meeting the effective learning needs of prospective teachers. Many teacher education programs do not fully equip students with 4C skills (critical thinking, creativity, communication, and collaboration). This is a significant weakness, given the importance of these skills in 21st-century learning (Cochran-smith & Villegas, 2015). Current teacher education still grapples with traditional practices and the search for better strategies (Cochran-smith & Villegas, 2015). Traditional learning practices remain dominant, and research focused on fostering these skills is still limited (Stahl et al., 2018), indicating an urgent need for more innovative teacher education reforms.

Microteaching, as one of the teaching methods to train prospective teachers in skills such as lesson opening and closing, explaining material, questioning, and classroom management, has not yet integrated PjBL, blended learning, or accommodated the development of 4C skills. Although microteaching has long been recognized as an effective way to train basic teaching skills, it remains insufficient in preparing prospective teachers to face the challenges of 21st-century learning (Donnelly & Fitzmaurice, 2011). These limitations indicate the need for a more comprehensive and future-oriented approach to microteaching.

Microteaching needs renewal to be future-oriented, especially in preparing prospective biology teachers with the 4C skills required for 21st-century learning. The competencies of prospective biology teachers include pedagogical, professional, social, personal, and technological competencies.

The role of 4C skills for prospective biology teachers is to train critical thinking, creativity, collaboration, and communication skills. With critical thinking skills, prospective biology teachers can analyze learning needs. With creative thinking skills, a biology teacher can create engaging biology learning media. With collaboration skills, prospective biology teachers can work with peers to solve problems and review each other's learning practices. With good communication skills, prospective biology teachers can effectively plan and implement biology lessons.

The role of microteaching in enhancing 4C skills by integrating PjBL and blended learning. The theoretical construction of the microteaching model-based on PjBL and blended learning can train the 4C skills of prospective biology teachers. The PjBL and blended learning steps encourage prospective biology teachers to think critically and creatively, collaborate, and communicate effectively. PjBL trains critical, creative thinking, collaboration, and communication skills (Khafah & Suprpto, 2023). Blended learning makes learning more effective and efficient because it is not constrained by space and time. Blended learning can encourage students to be creative, critical and maximize collaboration (Astuti & Febrian, 2019).

Implementing PjBL and blended learning in microteaching offers significant opportunities to address these gaps. This PjBL encourages students to solve real-world problems, training academic and 4C skills. Constructive and project-oriented learning experiences increase student participation, motivate them to learn, and help in mastering various skills (Gómez-Pablos et al., 2017). This aligns with implementing the MBKM (Merdeka Belajar Kampus Merdeka) curriculum, which advocates using PjBL and blended learning models. This demonstrates the potential of PjBL and blended learning to enhance the effectiveness of microteaching.

Understanding and mastering 4C skills become essential for prospective teachers facing modern learning challenges. The ability to think critically, creatively, communicate, and collaborate enriches learning and prepares students for future success. Critical thinking supports evidence-based decision-making; creativity fosters innovation; communication allows for smooth information exchange; and collaboration facilitates effective teamwork (Trilling & Fadel, 2009). Innovations in microteaching based on PjBL and blended learning can make learning more flexible, effective, and efficient in enhancing teaching and 4C skills.

Further integration of 4C skills through PjBL and blended learning in microteaching promises substantial improvements in learning quality. PjBL and blended learning support the development of these skills by providing relevant and challenging learning contexts, enabling prospective teachers to apply theory in actual practice. This approach not only equips them with effective teaching skills but also prepares them to be adaptive and responsive educators to the needs of 21st-century students (Kızıkan & Bektaş, 2017).

Preparing prospective biology teachers for effective and efficient teaching is a top institution priority. Previous research highlights the importance of innovation in teaching methods to educate prospective teachers (Nye et al., 2004; Cochran-smith & Villegas, 2015). (2015) emphasized that current teacher education programs do not fully equip

students with the 4C skills (critical thinking, creativity, communication, collaboration) essential for 21st-century learning. Stahl et al. (2018) also pointed out that traditional practices still dominate teacher education, and research focused on developing these skills is still limited.

Previous research has shown the effectiveness of microteaching in training basic teaching skills (Donnelly & Fitzmaurice, 2011). However, this method is still inadequate for facing 21st-century learning challenges. Moreover, research by Khafah & Suprpto (2023) demonstrated that PjBL could train critical thinking, creativity, collaboration, and communication skills. Astuti & Febrian (2019) also state that blended learning makes learning more effective and efficient and encourages students to be more creative and collaborative.

In this context, this research proposes integrating PjBL and blended learning in microteaching to address existing gaps. This PjBL model not only trains academic skills but also 4C skills, enhancing student participation and motivation to learn (Gómez-Pablos et al., 2017). Moreover, this integration aligns with implementing the MBKM curriculum, encouraging the use of PjBL and blended learning models, demonstrating the potential to enhance the effectiveness of microteaching. From the description provided, this research aims to develop a theoretical construct of a microteaching model-based on PjBL and blended learning to enhance the 4C skills of prospective biology teachers.

B. Material and method

This study is a development study that utilizes the ADDIE model. The ADDIE model consists of several stages: analysis, design, development, implementation, and evaluation (Branch, 2009; Rusdi, 2018). In the analysis stage, the existing problems in the field are identified. The steps taken in this stage include distributing questionnaires to students, lecturers, and biology teachers. A microteaching model product based on PjBL to train 4C skills is developed in the design stage. In the development stage, activities include implementing the product design previously designed in the design stage. This stage focuses on product production and validation. Steps taken include content creation, provision of the required logbook, preparation of the LMS, conducting revisions, product validation, individual trials, and small group trials. In the implementation stage, field testing (field trial) activities are conducted to see the effectiveness of the developed product in the learning process. The aim is to gather responses and feedback from students and lecturers of the microteaching course. In the evaluation stage, summative evaluation is conducted by applying pre-tests and post-tests. The experimental research design used is the one-group pretest-posttest design (Rusdi, 2018).

The research subjects include students of the biology education program who are currently taking the microteaching course. Biology education students in the microteaching course are in their fourth semester. The research subjects consist of 34 students. From 3 classes of fourth-semester students who took the microteaching course during the even semester of the academic year 2023/2024, class R002 was selected using a purposive sampling technique with the criteria as the class that has the lowest variance based on the results of the homogeneity test that has been conducted.

Data collection instruments include questionnaires, validation sheets, observation sheets, and documentation. Questionnaires gather data on the desired learning type for prospective biology teachers. Validation sheets collect feedback from validators on the developed product. Observation sheets gather data on the 4C skills of prospective biology teachers.

Data analysis techniques

The data analysis technique employed uses the t-test to observe differences in 4C skills before and after instruction using an integrated microteaching model with PjBL and blended learning. The data analysis techniques include (1) homogeneity test, (2) normality test, and (3) paired t-test.

Homogeneity test

This field trial was conducted during the even semester of the academic year 2023/2024 with prospective biology teachers in their fourth semester. Out of three fourth-semester classes that registered for the microteaching course during the even semester of the academic year 2023/2024, class R002 was selected using the purposive sampling technique. The criteria were the class with the lowest variance based on the homogeneity test results presented in Table 1.

Based on Table 1, which delineates the outcomes of the homogeneity test performed, it can be concluded that while variances differ among the three classes, no statistically significant variability exists between them according to the established significance threshold ($p > 0.05$). Class R002, exhibiting the lowest variance, was selected as the group with the most homogeneous conditions for field testing. This selection is corroborated by an analysis of variance, indicating a more consistent data distribution within this class.

Normality test

The Kolmogorov-Smirnov normality test was conducted on the residual data from the pre-test and post-test of the 4C skills of prospective biology teachers in the Biology Education program at Universitas Jambi who participated in the developed microteaching course based on PjBL and blended learning. The results of the normality test are detailed in Table 2. The normality test results using the

Kolmogorov-Smirnov test on four assessment aspects, namely Critical Thinking, Creativity, Communication, and Collaboration, indicate that all aspects conform to a normal distribution with Asymp. Sig. (2-tailed) values of 0.425, 0.744, 0.204, and 0.200, respectively (> 0.05). This indicates that the data for all these assessment aspects are uniformly distributed normally. Consequently, all aspects are eligible for further testing with the paired t-test, as they meet the normality assumption required for this test.

Paired t-test

The statistical test conducted was the paired t-test, adjusted according to the normal distribution of the data for each aspect. The results of the statistical test are presented in Table 3. The statistical test results

conducted on the four aspects of 4C skills—Critical Thinking, Creativity, Communication, and Collaboration—using the paired t-test method indicate a significant improvement in all these aspects following the implementation of the microteaching model-based on PjBL. With p-values for Critical Thinking ($T=-2.679$, $P=0.011$), Creativity ($T=-3.017$, $P=0.005$), Communication ($T=-2.597$, $P=0.014$), and Collaboration ($T=-9.048$, $P=0.000$), it is evident that the intervention was effective in enhancing the skills of prospective biology teachers. These results affirm the effectiveness of the microteaching model-based PjBL used, where this instructional method has been proven to significantly facilitate improvements in critical and creative competencies and the students' communicative and collaborative skills.

Table 1 Homogeneity test

Class	Numbers of students	Variance	Levene's test statistics	p-value	Conclusion
R001	39	24.56	2.45	0.087	Relatively high variance
R002	34	15.32	2.45	0.087	Lowest variance - Selected
R003	36	29.88	2.45	0.087	Relatively high variance

Table 2 Normality test

Aspect	p-value Kolmogorov-Smirnov normality test	Conclusion
Critical thinkings	0.425	Normal
Creativity	0.744	Normal
Communication	0.204	Normal
Collaboration	0.200	Normal

Table 3 Paired t-test results

Aspect	Test statistics (T/Wilcoxon)	Conclusion
Critical thinkings	$T= -2.679$, $P=0.011$	Significant
Creativity	$T=-3.017$, $P=0.005$	Significant
Communication	$T=-2.597$, $P=0.014$	Significant
Collaboration	$T=-9.048$, $P=0.000$	Significant

C. Results and discussion

Analysis stage

This study identifies an urgent need to enhance the 4C skills (Communication, Collaboration, Creativity, Critical Thinking) among prospective biology teachers. This finding supports prior research by Sagala et al. (2019), which highlighted that applying PjBL can effectively improve collaboration and communication skills. Collaboration and communication are essential in contemporary education, especially within the context of the Industrial Revolution 4.0.

The implementation of PjBL in this study shows positive results in enhancing the 4C skills of students. Çelik et al. (2018) state that projects within PjBL allow students to think critically, collaborate with team members, and encourage independent research. This aligns with research findings that show significant improvements in critical thinking, creativity, communication, and collaboration.

The study also indicates that the blended learning model can enhance learning effectiveness. According to Horn & Staker (2017), blended learning provides a robust foundation for developing the 4C skills. This research supports these findings by demonstrating that blended learning enables more flexible and extensive learning, supporting the mastery of the 4C skills among prospective biology teachers.

The results of this study suggest that the microteaching model-based on PjBL and blended learning can enhance the pedagogical competencies of prospective biology teachers. This complements studies by (Wakimoto et al., 2019); (Yun, 2022), which show the effectiveness of various microteaching models in enhancing teaching skills. This research adds evidence that the integration of PjBL and blended learning within microteaching is effective in training essential interpersonal and professional skills.

This research not only supports the findings of previous studies but also enriches the literature by adding empirical evidence on the effectiveness of the

microteaching model-based on PjBL and blended learning. For instance, Schweig et al. (2019) asserts that students collaborate to achieve common goals through group projects, combining each other's strengths and expertise. This research demonstrates that this approach is also effective in the microteaching context for prospective biology teachers.

This research strengthens the existing literature and adds new insights regarding applying a microteaching model-based on PjBL and blended learning in biology teacher education. The results affirm the importance of this learning approach in preparing holistic and competent prospective teachers, ready to face future educational challenges.

A needs analysis was conducted with 62 respondents: biology students, biology teachers, and lecturers who teach microteaching. Survey results from biology teachers revealed difficulties in teaching biology in the classroom by integrating the 4C skills (collaboration, communication, creativity, and critical thinking). This indicates that biology teachers must master these 4C skills to support their educator roles.

Based on a survey of 44 students from the Biology Education program who have completed microteaching, data indicated four primary deficiencies in the execution of microteaching. First, the lack of repeated practice (reported by 52% of respondents) underscores the need to increase the frequency and quality of training. Second, a lack of pedagogic understanding (29% of respondents) highlights the need for improved knowledge of teaching methods to be facilitated during microteaching sessions. Third, insufficient facilities and infrastructure (10% of respondents) confirm the necessity for adequate facilities. Fourth, a lack of content/material understanding (9% of respondents) signifies the importance of strengthening the grasp of biological material. The survey results show that "lack of repeated practice" has been a significant issue in microteaching sessions, underscoring an urgent need to facilitate and enhance the quality of microteaching lectures to overcome these barriers effectively.

Furthermore, challenges faced by biology students who have completed microteaching during their teaching practicum (PLP) in schools include collaboration, critical thinking, communication, and creativity. In the collaboration category, "Adjusting to student character differences" emerged as a dominant challenge, nearing a 96% difficulty level, followed by "Implementing collaboration with mentor teachers" and "Cooperating with a team during PLP," both exceeding 90%. For critical thinking, "Reflecting on every learning failure" reached a difficulty level of approximately 94%. In communication, "Effectively conveying thoughts and ideas" and "Communicating nonverbally in various forms" presented difficulty levels ranging from 80% to 88%. Lastly, in creativity,

"Presenting new ideas or concepts in learning" and "Integrating various inputs and feedback" recorded difficulty levels close to 90% and 94%, respectively. This emphasizes the importance of reinforcing 4C skills in the microteaching curriculum for prospective biology teachers to better prepare them for challenges in the field.

Based on a survey distributed to students who have not yet taken the microteaching course, answered by 177 respondents, there is a preference for PjBL and blended Learning. The respondents are students from the Biology Education program at the Faculty of Teacher Training and Education, Universitas Jambi. Data revealed that 155 students (87.32%) desire the microteaching course to be taught using the PjBL model. Furthermore, concerning the learning strategies students prefer for the microteaching course, 132 respondents (74%) indicated that microteaching should be implemented using blended learning strategies to provide broader and more flexible learning opportunities.

Based on the survey and analysis results, there is an urgent need to develop a more effective microteaching model for prospective biology teachers. The challenges faced by biology teachers during instruction and the difficulties encountered by students during their School Field Introduction (PLP) indicate that strengthening 4C skills (collaboration, critical thinking, communication, and creativity) is essential. These 4C skills form a crucial foundation in learning and teaching, especially in biology, which requires deep understanding and innovative teaching methods.

Additionally, the positive response from students towards implementing the PjBL and blended learning models shows excellent potential in enhancing the effectiveness of microteaching. As many as 87.32% of students favor the PjBL model, while another 74% prefer blended learning strategies. Both learning models can offer broader, more flexible learning opportunities and facilitate mastering 4C skills. According to Çelik et al. (2018), projects in PjBL allow students to engage in critical thinking, collaborate with teammates, and encourage them to conduct independent research and gather information. Furthermore, Khafah & Suprpto (2023) state that PjBL can help students develop critical thinking skills, communicate effectively, collaborate with teams, and adapt to changes. Horn & Staker (2017) add that blended learning provides a strong foundation for developing 4C skills as students can learn independently online and then collaborate in face-to-face interactions. Anderson (2008) also emphasizes that educators need to consider various factors, such as effective instructional design, appropriate technology, and adequate support to implement blended learning successfully.

Table 4 Analysis results of microteaching models from various literature

Component	TM	MLS	LCMT	MBIM	MMS	ETM	MRT	RTC	PBM	SBM	IM	MPB
Concept	✓	-	-	✓	✓	-	-	-	-	✓	✓	✓
Plan	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Teach	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observation	✓	-	✓	✓	✓	✓	✓	-	✓	✓	✓	✓
Reflection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Re-teach	✓	-	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Revision	-	-	-	✓	-	-	-	-	-	-	-	✓
Videotaping	-	-	✓	✓	-	-	-	-	-	-	-	✓
Evaluation	-	-	-	✓	-	-	-	-	-	✓	-	✓
Sinkronus	-	-	-	✓	-	-	-	-	-	-	-	✓
Asinkronus	-	-	-	-	-	-	-	-	-	-	-	✓
Review students	-	-	-	-	-	-	-	-	-	-	-	✓
Review teacher	-	-	-	-	-	-	-	-	-	-	-	✓
Project	-	-	-	-	-	-	-	-	-	-	-	✓
Media	-	-	-	✓	-	-	-	-	✓	-	-	✓
Skill teaching	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Skill 4 C	-	-	-	-	-	-	-	-	-	-	-	✓

Description:

TM : Traditional microteaching
MLS : Microteaching lesson study
LCMT: Learner-centered micro teaching
MBM : Internet and media based microteaching
MMS : Microteaching is based on medical science
ETM : Extended technique microteaching

MRT : Microteaching re-teach
RTC : Microteaching real time centered
PBM : Puppet-based microteaching
SBM : Studio-based microteaching
IM : Indonesian microteaching
MPB : Microteaching based on PjBL and blended learning

Therefore, developing a microteaching model-based on PjBL and blended learning represents a strategic step in preparing prospective biology teachers to face challenges in the education sector. This success not only underscores the importance of PjBL and blended learning models in teacher education but also highlights the potential of this microteaching model in training holistic and competent teachers, who are adept not only in academic knowledge but also in essential interpersonal and professional skills required for success in the teaching profession. The study by Sagala et al. (2019), focusing on applying PjBL to enhance collaboration and communication skills, emphasizes that PjBL can effectively elevate these skills to an intermediate level, underlining the importance of collaboration and communication in contemporary education, especially in the context of the Industrial Revolution 4.0. According to Çelik et al. (2018), projects in PjBL provide opportunities for students to think critically, collaborate with teammates, and encourage them to conduct independent research and gather information. Further, the OECD (2018) mentions that PjBL can help students develop critical thinking skills, communicate effectively, collaborate with teams, and adapt to changes. The implementation of PjBL in various countries demonstrates that this approach can enhance student motivation, conceptual understanding, and critical thinking skills (Raja & Abirami, 2022).

However, it is essential to note that the success of PjBL greatly depends on the project design, support from educators, and the available resources (Rehani & Mustofa, 2023). Through group projects, students

collaborate to achieve a common goal, combining their strengths and expertise for more optimal results (Schweig et al., 2019). Therefore, teachers must ensure ample opportunities for students to discuss, share ideas, and provide feedback to one another (Hudapoti & Fauzi, 2023).

Integrating a blended learning model can develop the 4C skills needed in the global economy (Horn & Staker, 2017). Blended learning provides a strong foundation for developing these skills, as students can learn independently online and then collaborate in face-to-face interactions. However, implementing blended learning is not straightforward. Terry Anderson, in "Theory and Practice of Online Learning", explains that educators need to consider various factors such as effective instructional design, appropriate technology, and adequate support (Anderson, 2008). Teachers need to be facilitators of learning, guiding students in the use of online resources and encouraging them to think critically (Garrison & Vaughan, 2008).

From various references, 11 models of microteaching have been identified worldwide (see Table 4). (1) The Lesson Study-Based Microteaching Model includes stages of planning, teaching, reflection, and revising the lesson plan (Fernández, 2005). (2) Learner-Centered Micro Teaching (LCMT) Model is a student-centered approach to microteaching (Kilic, 2010). (3) Internet and Multimedia-Based Microteaching Model involves using the internet and multimedia as tools and facilities for implementation (Jiugen et al., 2013). (4) Medical Faculty Microteaching Model is specifically for prospective medical teachers teaching at medical faculties (Remesh, 2013). (5)

Extended Technique-Based Microteaching is a model with a cycle; the process from teaching, critiquing, replanning, reteaching, and re-critiquing (Peker, 2009). (7) Traditional microteaching involves stages of planning (plan), teaching (teach), observation (observe/critique), replanning (re-plan), reteaching (re-teach), re-observation (re-observe/critique), and returning to planning (Onwuagboke et al., 2017). (8) Real Time Coaching (RTC) Microteaching Model involves stages of preparation, teaching, and feedback followed by authentic teaching in the actual classroom for prospective teachers (Stahl et al. 2018). (9) Microteaching Lesson Study (MLS) can enhance the teaching skills and collaborative abilities of prospective teachers, including plan, teaching, reflection, and revision (Zhou & Xu, 2017). (10) Japanese Doll-Based Microteaching includes: (1) ensuring learners' understanding in groups, (2) instructions for learners in groups, (3) one-on-one interactions about learners' understanding, (4) one-on-one interactions about class content, (5) one-on-one interactions about discipline (Wakimoto et al., 2019). (11) Studio-Based Microteaching involves: plan, implementation, decision changes, and evaluation (Yun, 2022).

Design stage

Formulating Learning Objectives: Based on the review of the analysis results conducted previously, the learning objectives designed for the microteaching model-based on PjBL and blended learning are to train the 4C skills (Communication, Collaboration,

Creativity, and Critical Thinking) with the construction of PjBL theory and blended learning theory.

Developing Assessment Instruments: Assessment instruments are designed and consist of questionnaires, validation sheets, observation sheets, and documentation. The questionnaire instrument collects data on the type of learning desired by prospective biology teachers. The validation sheet collects input and comments from validators on the developed product. The observation sheet is used to gather data on the 4C skills of prospective biology teachers. Indicators for measuring the 4C skills are adapted from Greenstein (2012). These 4C skill indicators are also integrated into each stage of the microteaching model developed based on PjBL and blended learning.

Developing Learning Strategies: The development of the microteaching model designed is an integrated microteaching model of PjBL and blended learning to enhance the 4C skills of prospective biology teachers with the stages: (1) Project orientation (synchronous), (2) Development of teaching modules (asynchronous), (3) Peer review (asynchronous), (4) Presentation of peer review results (synchronous), (5) Teaching practice one and peer review (asynchronous), (6) Presentation of teaching practice one results (synchronous), (7) Teaching practice two and peer review (asynchronous), (8) Presentation of teaching practice two results (synchronous), (9) Collection of video learning projects (synchronous), and (10) Assessment and evaluation of the project (synchronous).

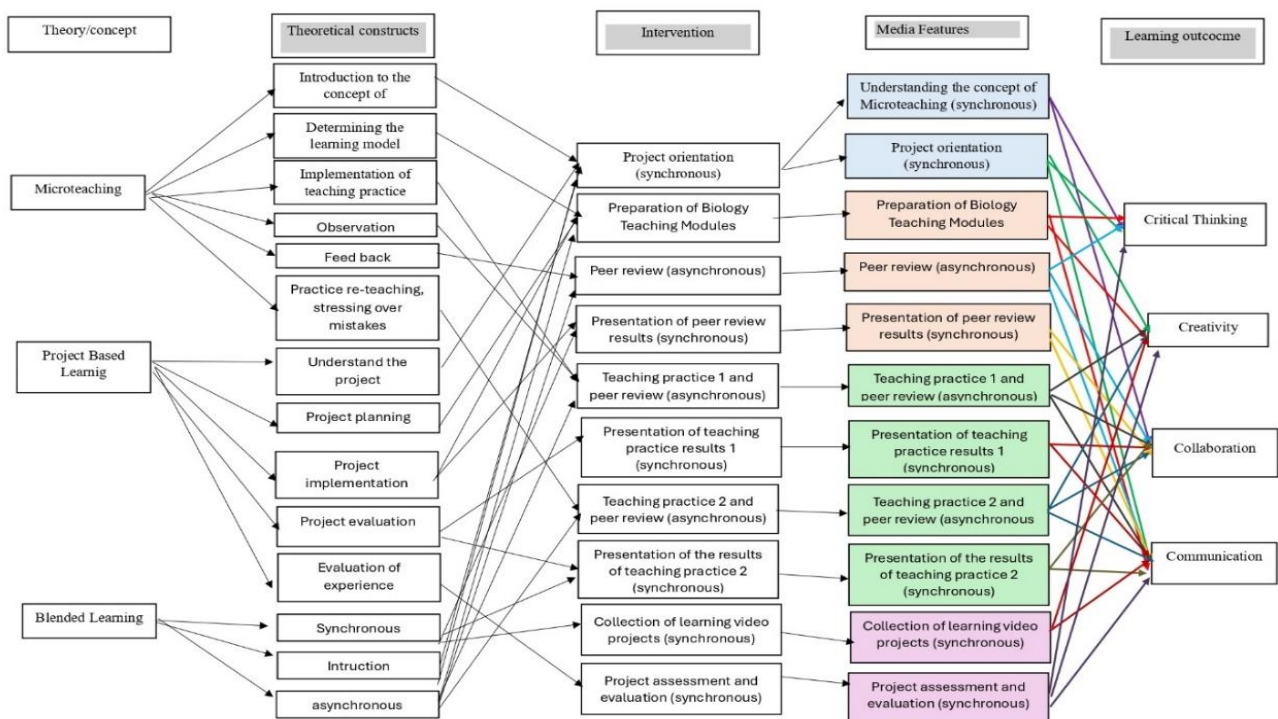


Figure 1 Theoretical construction of the microteaching model-based on PjBL and blended learning

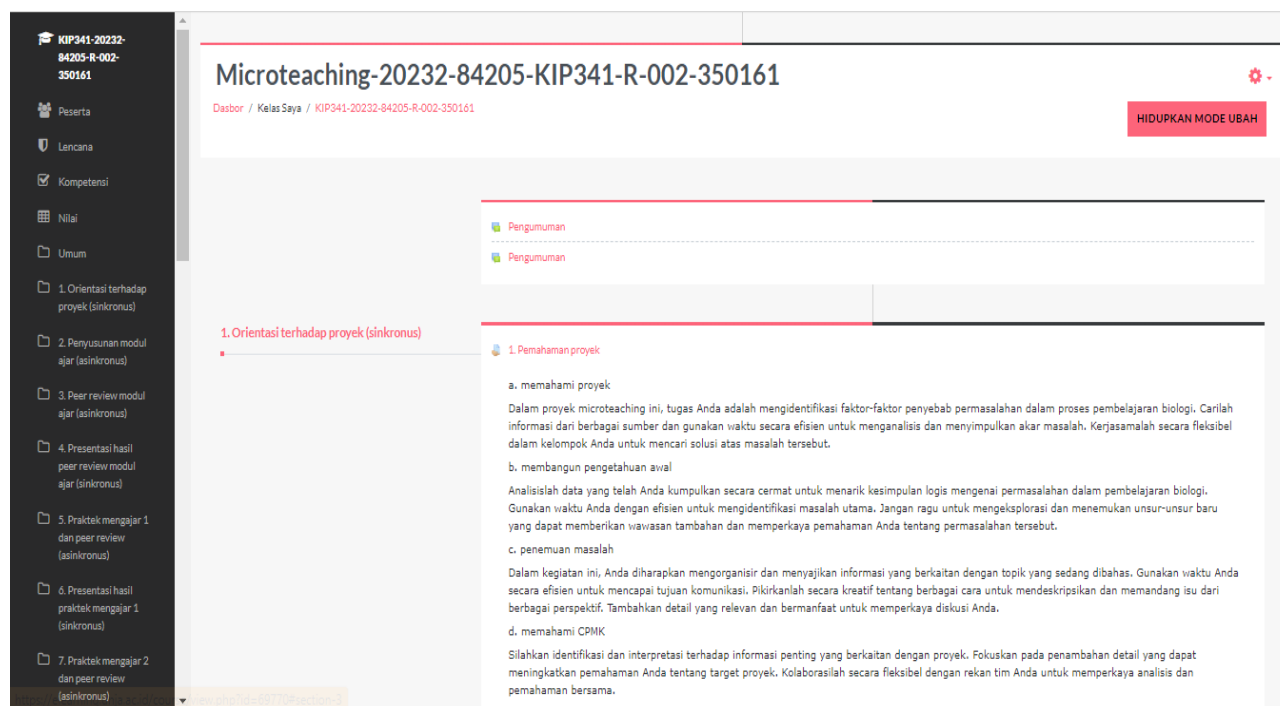


Figure 2 LMS microteaching course (in Indonesian)

This section describes the foundational theoretical constructs that support the integrated microteaching model of PjBL and blended learning to enhance the 4C skills of prospective biology teachers. Based on Figure 1, the theoretical construct of the microteaching model-based on PjBL and blended learning is structured by three theories: microteaching, PjBL, and blended learning. Each theory contributes a syntax, resulting in a new syntax that consists of orientation towards the project, development of biology teaching modules, peer review, presentation of peer review results, teaching practice 1, presentation of teaching practice 1, teaching practice 2, and presentation, project collection, and assessment. Subsequently, this syntax is translated into the Learning Management System (LMS) and logbook in the form of learning activities to achieve learning outcomes in the form of 4C skills.

Development stage

The microteaching model is developed by first arranging the details of each stage according to the design and applying it to the LMS (Learning Management System). A guidebook and project logbook are also compiled as tools for students to execute the project. The logbook is also structured according to the design, incorporating indicators of the 4C skills. The design of the LMS and logbook that have been developed can be seen in Figure 2.

Validation

Conceptual validation was carried out three times. Feedback included: supplement with a table showing the relationship between independent and dependent

variables. Ensure consistent naming of the independent variables throughout. Refer to them consistently as findings and novelty from the beginning to the end. Add indicators and descriptors of student activities, theoretical foundations, and the emergence of dependent variables. The indicators for the independent variables should include phases from the findings.

The media aspect of the development product was validated twice, with input and comments. The validator's suggestion is that the cover illustration should preferably use a photo or image of students engaged in microteaching activities, making it more relevant to the context and content of the logbook. An additional explanation in the title is needed, such as the Microteaching Project Logbook.

The validation of the development product from the aspect of biology materials was conducted using materials from the package for each group appearing in the teaching practice activities in the microteaching course. The biology materials include the digestive system, circulatory system, viruses, evolution, and ecosystems. Validator's feedback: the biology materials should be adjusted to the timing of the microteaching sessions and should ideally include examples and media images to clarify conceptual explanations.

Individual trial

The integrated microteaching model-based on PjBL and blended learning showed highly satisfactory results in communicating learning objectives, accessibility, understanding of PjBL, enhancement of communication skills (100%); supporting

collaborative learning, enhancing critical and analytical skills, effectiveness of assessment methods (93.3%); encouraging the search for applicable cases, active participation (86.7%); and was reasonably satisfactory in supporting the search for references (80%). These results indicate the need for improvements to enhance support that guides students in reference searching. These individual trial results also suggested that logbooks and LMS should include videos and articles that students can access directly. For video production projects, a more extended timeframe would be beneficial. Regarding difficulties and challenges in using the logbook and LMS, students clearly understood each stage.

Small group trial

A small group trial was conducted with six students after revisions based on the results and feedback from the individual trial. Respondents gave high scores in the small group trial of the integrated microteaching model using PjBL aimed at developing the 4C skills of prospective biology teachers. All main aspects, such as communication of learning objectives, logbook accessibility, understanding of PjBL concepts, encouragement towards searching for relevant cases or applications, course design for active participation, enhancement of communication skills, and support for collaborative learning, were rated with perfect scores of 100%. This reflects clarity of objectives, ease of use, and effectiveness of the assessment methods offered by the model. Only two aspects received slightly lower scores, namely, logbook support in finding sufficient references for the discussed material and the potential of this microteaching design to enhance communication skills, with scores of 93.33% still indicating a "Very Suitable" assessment. This evaluation indicates that the model is highly effective in supporting the development of essential skills for prospective biology teachers, with a few suggestions for improvement that could be a focus for further enhancement. The small group trial also produced feedback suggesting that example teaching modules that could be used in biology learning be provided. Suggestions for the logbook included adding the

student identification number (NIM). For contractual meeting times and project understanding, two meetings should ideally be held to allow more freedom in conducting research or interviews at schools. For initial activities, more references should be provided to prevent material misunderstandings.

Field trial

After carefully conducting individual and small group trials, the research process advanced to a more comprehensive test through the field trial. This stage is crucial in validating the effectiveness and practicality of the microteaching model integrated with PjBL aimed at developing the 4C skills of prospective biology teachers in real-world classroom settings. A pre-experimental design utilizing pre-tests and post-tests involving only one class was used to gain insights into the impact of the microteaching model integrated with PjBL on the 4C skills of students enrolled in this course.

This field trial was conducted during the even semester of the academic year 2023/2024 with prospective biology teachers in their fourth semester. Out of three fourth-semester classes that registered for the microteaching course during the even semester of the academic year 2023/2024, class R002 was selected using the purposive sampling technique, with the criteria being the class that has the lowest variance based on the results of the homogeneity test that has been conducted. The following data present the complete results of the homogeneity test that underpins the sample selection as the subject of the field trial, as shown in Table 5.

Through the results of the homogeneity test conducted, it can be concluded that although there are variances between the three classes, there are no statistically significant differences in variability among the classes based on the established significance threshold ($p > 0.05$). Class R002, with the lowest variance, was selected as the group with the best homogeneity conditions for field trial purposes. This decision is supported by an analysis of variance that shows this class has a more consistent data distribution.

Table 5 Homogeneity test results

Class	Number of students	Variance	Levene's test statistics	p-value	Conclusion
R001	39	24.56	2.45	0.087	Relatively high variance
R002	34	15.32	2.45	0.087	Lowest variance-Selected
R003	36	29.88	2.45	0.087	Relatively high variance

Table 6 Normality test results

Aspect	p-value	Conclusion
Critical Thinking	0.425	Normal
Creativity	0.744	Normal
Communication	0.204	Normal
Collaboration	0.200	Normal

Table 7 Statistical test (paired t-test)

Aspect	Test statistics (T/Wilcoxon)	Conclusion
Critical Thinking	T= -2.679, P=0.011	Significant
Creativity	T=-3.017, P=0.005	Significant
Communication	T=-2.597, P=0.014	Significant
Collaboration	T=-9.048, P=0.000	Significant

Table 8 Statistical test results (output)

		Paired samples test							
		Paired differences					t	df	Sig. (2-tailed)
		Mean	Std. deviation	Std. error mean	95% confidence interval of the difference				
					Lower	Upper			
Pair 1	Pretest_Critical Thinking & Posttest_Critical Thinking	-.34118	.74269	.12737	-.60031	-.08204	-2.679	33	.011
Pair 2	Pretest_Creativity & Posttest_Creativity	-.38206	.73850	.12665	-.63973	-.12438	-3.017	33	.005
Pair 3	Pretest_Communication & Posttest_Communication	-.33676	.75623	.12969	-.60063	-.07290	-2.597	33	.014
Pair 4	Pretest_Collaboration & Posttest_Collaboration	-.86941	.56030	.09609	-1.06491	-.67391	-9.048	33	.000

Subsequently, a field trial was conducted using a pre-experimental design with pre-and post-tests for class R002. The microteaching model integrated with PjBL was applied according to the revised design based on the results of previous trials. The field trial was conducted with structured steps. The process began with administering a pre-test to the students in class R002. The aim was to assess their initial abilities in Critical Thinking, Creativity, Communication, and Collaboration before applying the learning intervention.

Next, the microteaching model integrated with PjBL was implemented during the even semester of the academic year 2023/2024. In this phase, students were involved in projects designed to challenge and develop the 4C skills. The learning activities were designed to encourage exploration, innovation, and collaboration while providing opportunities for students to communicate and critique ideas constructively. After the learning model's implementation period, a post-test was conducted to measure the changes and developments in the students' 4C skills.

Data on the students' 4C skills were collected through a questionnaire designed based on recommendations (Greenstein, 2012). This questionnaire was crafted to measure critical thinking, creativity, communication, and collaboration aspects accurately, which were also used as the basis for developing this microteaching model-based PjBL. Indicators set as standards for each of the 4C skill aspects were also integrated into the instructions on the Learning Management System (LMS) during the execution of this field trial.

Subsequently, statistical analysis was conducted on the pre-test and post-test data obtained

from the field trial. The statistical tests provided a detailed overview of the impact of the microteaching model integrated with PjBL on the development of prospective biology teachers' 4C skills (Critical Thinking, Creativity, Communication, and Collaboration). This analysis was carried out through two main stages: normality testing and statistical testing.

The Kolmogorov-Smirnov normality test was conducted on the residual data from the pre-test and post-test of the 4C skills of prospective biology teachers in the Biology Education program at Universitas Jambi who participated in the developed microteaching course based on PjBL. The results of the normality test are detailed in Table 6.

The normality test results using the Kolmogorov-Smirnov test on four assessment aspects—Critical Thinking, Creativity, Communication, and Collaboration—indicate that all aspects follow a normal distribution with Asymp. Sig. (2-tailed) values of 0.425, 0.744, 0.204, and 0.200, respectively (> 0.05). This signifies that the data for all these assessment aspects conform to a normal distribution. Consequently, all aspects will be further tested using paired t-tests, as they meet the normality assumption required for this test.

The statistical tests conducted consist of paired t-tests, adjusted based on the normality distribution of each aspect's data. The results of the statistical tests are presented in the Tables 7 and 8. The statistical test results on the four aspects of 4C skills—Critical Thinking, Creativity, Communication, and Collaboration—using the paired t-test method showed significant improvements after implementing the microteaching model-based PjBL. With p-values for Critical Thinking ($T=-2.679$, $P=0.011$), Creativity ($T=-$

3.017, $P=0.005$), Communication ($T=-2.597$, $P=0.014$), and Collaboration ($T=-9.048$, $P=0.000$), it is evident that the intervention was effective in enhancing the skills of prospective biology teachers. These results affirm the effectiveness of the microteaching model-based PjBL used, where this learning method has proven to significantly facilitate improvements in critical and creative competencies, as well as communication and collaborative skills of the students. Implementing the microteaching model-based PjBL and blended learning enhanced the pedagogical competencies of prospective biology teachers, making them skilled in teaching, collaborating with teams, creatively developing media, critically analyzing learning, and communicating within teaching teams. Hopefully, these competencies will serve them well when they become actual teachers (in-service teachers).

Specifically, Critical Thinking, with a T-value of -2.679 and a P-value of 0.011, shows that students were able to develop the ability to analyze information critically and make evidence-based decisions post-participation in the program. This is crucial in the modern educational landscape, where teachers are expected to absorb information and evaluate, interpret, and apply it in dynamic and diverse teaching practices. Critical thinking encompasses the ability to analyze, evaluate, and create coherent and logical arguments, thus enabling individuals to solve complex problems and make efficient decisions. The development of critical thinking skills is essential for educational success and effective participation in a rapidly evolving global landscape, highlighting the importance of educational interventions designed to enhance these skills (Sutoyo et al., 2023).

Creativity, indicated by a T-value of -3.017 and a P-value of 0.005, emphasizes growth in students' abilities to think creatively and develop innovative ideas. This reflects the success of the PjBL model in triggering and nurturing the creative process, an essential aspect of effective teaching. The ability to present subject matter creatively enhances teaching and learning activities and stimulates students' interest and curiosity, which are vital aspects of creating an interactive and enjoyable learning environment. PjBL has been shown to significantly enhance creative thinking skills, particularly emphasizing innovative factors such as fluency and originality, which are crucial for fostering quick and effective responses to new situations. Additionally, this learning approach positively impacts self-directed learning, encouraging students to actively manage their learning processes, which is vital for academic achievement and adapting to diverse educational demands (Zakiah & Fajriadi, 2020).

Communication, with a T-value of -2.597 and a P-value of 0.014, indicates improved students' skills to convey ideas and information effectively. In the educational context, good communication skills are

essential for transmitting knowledge, providing constructive feedback, and building positive relationships between teachers and students. The PjBL model, emphasizing group discussions and presentations, provides a rich platform for students to practice and refine their verbal and non-verbal communication skills. The implementation of PjBL in this study fostered an innovative learning environment where learners could express creative ideas and communicate their thoughts and solutions effectively, meeting the demands of 21st-century education (Viorita et al., 2022).

The Collaboration aspect, showing the most significant increase ($T=-9.048$, $P=0.000$), highlights how the microteaching model-based PjBL effectively builds students' team collaboration abilities. Collaboration is an essential skill in the teaching profession, where teachers often need to work with colleagues, parents, and communities to support student learning. The significant growth in this aspect indicates that through participation in joint projects, students learn to share responsibilities, listen actively, and appreciate the contributions of others, while collectively achieving set goals. Studies by Sagala et al. (2019) focusing on the implementation of PjBL to enhance collaboration and communication skills emphasize that PjBL can effectively improve these skills to an intermediate level, underscoring the importance of collaboration and communication in contemporary education, particularly in the context of the Industrial Revolution 4.0. Collaboration is working effectively and respectfully in diverse teams to achieve common goals, emphasizing shared responsibility. On the other hand, communication is described as the ability to articulate thoughts and ideas clearly and effectively through verbal, written, and non-verbal means in various forms and contexts.

Overall, the results of this analysis confirm that the microteaching model-based PjBL successfully enhanced the 4C skills of prospective biology teachers. This success demonstrates the importance of implementing PjBL approaches in teacher education. It highlights the potential of this microteaching model in training holistic, competent teachers who are not only academically knowledgeable but also skilled in essential interpersonal and professional skills required for success in the teaching profession.

D. Conclusion

From the results of this development, it can be concluded that implementing the microteaching model-based PjBL integrated with 4C skills for prospective biology teachers is highly feasible in one-on-one tests and small group trials. Furthermore, the field trial confirms that this 4C integrated microteaching model-based PjBL is effective in enhancing the 4C skills of prospective biology teachers. This research strengthens the existing literature and adds new insights regarding implementing the

microteaching model-based PjBL and blended learning in biology teacher education. The results affirm the importance of this learning approach in preparing holistic and competent future teachers, ready to face the challenges of future education.

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