

DEVELOPING FLIPPED CLASSROOM BASED ON PROJECT-BASED LEARNING AND ETHNOSCIENCE FOR PRE-SERVICE TEACHERS

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Abstract

The study aims to develop and validate a flipped classroom instructional design based on Project-Based Learning (PjBL) and ethnoscience for pre-service teachers. The study was a research and development. It used the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The subjects include two expert, namely a content and an instructional media expert. The instruments used consist of interview guidelines, observation sheets, diagnostic tests, and validation sheets to assess the instructional design. Qualitative data were analyzed descriptively, while quantitative data were analyzed using descriptive statistics. The study resulted in a flipped classroom instructional design integrating PjBL and ethnoscience for prospective teachers. The product specifications include lesson plans, worksheets, teaching materials, and a Learning Management System (LMS). The flipped classroom instructional design based on Project-Based Learning (PjBL) and ethnoscience was deemed valid feasible for implementation in teaching and learning activities.

Keywords: *flipped classroom, project-based learning (PjBL), ethnoscience*

Abstrak

Penelitian ini bertujuan untuk mengembangkan dan memvalidasi desain pembelajaran flipped classroom berbasis Project-Based Learning (PjBL) dan etnosains untuk mahasiswa calon guru. Penelitian & pengembangan ini menggunakan model ADDIE (Analysis, Design, Development, Implementation, and Evaluation). Subjek penelitian meliputi dua validator yaitu ahli konten dan ahli media pembelajaran. Instrumen penelitian yang digunakan pedoman wawancara, lembar observasi, tes diagnostik, dan lembar validasi untuk menilai desain pembelajaran. Data kualitatif dianalisis secara deskriptif, data kuantitatif dianalisis menggunakan statistik deskriptif. Penelitian ini menghasilkan desain pembelajaran flipped classroom berbasis PjBL dan etnosains untuk mahasiswa calon guru. Spesifikasi produk meliputi rencana pelajaran, lembar kerja, bahan ajar, dan Learning Management System (LMS). Desain pembelajaran flipped classroom berbasis desain PjBL dan etnosains dinyatakan valid dan layak untuk diimplementasikan dalam pembelajaran.

Kata Kunci: *flipped classroom, pembelajaran berbasis proyek, etnosains*

Submitted: 2025-05-05; Accepted: 2025-05-26; Published: 2025-06-01

INTRODUCTION

Higher education institutions encounter challenges in adapting the Industrial Revolution 4.0. to ensure that graduates remain competitive in the global job market. Universities must provide students with 21st century competencies that align with

industry demands. 21st century competencies integrate cognitive skills including knowledge acquisition, critical thinking, creativity, innovation, interpersonal and intrapersonal competencies, shaping individuals into well-rounded professionals (Elçiçek and Erdemci, 2021). Interpersonal competencies encompass communication, collaboration, and responsibility, while intrapersonal competencies include flexibility, initiative, and metacognition (Shum and Crick, 2016). Among these essential competencies, the critical thinking, creativity, collaboration, and communication are crucial for students to succeed in the workforce and compete in the global market. Therefore, higher education institutions must prioritize the development of these skills through their curricula and instructional strategies.

In several universities in Indonesia, the implementation of blended learning has not yet effectively encouraged students to engage in active learning and develop 4C skills critical thinking, creativity, collaboration, and communication (Fauzi and Khusuma, 2020; Kusuma and Hamidah, 2021). Currently, instructional materials and assignments provided by lecturers primarily consist of handouts, practice questions, or written papers, which do not sufficiently stimulate higher-order thinking skills. During face-to-face sessions, lectures remain lecture-centered, with instructors dominating presentations, resulting in limited student engagement (Mulyati, 2021). Student participation in discussions is minimal, with only a small fraction of students expressing their opinions. Similarly, in group assignments, not all members contribute equally (Wulandari et al., 2020). Moreover, pre-service teachers' critical and creative thinking skills remain low. Student projects often involve mere repetition or duplication of existing work, rather than demonstrating modification or innovation (Siregar and Siagian, 2022). Given these challenges, innovative learning strategies are needed to foster the development of 4C competencies among students (Putra and Wahyuni, 2019).

One proposed solution to address these challenges is the integration of the flipped classroom model with Project-Based Learning (PjBL) and ethnoscience. The flipped classroom combines online and face-to-face learning, where students engage in pre-class online learning before attending in-person sessions (Julia et al., 2020). In this model, instructors provide learning materials and project-based assignments for students to complete before face-to-face sessions (Goedhart et al., 2019). During in-person meetings, students exchange ideas and discuss the assigned topics and projects (Magaña et al. 2020). The instructor then validates students' findings and reinforces key concept (Fung et al., 2021). The project-based tasks assigned during the online phase encourage students to develop critical and creative thinking skills in solving real-world problems. Thus, the flipped classroom approach is well-suited for integration with Project-Based Learning (PjBL) to enhance student engagement and competency development.

Project-Based Learning (PjBL) is an instructional model that guides students in constructing knowledge through projects assigned by instructors. The primary goal of PjBL is to develop problem-solving skills, creative and critical thinking, collaboration, and communication abilities (Nakada et al., 2018). The study by Aminuddin and Fauziah (2024) found that the implementation of the Project-Based Learning (PjBL) model effectively enhanced senior high school students' scientific communication skills on alternative energy topics. Students became more active in expressing ideas, demonstrated a deeper understanding of concepts, and improved their ability to collaborate and engage in scientific discussions. PjBL also increased students' motivation and engagement in the learning process. The PjBL process begins with a challenging question or real-world problem that students address through a project. It

involves project planning, scheduling, project execution, monitoring, product assessment, and process evaluation (MacLeod and Veen, 2020). The integration of the flipped classroom with PjBL enables students to become more engaged in independent learning through project-based activities, fostering creativity and motivation (Rahardjanto et al., 2019). Furthermore, PjBL is recommended to be applied to authentic, real-life problems relevant to students' daily experiences (Safaruddin et al., 2020). Therefore, PjBL can be further enhanced by integrating ethnoscience, allowing students to explore scientific concepts within the context of local wisdom and cultural knowledge.

Ethnoscience refers to indigenous knowledge possessed by specific communities and transmitted across generations (Stewart, 2015). It is a conceptual framework that integrates culture and local wisdom with scientific principles, forming an inseparable entity (Abonyi et al., 2014). Ethnoscience serves as a bridge between traditional cultural knowledge and scientific concepts, thereby enhancing the meaningfulness and contextual relevance of learning experiences (Sudarmin et al., 2018). Culturally and environmentally responsive science education fosters students' ability to comprehend real-world issues within their communities (Okwara and Upu, 2017). The integration of scientific knowledge with local wisdom enhances contextual learning and cultivates students' critical thinking skills (Fitriani and Setiawan, 2018; Qolbi et al., 2016). Empirical studies indicate that the implementation of ethnoscience-based instruction significantly improves academic achievement, enhances critical thinking abilities, and fosters an entrepreneurial mindset among students (Sudarmin et al., 2017) (Sudarmin et al., 2017). Moreover, ethnoscience-based instructional videos have been demonstrated to effectively strengthen students' critical thinking skills (Khusniati et al., 2017). The integration of these local values is considered capable of enhancing the contextualization of science learning, strengthening students' cultural identity, and promoting their engagement in the learning process (Warliani et al., 2024).

The flipped classroom based on Project-Based Learning (PjBL) and ethnoscience is designed by incorporating real-life phenomena and local wisdom as the contextual problems to be solved. The instructional steps of this model include the following: Before face-to-face sessions, students access the Moodle LMS to study learning materials and worksheets containing problems to be collaboratively solved. The problems provided are closely related to ethnoscience or local wisdom. Students design their projects, create schedules, conduct direct observations or video analysis, explore reference sources, and/or perform experiments at home while analyzing the findings of their investigations or experiments (Reyna, 2015). During face-to-face sessions, students present their project outcomes in class discussions, exchange ideas, and receive confirmation, conceptual reinforcement, and feedback from the instructor (Villalba and Laborda, 2019). After face-to-face sessions, the instructor guides students in evaluating and reflecting on their learning experiences regarding the topic studied (Santos and Serpa, 2020). The flipped classroom based on Project-Based Learning (PjBL) and ethnoscience is expected to enhance students' 4C skills (critical thinking, creativity, collaboration, and communication) and support the *Merdeka Belajar* (Independent Learning) program. This instructional design represents an innovative approach relevant to the post-pandemic educational landscape. The objectives of this study are to develop and validate the instructional design of the flipped classroom based on Project-Based Learning (PjBL) and ethnoscience to enhance 21st century skills.

METHODS

This study employs a research and development (R&D) approach using the ADDIE model. The development procedure consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). The research flowchart is illustrated in Figure 1. The subjects of this study consist of validators/experts who will evaluate the flipped classroom learning design based on PjBL and ethnoscience. The validators include two experts: subject matter and instructional media. The small group trial subjects are first semester students from the Physics Education program at UIN Sulthan Thaha Saifuddin Jambi, enrolled in the Basic Physics course for the 2023/2024 academic year. The total number of trial participants is 10 students.

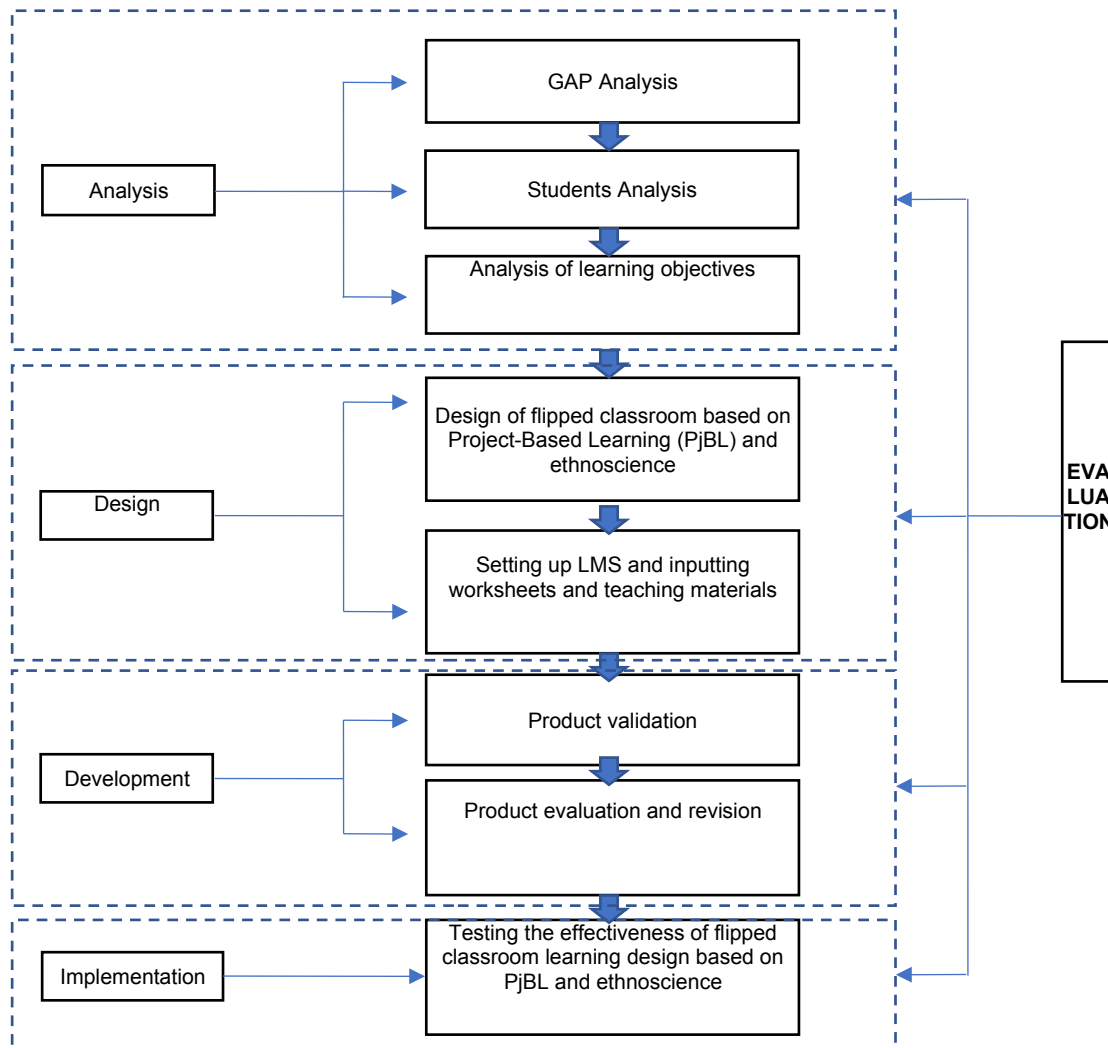


Figure 1. Research Procedure

Research Instruments: A validation sheet is used to assess the flipped classroom learning model based on PjBL and ethnoscience. This validation sheet employs a four-point Likert scale. It consists of two components: material Validation and Instructional Media Validation. The assessed aspects include content/material, construction and presentation, and language.

Data Analysis Techniques: Qualitative data analysis is conducted descriptively using Miles & Huberman's interactive model (Baltacı, 2017). The analysis process includes data collection, data reduction, data presentation, data analysis, and conclusion drawing. Qualitative data are obtained from needs analysis, material analysis, student analysis, and feedback from validators.

RESULTS AND DISCUSSION

Gap Analysis in Physics Education

Gap analysis was conducted to identify issues in physics learning through interviews with lecturers and students. The findings reveal several challenges in physics education:

1. **Blended Learning Implementation**

Since early 2023, learning has been conducted face-to-face, but lecturers are allowed to implement blended learning (a combination of online and face-to-face learning). The most commonly used online learning methods include virtual meetings via Zoom or Google Meet. However, lecturers do not utilize the *Spido/ Shuta* LMS of UIN Sulthan Thaha Saifuddin Jambi due to frequent system/server downtime, making it inaccessible. The current implementation of blended learning has not effectively encouraged students to actively develop 4C skills. Learning materials and assignments provided by lecturers are limited to handouts, papers, or practice questions. The flipped classroom model has not yet been applied.

2. **Limited Implementation of Project-Based Learning (PjBL)**

Project-based learning is rarely applied in basic physics courses. Common instructional models used by lecturers include problem-based learning, inquiry-based learning, discovery learning, and expository teaching.

3. **Lack of Integration with Local Wisdom (Ethnoscience)**

Physics instruction has been linked to real-life phenomena but has not been specifically integrated with *ethnoscience* or local wisdom from Jambi.

4. **Absence of a Flipped Classroom Design Integrating PjBL and Ethnoscience**

There is no existing instructional design that combines the flipped classroom approach with project-based learning (PjBL) and ethnoscience.

Student Analysis

Student analysis was conducted to determine student characteristics related to critical thinking, creativity, collaboration, and communication skills. The analysis was carried out using diagnostic tests and observations.

1. The diagnostic test results show that the average critical thinking skill score is 57, while the average creative thinking skill score is 54.
2. Students struggle to explain the application of physics concepts related to ethnoscience or local wisdom, such as batik-making, lemang cooking, the betangas tradition, brick-making, boat movement, fish traps (tangkul ikan), and traditional house stairs.
3. Observations indicate that 78% of students have good collaboration skills, while 75% have good communication skills.

Critical thinking, creativity, collaboration, and communication skills can be developed through project-based learning, which involves students in problem-solving through

exploration, investigation, and experimentation. Project tasks should be related to real-life phenomena or local wisdom. Group-based project learning helps students express ideas and collaborate effectively to complete tasks.

Learning Objectives Analysis

At this stage, an analysis of the learning outcomes for the Basic Physics course is conducted. This course is a compulsory subject in the Tadris Biology program, supporting the development of biological education knowledge with a credit load of 3 credits. The learning outcomes for the Basic Physics course are as follows.

Table 2. The learning outcomes for the Basic Physics course

Aspect	Learning Outcomes
Attitude	Demonstrate a responsible attitude towards work in his/her field of expertise independently
Knowledge	1. Mastering the physics concepts of quantity, units, measurement, vectors, particle kinematics, particle dynamics, work and energy, impulse and momentum, fluids, temperature and heat, vibrations and waves, sound, light, optical instruments, electricity and magnetic fields. 2. Being able to apply physics concepts in solving problems related to phenomena in everyday life or local wisdom/ethnoscience.
Skills	1. Able to apply logical, critical, systematic, and creative thinking in solving physics problems. 2. Able to communicate ideas/concepts verbally/in writing according to scientific ethics. 3. Able to work together/collaborate in groups to complete the work given

This research is limited to the material of work and energy, impulse and momentum, fluid, temperature and heat. The formulation of learning objectives is shown in table 3.

Tabel 3. The learning objectives

No	Topic	Learning Objectives
1	Work & Energy	1. Students are able to explain the concept of work, energy, the law of conservation of energy, and power. 2. Students are able to explain the application of the concept of work and energy in everyday life and local wisdom.
2	Impuls & momentum	1. Students are able to explain the concept of impulse and momentum 2. Students are able to explain the application of the concept of impulse and momentum in everyday life and local wisdom.
3	Fluid	1. Students are able to explain the concept of hydrostatic pressure, Pascal's law,

		Archimedes' law, surface tension.
	2.	Students are able to explain the concept of fluid discharge, continuity equation, and Bernoulli's law.
	3.	Students are able to explain the application of fluid concepts in everyday life and local wisdom.
4	Temperature & heat	1. Students are able to explain the concepts of temperature, expansion, heat, and heat transfer. 2. Students are able to explain the application of the concepts of temperature and heat in everyday life and local wisdom.

The next stage is conducting an analysis of Jambi's local wisdom to be integrated into the learning process. This analysis is carried out by identifying aspects of Jambi's local wisdom that can be linked to the topics of work and energy, impulse and momentum, fluids, temperature, and heat. The result of this analysis is a mapping of Jambi's local wisdom, as shown in Table 4.

Table 4. Mapping of Jambi local wisdom

No	Topic	Jambi local wisdom
1	Work & Energy	1. Traditional Boat 2. Cart/lorry 3. Tangkul 4. Traditional Kajang Lako House 5. Traditional Waterwheel
2	Impuls & momentum	1. Traditional boat racing 2. Marbles 3. Bekel balls/shell balls 4. Bamboo guns
3	Fluid	1. Traditional Boat 2. Batik waxing process 3. Tradition of Catching Fish with Lukah 4. Lampion Festival
4	Temperature & heat	1. Blacksmith 2. Betangas 3. Bamboo leman 4. Batik making

Flipped Classroom Design Based on PjBL and Ethnoscience

The flipped classroom design based on Project-Based Learning (PjBL) and ethnoscience consists of a Lesson Plan, Worksheets, Teaching Materials, and a Learning Management System (LMS). The lesson plan is developed based on the learning outcomes and objectives of Basic Physics. After designing the lesson plan, the next step is to develop the conceptual framework for the flipped classroom learning scenario integrated with PjBL and ethnoscience. This learning approach combines the

steps of flipped classroom, PjBL, and ethnoscience. The steps of the flipped classroom based on PjBL and ethnoscience are as follows:

1. Before face-to-face sessions, students access the LMS to study learning materials and worksheets containing problems to be solved collaboratively. The given problems are closely related to ethnoscience/local wisdom. Students design projects, create schedules, conduct direct observations or watch videos, explore reference sources, and/or conduct experiments at home while analyzing their investigation or experiment results. Students access the LMS Classroom to study the materials and project assignments in the worksheet (PjBL Syntax 1). The given problems are closely related to ethnoscience/local wisdom (Ethnoscience Integration). Students collaboratively design a project and create a schedule. The project plan and schedule are then uploaded to the Classroom (PjBL Syntax 2). Students carry out the project according to the established plan and schedule (PjBL Syntax 3). Students prepare a report and upload it to the Classroom.
2. Face-to-face sessions, students present their project findings in class and exchange ideas, while the lecturer provides confirmation, concept reinforcement, and feedback. Students present their projects classically and exchange ideas (PjBL Syntax 4). The lecturer provides confirmation, concept reinforcement, and feedback. The lecturer guides students in conducting evaluation and reflection (PjBL Syntax 5).
3. After face-to-face sessions, the lecturer guides students in evaluating and reflecting on the learning topics.

This learning scenario is supplemented with teaching materials in the form of PowerPoint slides, videos on Jambi's local wisdom, and worksheets. The teaching materials and worksheets are developed for four topics: work and energy, impulse and momentum, fluids, and heat and temperature. At this stage, the LMS is designed, and the worksheets and teaching materials are uploaded. The assignment menu layout in the classroom follows the PjBL syntax, consisting of materials, problem/project tasks, project planning and scheduling, project monitoring, project presentation, and project evaluation (MacLeod and Veen, 2020).

Validation Results

At the development stage, product validation was conducted. The flipped classroom learning design based on PjBL and ethnoscience was validated by subject matter experts and media experts. The assessment and suggestions from the validators served as the basis for revising the product to ensure a feasible and effective learning design. Three aspects were evaluated by the experts: content/material, construction, and language. The validation results of the flipped classroom learning design based on PjBL and ethnoscience are presented as follows.

Table 5. The validation results

Aspect	Score	Category
Content	3,70	Very Good
Construction	3,80	Very Good
Language	3,85	Very Good

Based on the validation results of the flipped classroom design based on PjBL and ethnoscience in Table 5, the product is deemed valid and feasible, falling into the excellent category. This instructional design product can be tested in the field to determine its effectiveness in enhancing 4C skills (critical thinking, creativity, collaboration, and communication).

These research findings align with those of (Sumarni and Kadarwati, 2020), who investigated project-based learning integrated with Ethno-STEM. Their pre-experimental study applied Ethno-STEM project-based learning to 230 high school students in Central Java, revealing a significant impact on critical and creative thinking skills. Similarly, (Sudarmin et al., 2019) explored the implementation of a project-based learning model integrated with Ethno-STEM at Universitas Negeri Semarang (Unnes), demonstrating its success in enhancing students' entrepreneurial character. The fundamental difference in this study lies in its combination of flipped classroom, PjBL, and ethnoscience, without incorporating STEM elements. This research follows a research and development (R&D) approach, resulting in a learning design product for flipped classroom-based PjBL with an ethnoscience perspective. The dependent variables examined include 4C skills (creativity, critical thinking, collaboration, and communication), whereas previous studies focused on critical thinking, creativity, and entrepreneurial character.

Ariyatun conducted a study on project-based and ethnoscience-based chemistry learning in 11th-grade high school students (Ariyatun et al., 2020). Their quantitative descriptive research indicated that project-based learning and ethnoscience improve scientific literacy. Similarly, Sholahuddin analyzed the impact of project-based learning using ethnoscience resources related to traditional Banjar cuisine on students' scientific literacy. This study employed a Pre-test-Post-test Nonequivalent Control Group Design, involving 68 high school students divided into two groups. The experimental group underwent project-based learning, while the control group received expository instruction. The findings concluded that students in the experimental group exhibited higher scientific literacy than those in the control group (Sholahuddin et al., 2021).

CONCLUSION

This study developed a flipped classroom learning design incorporating Project-Based Learning (PjBL) and ethnoscience. The instructional design includes lesson plans, worksheets, teaching materials, and a Learning Management System (LMS). The flipped classroom learning process based on PjBL and ethnoscience consists of the following stages: 1) Pre-class phase: Before face-to-face meetings, students access the LMS to study instructional materials and worksheets containing problem-based tasks to be solved collaboratively. These problems are closely related to ethnoscience and local wisdom. Students engage in project planning, scheduling, direct observation or video analysis, reference exploration, and/or home-based experimentation, followed by data analysis and synthesis. 2) In-class phase: During face-to-face sessions, students communicate their project findings in a classical setting, exchange ideas, and receive lecturer confirmation, conceptual reinforcement, and feedback. 3) Post-class phase: After the face-to-face session, the lecturer guides students in evaluating and reflecting on the topic studied. Expert validation results confirm that the flipped classroom learning design based on PjBL and ethnoscience is valid and feasible for implementation. Recommendation: Future research should explore the implementation of flipped classroom learning design based on PjBL and ethnoscience to improve 21st century skills. Furthermore, integrate the flipped classroom model with other models,

such as Inquiry-Based Learning, Problem-Based Learning, Discovery Learning, 5E Learning Cycle, or other teaching models. In addition, teachers and lecturers are encouraged to implement this model in various subjects and learning contexts by following the structured steps of the flipped classroom approach integrated with PjBL and ethnoscience developed in this study.

ACKNOWLEDGMENT

The author would like to thank the Institute for Research and Community Service (LPPM) UIN Sulthan Thaha Saifuddin Jambi for funding this research according to the 2023 fiscal year research contract Number: B-1737/UN.15/PPK/KU.01/6/2023

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