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Developing a Local Culture-Based Microlearning Strategy to Improve University Students' Conceptual Understanding and Problem-Solving Ability in Mathematics

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Abstract

This study aims to develop a Local Culture-Based Microlearning Strategy to enhance university students' conceptual understanding and problem-solving ability in mathematics. Although microlearning has been widely recognized as an effective digital learning innovation, there remains a research gap in contextualizing this approach within local cultural frameworks to improve mathematical understanding at the higher education level. Grounded in constructivist and contextual learning theories, this study adopts a Research and Development (R&D) method using Thiagarajan's 4D model (Define, Design, Develop, and Disseminate). The study involved 40 first-semester students of the Primary School Teacher Education Program (PGSD) at STKIP Yapis Dompu. The developed microlearning videos integrated Dompu's local cultural elements to connect abstract mathematical concepts with students' lived experiences. Data were analyzed through expert validation, student response questionnaires, and pretest–posttest comparisons using Normalized Gain (N-Gain) statistics. The expert validation yielded a mean score of 90.13%, categorized as Highly Valid, while student responses averaged 98.5% (Very Positive). The N-Gain analysis showed an average score of 0.7, indicating a moderate improvement in conceptual understanding and problem-solving ability. Theoretically, the findings demonstrate that embedding local culture within microlearning not only strengthens conceptual comprehension through contextual learning but also enhances cognitive engagement in mathematics. This study contributes to digital pedagogy by providing empirical evidence that culturally contextualized microlearning serves as an effective and feasible strategy for mathematics education in higher education.

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Keywords:*Instructional Strategy; Microlearning Videos; Local Culture-Based Learning; Conceptual Understanding; Problem-Solving Skills*

1. Introduction

The integration of technology in the digital era has become not merely an option but a fundamental necessity for students, including those enrolled in Primary School Teacher Education (PGSD) programs. The utilization of digital media, such as instructional videos, has been shown not only to enhance the effectiveness of learning but also to cultivate students' confidence in engaging with technology (Popoola & Adedokun, 2023). Nevertheless, persistent challenges remain, particularly with regard to students' limited comprehension of essential mathematical concepts—such as the real number system and set theory—which consequently undermines the effectiveness of subsequent instructional interactions. A pedagogical approach that integrates local cultural values is firmly anchored in the theoretical foundations of constructivism and contextual learning. Constructivist perspectives emphasize that students achieve deeper understanding when they are able to relate new concepts to their

prior experiences, situating subject matter within familiar cultural practices, thereby rendering learning more meaningful, relevant, and enduring (Mania & Alam, 2021). This underscores the pedagogical significance of adopting a local culture-based learning approach, as it offers the potential to bridge abstract theoretical knowledge with students' lived experiences, ensuring that learning is not only cognitively accessible but also socially and culturally embedded. Such an approach, therefore, is indispensable in fostering relevance, integration, and sustainability within the everyday educational practices of students (Ikeda & Binarkaheni, 2024).

This condition underscores the need for strategic interventions in the learning process to bridge the gap in students' prior abilities, particularly through the adoption of innovative learning approaches. Learning Management Systems (LMS) are designed as macro-level learning platforms (e-learning) that can be integrated with multimedia tools to enhance the overall learning experience (Ghasia & Rutatola, 2021). In this context, microlearning emerges as both an innovation and an effective solution within digital education (Kaklij et al., 2019). Microlearning not only enables students to gradually comprehend fundamental concepts but also improves time efficiency for lecturers in delivering instruction. Furthermore, the enhancement of students' abilities through targeted training supports the development of self-directed and confident learners in technology-based learning environments (Chibisa et al., 2021). Conversely, students' limited ability to operate computers may negatively affect their academic performance (Katsarou, 2021). One of the distinctive advantages of microlearning lies in its flexibility, as learning materials can be accessed anytime and anywhere, thereby meeting the diverse needs of students (Shabrina et al., 2024). With its short duration—typically less than 10 minutes—microlearning emphasizes the essence of information delivery, allowing students to concentrate more deeply on a specific topic and its problem-solving aspects (Alias & Razak, 2023). Moreover, problem-solving is rendered more effective when contextualized within local cultural frameworks (Pujiarti et al., 2023). Finally, it must be emphasized that conceptual understanding serves as the foundation for developing the ability to solve mathematical problems (Pujiarti, 2024).

Many students, especially those from non-mathematics backgrounds, often exhibit limited conceptual understanding and weak problem-solving skills in mathematics. They tend to depend on rote memorization rather than meaningful comprehension, which hinders their ability to apply concepts to unfamiliar or real-life problems. This condition reveals a gap between expected mathematical competency and the actual learning outcomes produced by current instructional practices. Therefore, this study seeks to develop an instructional strategy that directly addresses these deficiencies by fostering deeper conceptual understanding and more effective problem-solving abilities, thereby providing an evidence-based solution to improve mathematics learning quality.

The microlearning approach has gained increasing attention through the use of short videos, infographics, and other digital media that enhance accessibility and self-directed learning while overcoming the limitations of traditional long-duration instruction. Theoretically, microlearning is grounded in constructivist and self-regulated learning theories, emphasizing that students actively construct knowledge when learning experiences are meaningful, contextual, and culturally relevant. Integrating *Dompu's local culture* within microlearning represents not only an innovative pedagogical response but also an academic realization of contextual learning theory, which bridges abstract mathematical concepts with students' real-life experiences. This integration aligns with Asta Cita 4, which prioritizes the development of high-quality human resources through educational innovation, and Asta Cita 8, which promotes cultural harmony and identity preservation. Thus, the national agenda provides a contextual foundation that strengthens the academic rationale for developing a *local culture-based microlearning strategy* aimed at improving students' conceptual understanding and problem-solving skills through valid, practical, and effective digital pedagogy. A

similar opinion states that the discrepancy occurs because the use of interactive media is not optimal in improving problem-solving skills. (Choirudin et al., 2025)

2. Method

The research method employed in this study is Research and Development (R&D). Among the various development models within R&D, this study adopted the 4D development model, which consists of four stages: Define, Design, Develop, and Disseminate (Widodo, 2017). The 4D model was selected because it provides a systematic and iterative framework suitable for developing validated instructional products. Each stage—Define, Design, Develop, and Disseminate—supports the study's goal of producing a valid, practical, and effective local culture-based microlearning strategy. Compared to broader R&D frameworks such as Borg and Gall, the 4D model offers focused guidance for classroom-level product validation and implementation. This model was applied with the purpose of developing a Local Culture-Based Microlearning Strategy and producing a new product in the form of a Basic Mathematics Textbook integrated with local cultural elements. The feasibility of the product was assessed through validity testing and product trials to determine the extent to which the implementation of the local culture-based microlearning strategy could enhance the conceptual understanding and problem-solving abilities of PGSD students. The study was conducted at STKIP Yapis Dompu, located at Jl. STKIP Yapis Dompu No. 1, Saleko, Sorisakolo, Dompu, West Nusa Tenggara, involving 40 first-semester students of Class IA PGSD during the odd semester of the 2025/2026 academic year.

Participants consisted of 40 first-semester PGSD students (7 males and 33 females) aged 18–21 years enrolled in the Basic Mathematics course. A *purposive sampling* technique was used because this group represents novice teacher-education students who typically experience conceptual difficulties in mathematics. Therefore, they were considered the most appropriate sample for evaluating the effectiveness of a local culture-based microlearning strategy.

2.1 Research Procedure

The Research and Development (R&D) method was employed in this study as it is intended not only to generate a specific product but also to examine its effectiveness. The research design adopted was the 4D development model (Four-D Models) introduced by Thiagarajan, which consists of four sequential stages: Define, Design, Develop, and Disseminate.

In the define stage, information relevant to the product was systematically collected. This included conducting an initial analysis, examining students' needs through task and material analysis, and specifying clear instructional objectives. These steps were crucial in ensuring that the development of the product aligned with both pedagogical requirements and learners' characteristics.

The design stage was directed toward producing an initial framework of the product. At this stage, test instruments were developed, appropriate media and formats were selected, and a preliminary prototype was constructed to serve as the foundation for further development.

The development stage involved expert validation, developmental testing, and product trials to evaluate the feasibility and effectiveness of the Local Culture-Based Microlearning Strategy. The research employed a quasi-experimental design with a pretest–posttest control group approach to determine the product's impact on students' conceptual understanding and problem-solving skills. The trial was conducted over four weeks involving 40 first-semester students of Class IA PGSD during the odd semester of the 2025/2026 academic year, with one class serving as the experimental group and the other as the control group. Data were collected using validated instruments, including a conceptual understanding test, a problem-solving performance test, and a student response questionnaire. Expert validation covered media, material, and instrument evaluation, focusing on visual presentation, textual clarity, and cultural relevance to ensure that the developed product was engaging, pedagogically sound, and accessible to learners.

Finally, the disseminate stage focused on promoting and distributing the completed product to its intended users, namely lecturers and students. The distribution process was conducted offline within the local campus environment of STKIP Yapis Dompu through a series of workshops and demonstration sessions. During these activities, lecturers and students were introduced to the use of the Local Culture-Based Microlearning Strategy and the accompanying learning materials, allowing the product to be directly implemented and evaluated in authentic classroom settings.

2.1 Data Collection Techniques and Data Analysis

The data collection in this study was conducted through observation, interviews, questionnaires, tests, and documentation, using several instruments, namely validation sheets, student response questionnaires, interview guidelines, and test items. The validation sheets were used to collect data from experts to assess the feasibility of the developed product in terms of content, media, and instructional components, which were analyzed using descriptive statistics to determine the level of validity. The student response questionnaires were employed to obtain data on the practicality of the learning strategy based on students' perceptions, analyzed through percentage calculations. The interview guidelines were used to gather qualitative information from lecturers and students regarding the learning process and students' engagement, which were analyzed descriptively. Meanwhile, the test items were used to measure students' conceptual understanding and problem-solving skills before and after the use of the Local Culture-Based Microlearning Strategy, with data analyzed using the normalized gain (N-gain) test to determine the level of improvement in learning outcomes.

Once the data were collected, they were subjected to systematic analysis. The validity analysis was carried out using expert validation results from media and content specialists. The practicality analysis was conducted by distributing questionnaires, with item-by-item analysis derived from student responses. The study primarily emphasized the feasibility of the designed microlearning strategy, presented in the form of video-based learning materials.

The effectiveness analysis was conducted using test instruments administered in the form of pretests and posttests. The improvement in students' performance was then measured by applying the Normalized Gain (N-Gain) test to determine the extent to which the Local Culture-Based Microlearning Strategy enhanced students' conceptual understanding and problem-solving skills. The indicators of conceptual understanding included the ability to explain mathematical concepts in their own words, identify relationships between concepts, and apply these concepts to examples related to the real number system. Meanwhile, the indicators of problem-solving skills covered students' abilities to analyze contextual problems, select and implement appropriate solution strategies, and interpret results within the context of local cultural examples. The data from the pretest and posttest results were analyzed using descriptive statistics and the normalized gain formula to assess the level of improvement.

$$N - Gain = \frac{Skor\ Posstest - Skor\ Pretest}{Skor\ Ideal - Skor\ Pretest}$$

3. Result and Discussion

The study was conducted in the context of Basic Mathematics instruction within the PGSD program, specifically involving Class IA students in the first semester, with a total of 40 participants. The use of instructional media has previously been applied across several courses, including Basic Mathematics. The research method employed in this study followed the model developed by S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel (1974:5), which comprises four stages: Define, Design, Develop, and Disseminate.

Define

In the define stage, information was collected through several steps, beginning with an initial analysis of both students' needs and instructional requirements. The analysis revealed that lecturers had not fully optimized the use of digital learning strategies, particularly the integration of video, to support the learning process. By incorporating technology into teaching, learning activities can be maximized and made more effective. Within this stage, the analysis conducted included a student analysis—comprising task analysis and content analysis—as well as the specification of instructional objectives.

Classroom observations were carried out during the learning process in Class IA of the PGSD program. The results showed that students tended to be passive, acting more as recipients of information rather than actively responding or engaging critically. Moreover, students struggled to comprehend material delivered through conventional methods, which often led to passivity and even drowsiness during lectures. To address this issue, a strategy is needed that accommodates students' familiarity with technology while also contextualizing content through local culture. Such a strategy would enable students to better understand the material by engaging with short, accessible videos that they could review anytime and anywhere. This approach would stimulate active participation, encouraging

students to respond and ask questions during class, ultimately leading to deeper conceptual understanding and improved problem-solving skills.

Interviews were conducted with lecturers and students of the Basic Mathematics course to validate the findings from classroom observations and ensure that the identified learning issues were supported by actual evidence rather than researcher assumptions. The interview data confirmed that many students appeared passive and frequently drowsy during class sessions due to their limited mastery of foundational mathematical concepts. Lecturers noted that this lack of conceptual understanding made it difficult for students to actively participate in discussions or solve assigned problems. The consistency between observation and interview results provided a strong empirical basis for determining that a Local Culture-Based Microlearning Strategy would appropriately address these challenges in the learning process.

The problems identified through classroom observations and interviews formed the basis for developing an appropriate instructional solution. The data revealed that students were generally passive and less responsive during lessons, often appearing drowsy and struggling to grasp fundamental mathematical concepts. These issues negatively affected their participation and academic achievement. Therefore, selecting an effective instructional strategy was essential to address these specific learning challenges and achieve the learning outcomes and course objectives stated in the semester learning plan. Supported by these empirical findings, this study developed a Local Culture-Based Microlearning Strategy designed to foster active learning, improve students' conceptual understanding, and strengthen their problem-solving abilities.

Design

At this stage, the design of the microlearning strategy to be developed was carried out, namely the Local Culture-Based Microlearning Video. The video was produced using several applications, including CapCut, Canva, and Filmora. The process of designing the local culture-based microlearning strategy consisted of several steps: selecting the strategy, choosing the appropriate type of strategy, and creating the initial design. Among the various forms of microlearning—such as video microlearning, infographics, audio podcasts, short text articles, quizzes, digital simulation games, and microlearning applications—the chosen strategy was video microlearning, as it enables the integration of contextual materials with the local culture of Dompu. The design of the local culture-based microlearning video on the topic of the real number system ultimately resulted in a series of instructional video outputs with structured visual and contextual features.

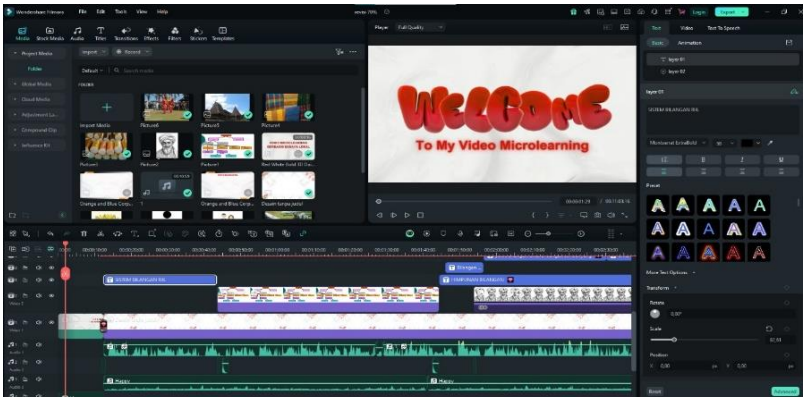

Figure 1. Initial Display of the Video

The initial display of the video was designed using Filmora, featuring a simple layout with a plain background and the text *"Welcome to My Video Microlearning."* This introductory screen served as the opening element to familiarize students with the learning medium. The subsequent slide presented the main menu, offering a structured navigation interface that guided users to the core content of the microlearning material.

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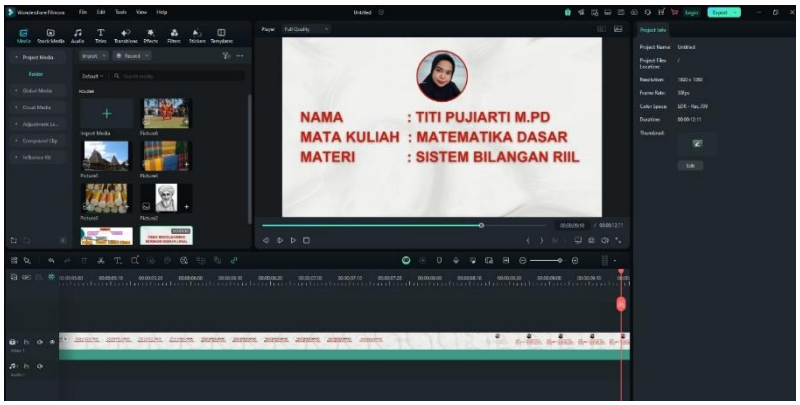

Fugure 2. Main Menu Display

The video was then designed using several segments with a duration ranging from 7 to 11 minutes, each containing instructional material on the Real Number System. The content was further enriched by integrating locally relevant examples and problem-solving tasks drawn from the cultural context of Dompu. This design allowed students to not only engage with abstract mathematical concepts but also to relate them to familiar real-life and cultural situations. The material display is presented as follows:

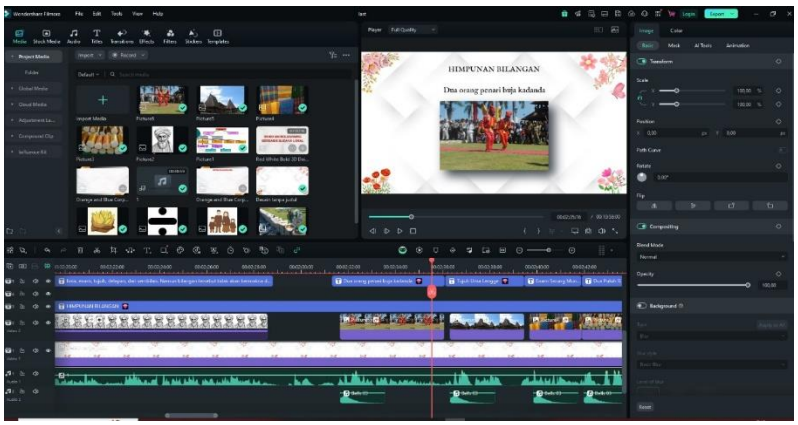

Figure 3. Content Menu Display

The content display was designed by incorporating images related to the local culture of Dompu, which were used as examples for problem-solving tasks. This integration provided a contextualized and culturally relevant approach, enabling students to more easily understand abstract concepts and apply them in meaningful ways within their learning process.

Develop

This product was designed using CapCut, Canva, and Filmora, and consists of four video segments, each covering a subtopic of the real number system. The first video addresses sets of numbers, the second covers exponents, the third discusses roots, and the fourth explains logarithms. The microlearning videos were developed in accordance with the needs of both lecturers and students. They were distributed to lecturers and students via shareable links, allowing the videos to be downloaded and accessed anywhere without requiring an internet connection. Once the product had been completed, the subsequent step was to carry out its validation.

Table 1. Mean Score of Expert Validation

Validator	Percentage	Category
Content Expert	90,23%	Highly Valid
Media Expert	86,96%	Highly Valid
Instructional Design Expert	93,21%	Highly Valid
Mean Score	**90,13%**	Highly Valid

The validation results indicated that the local culture-based video learning strategy developed in this study is highly feasible for implementation in the Basic Mathematics course for Class IA of the

PGSD program. This was evidenced by the validation scores, namely 90.23% from the content expert, 86.96% from the media expert, and 93.21% from the instructional design expert, all of which were categorized as *highly feasible*. Overall, the average validation score reached 90.13%, placing it within the *highly feasible* category.

The implementation of local culture-based instructional videos formed an integral part of the microlearning strategy, in which the learning materials were segmented into four parts with a duration ranging from 7 to 11 minutes each. Subsequently, the practicality of these videos was evaluated through student response questionnaires. The product trials were conducted in two stages: the first was a small-scale trial involving 28 students, followed by a large-scale trial with a total of 40 students.

Table 2. Mean Scores of Student Response Questionnaires

Trial	Percentage	Category
Small-Scale Trial	100%	Highly Positive
Large-Scale Trial	97%	Highly Positive
Mean Score	**98,5%**	**Highly Positive**

The results of the trials demonstrated that the student response in the first test reached 100%, with the small-scale group of 28 students classified in the *highly practical* category, while the large-scale group of 40 students obtained an average score of 97%, also categorized as *highly practical*. These results confirm that the Class IA PGSD students responded positively to the local culture-based microlearning videos, as reflected in their more active participation during lessons, increased critical questioning, and greater flexibility in comprehending concepts, which in turn contributed to more accurate and effective problem-solving in test tasks. Moreover, the findings are in line with previous research by Santi et al., (2024) which highlighted that the microlearning model has considerable potential as an innovative learning strategy for the development of effective instructional materials..

The improvement in students' conceptual understanding during the Basic Mathematics learning process had a positive impact on enhancing their problem-solving skills, particularly through the integration of local culture into mathematical problem-solving contexts. This finding aligns with previous research by Sutarto et al., (2022) which demonstrated that the application of ethnomathematics can strengthen students' thinking abilities and consequently improve both conceptual understanding and problem-solving competence. The effectiveness of the developed product was further evidenced through testing. Students were administered a pretest prior to receiving access to the local culture-based microlearning video links, and the results showed that both groups achieved mean pretest scores of 72 (small-scale group) and 78 (large-scale group). Following the learning intervention, the mean posttest scores increased to 81 in the small-scale group and 90 in the large-scale group, indicating a significant difference between pretest and posttest results in both groups. To further examine learning gains, the N-gain test was employed, which categorized the improvement levels into three criteria: high, medium, and low (Amalia et al., 2022).

Table 3. Mean N-Gain Scores

Trial	N-Gain Scores	Improvement Criteria
Small-Scale Trial	0,67	Moderate
Large-Scale Trial	0,78	High
Average	**0,7**	**High**

From Table 3, it can be observed that the improvement in learning outcomes for Class IA PGSD demonstrated a significant increase, with an N-gain score of 0.67 in the small-scale group and 0.78 in the large-scale group. Across both trials, whether in the small or large group, the average N-gain reached 0.7, which falls within the high improvement category.

Disseminate

This stage was carried out after the completion of all development phases. The product was then delivered to the lecturers responsible for the Basic Mathematics course in each first-semester PGSD class at STKIP Yapis Dompu. The local culture-based microlearning videos were offered with several considerations derived from the development process, namely the validation by experts, the highly positive responses from students, and the effectiveness demonstrated through pretest and posttest results.

4. Conclusion

This study demonstrated that the developed *Local Culture-Based Microlearning Strategy* is valid (expert validation = 90.13%), practical (student response = 98.5%), and effective (N-gain = 0.7, categorized as *High* per Hake, 1998) in improving students' conceptual understanding and problem-solving ability in mathematics. These results confirm that embedding local cultural contexts within microlearning enhances learning engagement and conceptual comprehension, thereby strengthening the alignment between digital pedagogy and contextual learning theory. The findings provide pedagogical implications for teacher education, suggesting that culturally grounded microlearning can serve as a replicable model for digital innovation in higher education. Nevertheless, the study's scope was limited to one institution and a relatively small sample of first-semester students, indicating the need for future research to involve diverse populations and longitudinal designs to evaluate long-term learning impacts and scalability.

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