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Culturally Responsive Game-Based Learning: Integrating PjBL to Enhance Students' Understanding of Linear Equations

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Abstract: This study aims to develop and evaluate PjBL-based educational games that integrate mathematics learning with local culture in senior high schools, specifically a game called "Uno Math Culture". This research is motivated by observations that high school students' understanding of learning is limited by conventional methods and the lack of interactive media, so it is necessary to develop PjBL-based educational games that integrate local cultural contexts to create more meaningful, contextual, and engaging mathematics learning. This study employed a Research and Development (R&D) approach based on the ADDIE model. The subjects consisted of 31 tenth-grade students. The data collection techniques used were questionnaires and tests: questionnaires were used to assess validity and practicality. In contrast, tests were used to assess the effectiveness of using educational games. The validation results from three academics and one practitioner indicated an 86.40% level, categorized as "highly valid". The results of the student response questionnaire showed a practicality of 85.32%, categorized as "very practical". In terms of effectiveness, the product significantly improved students' learning outcomes ($t(30) = -6.568$, $p < 0.05$) with a large effect size. Overall, the development of a PjBL-based educational game, entitled "Uno Math Culture," that integrates mathematics and local culture for 10th-grade students at SMA 1 Ponggok has proven to be valid, practical, and effective in integrating mathematics learning with the local cultural context.

Keywords: educational games, local culture, mathematics learning, PjBL.

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INTRODUCTION

Mathematics education in high school not only serves as a means of transferring conceptual knowledge but also as a foundation for developing logical, systematic, and reflective thinking (Kuncoro et al., 2025). In the context of 21st-century education, learning must be oriented not only towards procedural mastery but also towards conceptual understanding, active engagement, and relevance to students' real-life contexts (SARKAR, 2025). Therefore, a learning approach that integrates cognitive, affective, and contextual aspects in a balanced manner is needed so that students can actively construct knowledge rather than passively receive information.

However, theory does not always align with the reality of learning practices. The reality in the classroom shows that mathematics learning is still dominated by an expository approach that places students as passive recipients of information (Lee & Paul, 2023). This condition becomes even more complex when the material being taught is highly abstract, such as three-variable linear equation systems. Material on three-variable linear equation systems requires students to understand the simultaneous relationships among variables, perform symbolic manipulations, and interpret solutions in mathematical representations; as a result, many students have difficulty understanding these relationships conceptually (I. L. K. Dewi, Zaenuri, Dwijanto, & Mulyono, 2020). This is also reinforced by observations made in January 2025 in class X at SMA Negeri 1 Ponggok, which found that most

students had difficulty understanding the conceptual relationships among variables. This observation included analyses of student needs, the material and curriculum, the school's learning conditions and infrastructure, and student characteristics. From the observation, conventional learning methods were found to be ineffective at involving students in the learning process, especially when solving equations with three variables. Another difficulty was the lack of interactive learning media, which made it hard for students to relate the material to real-life applications. This condition highlights the need for a learning approach that not only increases student engagement but also supports students' conceptual understanding of three-variable linear equation systems.

Based on these issues, a learning approach is needed to bridge the gap between abstract concepts and students' concrete realities. In response to these issues, several studies have examined and developed innovative approaches to overcome them. One effective approach is to integrate educational games into the learning process (Videnovik, Trajkovik, Kiønig, & Vold, 2020). The integration of educational games into mathematics learning not only provides a more engaging learning environment but also enhances students' ability to understand complex concepts (Fisher et al., 2020). The relevance of educational games in mathematics learning is significant, especially for middle school students, who begin to encounter more abstract and complex material (Ke et al., 2024). Educational games are considered capable of increasing intrinsic motivation, creating a more dynamic learning atmosphere, and providing challenge-based learning experiences (Arianti, Pamungkas, Hambali, Anisyah, & Supriadi, 2024). Through game mechanics, students are encouraged to actively engage and interact with the material in a more exploratory manner (Fang, Liu, Hu, Huang, & Wu, 2024). However, in many implementations, educational games focus on fun and competition without a systematic pedagogical framework, so their contribution to deepening understanding is still limited.

On the other hand, Project-Based Learning (PjBL) offers a learning framework that emphasizes active student engagement through the completion of authentic projects (Nagamalla, Geedipally, Bandu, & Suryadevara, 2024). Project-Based Learning (PjBL) is defined by The George Lucas Educational Foundation, as quoted in Zhao et al. (2023), as a learning approach that emphasizes students' active involvement in exploring real-life, curriculum-based, content-standard-oriented problems. Mathematics learning with a project-based approach is effective in increasing student engagement in the context of education (Gokhool, Lawson, Hodds, & Aslam, 2022). PjBL allows students to construct knowledge by exploring real problems relevant to their environment (Long, Subramaniam, Harrell, Harris, & Thompson, 2025). This approach has the potential to strengthen conceptual understanding because students not only solve problems but also relate concepts to contextual situations (Chi, 2023). However, in practice, the implementation of PjBL in mathematics learning is often still procedural and lacks interactive media to maintain consistent student engagement throughout the project.

In addition, the integration of local culture into mathematics learning is gaining attention as part of a contextual and culturally responsive approach to learning. Local culture refers to practices that develop in everyday life and are often adopted as values, norms, and traditions that refer to the identity of a society or community (Ratri, Rachmajanti, Anugerahwati, Laksmi, & Gozali, 2025). According to Djubaedi et al. (2024), local culture includes local wisdom that guides daily life in the community and an identity that distinguishes one community from another. The cultural diversity of Indonesia encompasses

various aspects of human life passed down from generation to generation, including art, customs, traditions, and cuisine, all of which reflect the community's identity (Sharma, 2025). This local culture is often integrated into education and character development, which helps the younger generation to understand and appreciate the cultural heritage around them (Andang & Hadi, 2025). Research by Ababil et al. (2025) shows that mathematics learning based on local culture can improve students' understanding of mathematical concepts. Local culture is not merely an ornament to learning but can serve as an authentic context that helps students understand mathematical concepts through experiences close to their lives (Andriani et al., 2020). In the context of Indonesia, which is rich in cultural diversity, this potential is enormous. However, previous studies have tended to limit their examination of cultural context to illustrative examples in story problems, without deeply integrating it into media design, the mechanics of mathematics learning, or project structure.

Thus, previous studies indicate that the integration of Project-Based Learning and educational games remains largely procedural, with insufficient theoretical grounding for embedding local cultural values into game design to enhance students' mathematical understanding (Myers, Piccolo, & Collins, 2023). When examined comprehensively, these three approaches to educational games, PjBL, and local cultural integration have the potential to complement each other. However, a critical review of previous studies shows that these approaches are often applied separately. Research on educational games often emphasizes motivation without integrating a systematic, project-based pedagogical structure. Conversely, the implementation of PjBL in mathematics classrooms is often not supported by interactive media that can sustain engagement throughout the project. On the other hand, culturally integrated mathematics learning generally uses cultural elements only as contextual illustrations, rather than integrating them deeply into instructional design, game mechanics, or project structure. As a result, there is a conceptual and methodological gap: no systematically structured instructional model integrates educational games, PjBL, and local cultural contexts into a cohesive design, especially for teaching three-variable linear equations at the high school level.

Therefore, the development of Project-Based Learning (PjBL) based educational games is highly relevant in creating a more meaningful educational experience (Bernini, Carvalho, & Carlos-Bender, 2019). Therefore, the Project-Based Learning (PjBL) approach can be developed as interactive learning content aligned with the curriculum to optimize learning. PjBL is an innovative approach that coordinates students in practices relevant to their surrounding environment, which can encourage greater involvement and motivation to learn (Maros, Korenkova, Fila, Levicky, & Schoberova, 2023). Thus, the approach to be applied is to use educational games with a Project-Based Learning (PjBL) approach so that students can participate fully in the mathematics learning process. By linking mathematical material to local culture, students can more easily understand and apply mathematical concepts in their daily lives and have a more engaging learning experience as they get to know the cultural context. Integrating Project-Based Learning (PjBL) into educational games grounded in local cultural contexts offers a relevant solution, as it enables curriculum-aligned content to be organized into meaningful projects that connect to students' everyday environments. The cultural context is drawn from local traditions and practices that remain familiar and relevant to students' lived experiences, enabling mathematical concepts to be contextualized more effectively. In addition, the game-based PjBL approach promotes social interaction through collaborative

gameplay mechanics that encourage teamwork, communication, and decision-making discussions. The learning content combines SPLTV problem-solving with local cultural elements, creating a balance between play and learning, as game rules and mathematical problem-solving processes are deliberately interconnected to support both cognitive development and engagement. For this reason, this study focused on students in grade X. In grade X, students begin to learn more complex mathematical concepts than those they learned in junior high school, requiring an innovative and supportive learning approach (Baog, Bartolome, Hayo, Agbon, & Roferos, 2024). Conceptually, this study uses Project-Based Learning (PjBL) as a pedagogical framework that guides the learning process through the completion of meaningful projects. At the same time, educational game mechanisms serve to enhance student engagement and interaction throughout the process. The integration of local culture is presented as the context for the project and the game's narrative, making learning activities more connected to students' real-life experiences.

The theoretical integration of these three elements is underpinned by constructivist learning theory, game-based learning theory, and culturally responsive pedagogy. Constructivist learning theory is an educational approach that emphasizes individual learning processes, focuses on student activity, and adapts to current curricula. It involves principles such as apperception, exploration, consolidation, attitude formation, and assessment, thereby fostering student engagement and critical thinking (Nurhuda, Al Khoiron, Syafi'i Azami, & Ni'mah, 2023). Game-based learning theory integrates game design elements with established learning theories, such as Cognitive Load Theory, to enhance student engagement and knowledge retention. It emphasizes adaptive challenges, real-world relevance, and social interactivity to foster meaningful learning experiences (Matthew, Pelser-Carstens, Bunt, & Bunt, 2025). Culturally responsive pedagogy is an educational framework that incorporates institutional, personal, and instructional dimensions to foster a culturally affirming, learner-centered educational atmosphere, in which students' cultural strengths, lived experiences, and identities are acknowledged and leveraged to enhance their academic success (Hsieh & Donahue, 2010). Culturally responsive pedagogy is a combination of knowledge, practices, and attitudes centered on the cultural traditions, experiences, and perspectives of students who are diverse in race, ethnicity, and language, thereby facilitating meaningful and transformative learning opportunities. Thus, culturally responsive pedagogical strategies enable teachers and students to reflect on themselves, critique, and connect their own learning experiences with future practices (Acquah, Szelei, & Katz, 2020). Culturally responsive pedagogy (CRP) is an educational approach that disrupts marginalization, strengthens multilingual learners' abilities, and involves implementing culturally relevant curricula, embracing diverse communicative repertoires, dismantling deficit perspectives, and practicing critical consciousness in teaching and learning (Wesley-Nero & Donley, 2024). The development of educational games with a local cultural context in mathematics learning requires a variety of appropriate approaches to make it more relevant to students. Relevant research by Al Khateeb (2019) developed a game-based mathematics learning system for simple operations, using a model-driven game development approach to create a mobile game for Android devices. In addition, Delport (2019) developed educational games to improve numeracy skills, demonstrating the effectiveness of games in mathematics learning. Based on several studies reviewed on the development of educational games for mathematics learning, contextualizing material

through everyday-life problems remains a general approach. It has not been systematically integrated with students' cultural backgrounds and environments, making the learning activities feel abstract and less meaningful. In addition, many studies focus primarily on game-based learning or problem-solving contexts, without integrating them into a Project-Based Learning framework and guiding students through meaningful projects. This situation indicates the need for a learning approach that not only increases student engagement but also supports conceptual understanding of the material. Integrating Project-Based Learning (PjBL) into educational games based on local culture addresses these limitations by organizing SPLTV content into culturally relevant projects, encouraging social interaction, and balancing mathematical problem-solving with engaging play activities.

Therefore, this study developed an educational game called "Uno Math Culture," which modifies the Uno card game by incorporating elements of local culture and mathematical concepts, using typical Blitar food products as card icons. This modification involves challenges that combine mathematical problems on three-variable linear equation systems with culture-based activities. With this approach, "Uno Math Culture" integrates Project-Based Learning with cultural exploration, creating opportunities for students to develop their mathematical abilities in a contextual and interactive manner while deepening their appreciation of local culture. The novelty of this research lies in its theoretical and methodological contributions through the formulation of a structured integration model that systematically connects Project-Based Learning, educational games, and local cultural contexts in mathematics learning based on design principles that can be reapplied as contextualization, authentic projects, and cultural representation in learning activities, making it adaptable to other mathematics topics and various cultural contexts beyond linear equations. Thus, this study contributes theoretically to the development of PjBL-based educational games that integrate culture and, in practice, offers a replicable learning framework for educators to design engaging, meaningful, and culturally responsive mathematics learning media. Thus, based on the above descriptions, the objectives of this study are to develop and evaluate PjBL-based educational games that integrate mathematics learning with local culture in senior high schools. Therefore, this study is expected to be useful for the development of Project-Based Learning (PjBL) based educational games that integrate mathematics and local culture, especially at the high school level, and can be an alternative learning method that is interesting, interactive, and supports the active participation of students, as well as enriches their knowledge of local culture.

METHOD

Participants

The subjects in this study were 31 students from class X4 at SMAN 1 Ponggok (Senior High School). The selection of research subjects was oriented towards students who had studied the material on three-variable linear equation systems, so they were expected to have a basic understanding of mathematics and demonstrate active participation in project-based learning activities. Class X4 was selected through purposive sampling based on the subject teacher's recommendation, as it represents diverse academic abilities and learning characteristics relevant to the research objectives. This research was conducted in the even semester of the 2024/2025 academic year.

Research Design and Procedures

This study uses the research and development (R&D) method to develop educational mathematics games integrated with local culture. The ADDIE model is used to

develop a Project-Based Learning (PjBL)-based educational game that integrates mathematics learning with local culture in the Three Variable Linear Equation System material for 10th-grade high school students. According to Branch (2010), the ADDIE design model involves five stages of the development process: analysis, design, development, implementation, and evaluation.

In the analysis stage, learning needs were identified by studying student characteristics, learning process conditions, and media needs. The analysis results showed that mathematics learning was still conventional and did not integrate local culture, so more interactive and contextual media were needed. In the design stage, a prototype of the "Uno Math Culture" media was developed, covering the game concept, rules, visual appearance, classroom use flow, and the preparation of research instruments such as expert validation sheets, practicality questionnaires, and learning outcome tests. The development stage involved creating a visual design of the media in Canva, formatting it in Microsoft Word, converting it to a PDF as the final version, and creating a physical version based on the original Uno cards. This product was then validated by experts to assess the suitability of its content and design before being declared ready for implementation.

During the implementation stage, the learning activities were conducted using the Project-Based Learning (PjBL) model. In the phase of posing essential questions, the teacher introduced contextual problems rooted in local culture to stimulate students' curiosity and critical thinking. At the stage of formulating basic questions, the Uno Math Culture game is used as a spark to develop key questions in understanding the Three Variable Linear Equation System (SPLTV). Uno cards, which contain culturally relevant problems, including traditional foods, relevant to the students' environment, are used collaboratively in groups. Each problem card requires students to identify relationships between variables in an authentic context, thereby naturally raising essential questions about variable dependencies and the application of SPLTV in everyday life. Furthermore, in the project plan formulation phase, the Uno Math Culture game mechanism serves as an exploration tool for conceptual understanding and contextual project frameworks. After completing the game, students discuss the cards they collected, the points they earned, and the various SPLTV challenges they faced. This discussion forms the basis for designing a culturally integrated project, as outlined in the student worksheet (LKPD). The cultural cards integrated into the game help students choose project themes, while the experiential engagement in solving SPLTV problems strengthens their conceptual readiness for project implementation. Then, the project scheduling and progress assessment phase occurs during Learning Session 2, when the instructor reconnects students' play experiences to project-monitoring activities. Variations in problems, levels of complexity, and common misunderstandings are identified during the Uno Math Culture game, so that the game acts as a bridge between initial engagement and more in-depth project implementation.

Next, in the results evaluation phase, students' project presentations are evaluated based on the accuracy of SPLTV concepts, the integration of local cultural contexts, and students' ability to explain the relationships between variables. This evaluation includes learning outcomes that were previously reinforced through the Uno Math Culture game. Finally, the evaluation of the experience is carried out through class discussions and individual written reflections recorded in the LKPD. Students reflect on their learning experiences, particularly how the Uno Math Culture game improved their understanding of SPLTV, encouraged collaboration, and

connected mathematics with local cultural narratives. The evaluation stage was carried out formatively at each stage to address deficiencies, and summatively at the end of the process to assess the overall quality of the product. The validators input and test results form the basis for revisions so that the resulting media can optimally integrate mathematics learning and local culture.

Data Collection and Instrument

The data collection techniques used in this study were questionnaires and tests. Questionnaires were used to assess the validity and practicality of the developed educational game media. The questionnaires used in this study included a validation questionnaire to assess the validity of the educational games and research instruments by validators before implementation, and a user response questionnaire for students to evaluate the practicality of implementing the educational games. To obtain data on the effectiveness of educational games, essay tests were used, compiled based on learning achievement indicators at the end of each learning evaluation activity.

Data Analysis

The validity and practicality of the educational game were evaluated using structured questionnaires based on clearly defined measurement constructs. The validity questionnaire measured two constructs, namely material validity and educational game design validity. The material validity construct consisted of four items, while the game design validity construct comprised eleven items, resulting in a total of 15 items. Each item was assessed using a 4 points Likert scale, where 1 = Strongly Disagree; 2 = Disagree; 3 = Agree; and 4 = Strongly Agree. Furthermore, the percentage results for each category were calculated, and the validity criteria were confirmed using the following table (Akbar, 2013). The questionnaire items were developed through a systematic process involving literature review, alignment with learning objectives and Project-Based Learning (PjBL) characteristics, and expert judgment. Content validity was established through expert validation, and the resulting scores were converted to percentages to determine validity levels against predefined criteria. For validity classification, a score of V_s e" 85% was categorized as highly valid or usable without revision, 70% d" < 85% as sufficiently valid or usable but requires minor revisions, 50% d" < 70% as less valid not recommended for use as major revisions are needed, and < 50% as not valid or should not be used. The developed product is declared suitable for implementation if it has been validated by the validator with a minimum validity criterion of "sufficiently valid".

Furthermore, data from the response questionnaire completed by the students are calculated as percentages to determine the practicality of the developed media using the following practicality test percentage scale (Darmayanti, Baiduri, & Inganah, 2022). The practicality questionnaire measured three constructs, instructional design, operational aspects, and visual communication, with a total of ten items. The same 4-point Likert scale was applied to ensure consistency across instruments. Practicality levels were classified as not practical (S d" 50%), fairly practical (50% < S d" 75%), practical (75% < S d" 85%), and highly practical (S > 85%).

Table 1. Response questionnaire score category

Score	Category
1	Poor
2	Fair
3	Good
4	Excellent

The developed product is declared practical with a minimum practicality criterion of "fairly practical".

To assess the effectiveness of the research design, a one-group pretest–posttest design was used. Before implementing the PjBL-based educational game, students were given a pre-test to measure their initial abilities in the material being studied. After the learning process was completed, students were given a post-test with equivalent indicators and difficulty levels. The test instruments were compiled based on learning outcome indicators and first validated by subject-matter experts. Then, learning outcomes were assessed using a four-level rubric: a score of 3 indicated complete understanding and correct procedures; a score of 2 indicated partial understanding with minor errors; a score of 1 indicated an attempt to answer but with conceptual or procedural errors; and a score of 0 indicated no response or an irrelevant response. Data analysis of effectiveness was conducted in two stages. First, descriptive analysis was performed to describe the distribution of scores, averages, and percentages of learning completeness with a minimum passing grade of 65 used as an administrative reference to describe the school's standard achievement in the context of the study, not as the main basis for drawing conclusions about effectiveness. Second, to test the significance of the increase in learning outcomes, a paired-sample t-test was conducted on the pre-test and post-test scores. This test aimed to determine whether there was a statistically significant difference after the intervention. The improvement in learning outcomes was declared significant if the significance value is less than 0.05.

■ RESULT AND DISCUSSION

Analyze

Based on direct observation and unstructured interviews with educators teaching mathematics in January 2025 in class X at 1 Ponggok Senior High School. The results show that the learning activities used tend to be teacher-centered and dominated by lecture methods. The learning media used are generally textbooks, printed worksheets, and blackboards, which tend to make students less active and less motivated when learning specific mathematical concepts such as the Three Variable Linear Equation System (SPLTV). Students also had difficulty understanding the relationships between variables due to the lack of a real-world context. Still, they showed interest in interactive learning, such as game-based learning and projects, and took pride in Blitar's local culture, which could be integrated into the learning process. This is a strong reason for researchers to integrate elements of local culture into learning media to create a learning experience closer to everyday life.

Based on the results of this analysis, the researcher is dedicated to developing the Uno Math Culture educational game using a Project-Based Learning (PjBL) approach, integrating local cultural elements from Blitar. This study introduces a novel framework for culturally responsive game-based learning, in which the game design intentionally reflects local culture and aligns with the learning objectives of the Three Variable Linear Equation Systems material. The design principles such as contextualizing content, embedding authentic problem-solving tasks, and representing cultural elements allow the model to be adapted for other mathematical topics or different cultural contexts. The Three Variable Linear Equation System (SPLTV) material was chosen as the focus of discussion because it requires high levels of logical thinking and problem-solving, which remain challenging for students in realistic contexts, and it has the potential to be integrated with local culture. Through this comprehensive study, it is hoped that the gap between theory and practice in mathematics education in schools can be addressed and that contextual and meaningful learning innovations can be introduced.

Design

This stage was designed with an educational game prototype, namely Uno Math Culture,

which is in line with the results of the needs analysis and learning objectives, and was designed with a Project-Based Learning (PjBL) approach so that students not only understand mathematical concepts but are also able to relate them to contextual problems in their environment through fun project activities and games. The research stages are as follows.

Table 2. Research stages

No	Aspect	Indicators
		Need Analysis
1	Learning objectives	Students are able to **understand** the general forms of SPLTV and non-SPLTV in a cultural context. (C2)
		Students are able to **transform** SPLTV concepts into problems relevant to the local cultural context. (C6)
		Students can analyze and solve SPLTV problems in cultural contexts. (C4)
2	Characteristics of students	Students in the 10th grade of high school.
		Determination of Learning Objectives
3	Formulation of objectives	The Uno Math Culture educational game can integrate mathematics and learning about local culture into the Three Variable Linear Equation System material through its media.
4	Success indicators	There are indicators of success in integrating mathematical concepts with local culture in high schools, which can motivate students to be more active and creative and strengthen collaboration and appreciation for the richness of local culture.
		Learning Media Design
5	Method	Group
6	Flow	Step-by-step guide to using the Uno Math Culture educational game.
		Development of Learning Media
7	Uno Math Culture Design	Cover, introduction, Learning Outcomes, Learning Objectives, Learning Objective Achievement Indicators, Uno Math Culture Game usage guide, teaching materials, student worksheets, scoring sheets, collection of questions and answer keys, usage guide, Three-Variable Linear Equation System materials, answer sheets, scoring sheets, collection of Three-Variable Linear Equation System questions in a cultural context along with answer keys, and bibliography.
8	Software and tools used	Uno cards, Microsoft Word software, and Canva.
		Media Validation
9	Review by experts	3 academics dan 1 practitioner.
10	Revision	Based on suggestions from validators.
		Implementation
11	User guide	The Uno Math Culture educational game guide is concise and clear.
12	Facility preparation	Using the Uno Math Culture educational game prepared by the researcher.
13	Implementation of learning	Conducting learning in accordance with the guidelines for using the Uno Math Culture educational game.

	Evaluation and Revision	
14	Evaluation of process and results	Evaluating both the process and the results.
15	Data collection	Data collection begins with the educator asking prompting questions to encourage students to recall basic concepts from previous material. Next, learning continues with the prepared Uno Math Culture educational game. Students then fill in the answers according to the questions they receive in the LKPD and complete the entire LKPD. Finally, students complete the evaluation questions after the lesson ends.
16	Revision	Based on the evaluation results.

The visual references in this media use images of Blitar's local culture from several relevant sources on Google. The background display was designed attractively in Canva, while the content packaging and evaluation components were created in Microsoft Word. Here are some examples of the display.

Figure 1. Cover of the educational game

The cover was designed using the Canva application with bright colors and cultural nuances, the specific use of Uno card images to illustrate learning using the Uno card game system, and distinctive cultural visual elements, such as Wayang illustrations and batik motifs. In terms of typography, the font is bold yet playful, maintaining a balance between academic nuances and a playful atmosphere. These characteristics align with the principles of educational media design: engaging, meaningful, and culturally oriented.

This section explains the steps for using the Uno Math Culture educational game, from preparation and how to play to the scoring system used. In general, the game begins with groups of 3-5 people forming, and then each player receives cards at random. Players take turns playing cards by color, number, or symbol, paying attention to special rules, such as cards depicting regional foods that are worth certain points, as well as odd- and even-numbered cards related to mathematics and culture. Scores are calculated based on the accuracy of answers and the number of points earned. In addition, this guide emphasizes integrating the Project-Based Learning (PjBL) model, as each game activity is linked to project stages, such as problem identification, group discussion, and contextual solution development.

The image presents teaching materials used as additional references during learning activities, including the definition of SPLTV, general forms, and solution methods (substitution, elimination, and mixed), contextualized through real-life, such as calculating the prices of typical Blitar food ingredients, along with other related information.

Translation:
User Guide Uno Math Culture Game
Before starting the game, make sure you understand how to play. Here is a user guide for the "Uno Math Culture" game on learning Three-Variable Linear Equation Systems. Let's take a look together!
Uno cards consist of 108 cards divided into four colors (red, yellow, green, and blue) with numbers 0-9 (76 cards) and action cards, such as "Skip" (8 cards), "Reverse" (8 cards), "Draw Two" (8 cards), and special cards 'Wild' (4 cards) and "Wild Draw Four" (4 cards). The way to play is to match the cards in your hand to the cards in the center pile by number or color. For example, if the card in the center pile is red with the number 5, you can place either a red card or a card of any color with the number 5. Tip: Action and special cards can make the game more strategic. Here are the detailed rules:

Figure 2. Guide to using educational games

SYSTEM OF THREE-VARIABLE LINEAR EQUATIONS

A. Definition of Three Variable Linear Equations

A three-variable linear equation is an algebraic equation in which each term contains a constant or a product of constants and has three variables raised to the power of 1. The general form of a three-variable linear equation can be expressed as $ax + by + cz = d$, where a, b, and c re constants with a, b and c not both zero. Example:

1.) $a + 3b - 2c = 7$
2.) $4x - 5y + z = 19$

B. System Equation LinearThree Variables

A system of three linear equations (SPLTV) is a mathematical equation that includes three linear equations, each of which has three variables (e.g., x, y and z). SPLTV is also defined as a concept in mathematics that is useful for solve a case that cannot be solved using a single variable linear equation or a two variable linear equation.

C. Characteristics of SPLTV

To identify whether a system of equations is an SPLTV, here are some of its characteristics:

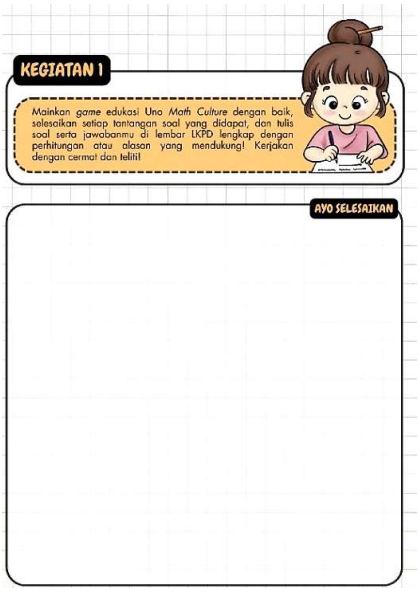
- There are three linear equations that must be satisfied.
- has three different variables (usually x, y and z).
- Each equation in this system is linear, meaning that the variables do not have a power greater than one, there is no multiplication between variables, or any other non-linear forms.

D. General Form of SPLTV

The general form of a Three-Variable Linear Equation System (SPLTV) is as follows:

$$\begin{cases} a_1x + b_1y + c_1z = d_1 \\ a_2x + b_2y + c_2z = d_2 \\ a_3x + b_3y + c_3z = d_3 \end{cases}$$

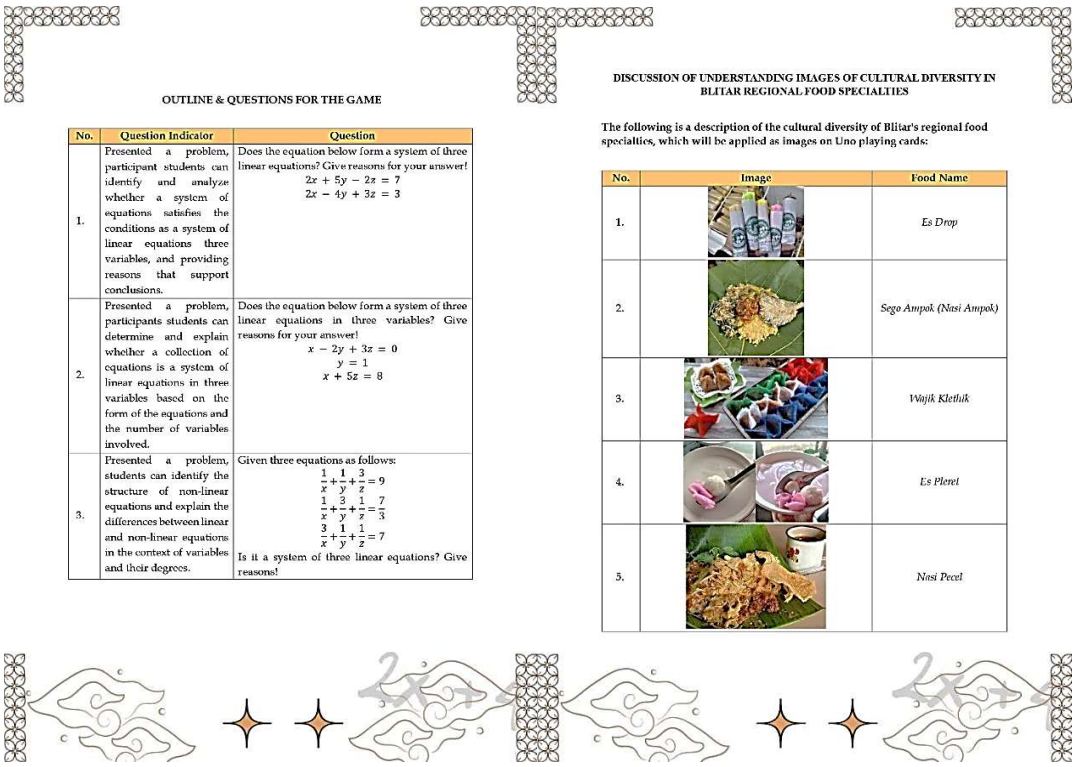
Figure 3. Display of materials



Translation:
Activity 1
Play the Uno Math Culture educational game well, complete each challenge question you get, and write down your questions and answers on the LKPD sheet, complete with calculations or supporting reasons! Work carefully and thoroughly! Let's get it done!

Figure 4. LKPD display

The LKPD is designed to encourage students to actively explore concepts and solve problems through project-based learning. In LKPD activity 1, students can work on the assignment while learning through educational games, followed by a discussion and activity 2 (project assignment) after learning through educational games. Each worksheet contains activities that guide students to observe, identify patterns, and solve SPLTV problems through a cultural context. These activities reflect learning by doing, which aligns with the PjBL principle.



OUTLINE & QUESTIONS FOR THE GAME

No.	Question Indicator	Question
1.	Presented a problem, participant students can identify and analyze whether a system of equations satisfies the conditions as a system of linear equations three variables, and providing reasons that support conclusions.	Does the equation below form a system of three linear equations? Give reasons for your answer! $2x + 5y - 2z = 7$ $2x - 4y + 3z = 3$
2.	Presented a problem, participants students can determine and explain whether a collection of equations is a system of linear equations in three variables based on the form of the equations and the number of variables involved.	Does the equation below form a system of three linear equations in three variables? Give reasons for your answer! $x - 2y + 3z = 0$ $y = 1$ $x + 5z = 8$
3.	Presented a problem, students can identify the structure of non-linear equations and explain the differences between linear and non-linear equations in the context of variables and their degrees.	Given three equations as follows: $\frac{1}{x}+\frac{1}{y}+\frac{3}{z}=9$ $\frac{1}{x}+\frac{3}{y}+\frac{1}{z}=\frac{7}{3}$ $\frac{3}{x}+\frac{1}{y}+\frac{1}{z}=7$ Is it a system of three linear equations? Give reasons!

DISCUSSION OF UNDERSTANDING IMAGES OF CULTURAL DIVERSITY IN BLITAR REGIONAL FOOD SPECIALTIES

The following is a description of the cultural diversity of Blitar's regional food specialties, which will be applied as images on Uno playing cards:

No.	Image	Food Name
1.		*Es Drop*
2.		*Sego Ampok (Nasi Ampok)*
3.		*Wajik Kletuk*
4.		*Es Pleret*
5.		*Nasi Pecel*

Figure 5. Collection of questions

The questions in the media are compiled using a grid that includes indicators of higher-order thinking skills (HOTS), including the ability to identify, model, and solve contextual SPLTV problems, as well as pictures of typical foods from the Blitar region that students need to guess on the Uno cards. Thus, this section reflects the characteristics of pedagogically effective media, supporting formative and summative assessments that are oriented towards deep understanding.

Development

This stage began with designing visual media in Canva, which was then finalized in Microsoft Word and converted to PDF. In addition to the digital version, the media was also developed in physical form as Uno cards for direct classroom use. Before implementation, the instruments and drafts of the educational games used were validated by four experts (three academics and one practitioner). The validation process assessed four main aspects, namely 1) aspect A in the form of material quality; 2) aspect B in the form of game design and interactivity; 3) aspect C in the form of relevance to mathematics learning; and 4) aspect D in the form of influence on student motivation. The validation results are detailed as follows.

Table 3. Educational game validation results

No	Validator	Aspect Assessment				Total	Average	%	Category
		A.1-A.5	B.1-B.4	C.1-C.4	D.1-D.4				
1	BK	19	15	15	15	64	3.76	94.12%	HV
2	AAPR	16	14	14	15	59	3.47	86.76%	HV
3	RDK	18	15	14	16	63	3.70	92.65%	HV
4	ASK	15	11	12	11	49	2.88	72.06%	SV
Total		68	55	55	57	235			
Average		3.4	3.4375	3.43	3.56	58.75			
Standard Deviation		1.34	1.5	0.96	1.5				
Validity								**86.40%**	**HV**

The validation process for the educational game draft involved four experts: three academics and one practitioner. Previously, the results were reported only as average percentage scores, which provide limited information regarding the consistency of the evaluators' judgments. To address this, an inter-rater reliability analysis was conducted using the Intraclass Correlation Coefficient (ICC), based on a two-way random-effects model for consistency (ICC (2.1)), as all four validators assessed all aspects of the game.

The validation considered four main aspects: material quality, game design and interactivity, relevance to mathematics learning, and influence on student motivation. Each aspect was scored individually by the validators, and the scores were used to calculate the mean, standard deviation, validity percentage, and ICC. The results indicated an overall validity of 86.40%, with each aspect categorized as "highly valid" (HV). According to Cicchetti (1994), the general interpretation of ICC values is as follows: values less than 0.40 indicate poor reliability, values between 0.40 and 0.59 indicate fair reliability, values between 0.60 and 0.74 indicate good reliability, and values between 0.75 and 1.00 indicate excellent reliability. In this study, the ICC value was 0.803, which falls into the "good" category, indicating a high level of agreement among validators despite minor variations in their individual scores.

These findings demonstrate that the draft educational game is both valid and reliable, with the inter-rater reliability confirming that the evaluation process is consistent across different experts. Furthermore, several constructive suggestions from the validators were incorporated to refine the content, improve the design and interactivity, and enhance the game's motivational aspects.

Implementation

After validation, the Uno Math Culture educational game media were implemented in mathematics instruction for class X-4 at 1 Ponggok Senior High School, with 31 students participating. The material implemented was the Three Variable Linear Equation System. The implementation process was carried out over three meetings, each lasting 3 × 45 minutes. The learning model used was Project-Based Learning (PjBL), integrating the local cultural context to increase the material's relevance for students. The following is a table of the research schedule.

Students' activities while playing the Uno Math Culture game in class showed high enthusiasm and increased their interaction with group members as they developed strategies to answer the math questions on the game cards.

Table 4. Research implementation schedule

Session	Date of Implementation	Learning Activities
1	May 20, 2025	Conducting learning activities using media/games (Learning Activity 1 focuses on introducing the concept of SPLTV)
2	May 22, 2025	Discussion and development of student projects (Lesson 2)
3	May 23, 2025	Presentation of project results, class discussion, reflection, and individual evaluation by students (Lesson 3)

Figure 6. Learning activities using uno math culture

Figure 7. One of the students' poster results

The posters were assessed using a weighted analytical rubric with a score range of 0–100 covering four main criteria, namely accuracy in relation to the learning material (35%), integration of local culture (25%), visual creativity (20%), and clarity of presentation (20%). Six groups were assessed. The analysis showed that the class average score was 96.16, with the highest score being 98 and the lowest being 93, indicating that all groups met the minimum passing grade of 65. The accuracy of the learning material received an average of 34.12 out of 35 (97.48%), local cultural integration 23.84 out of 25 (95.36%), visual creativity 19.08 out of 20 (95.40%), and presentation clarity 19.12 out of 20 (95.60%).

Overall, based on this data, in terms of accuracy in learning materials, all groups correctly constructed a three-variable linear equation system model, with consistent variable identification and systematic elimination or substitution procedures. Some student project results still showed simple algebraic manipulations that were solved using other methods to solve the three-variable linear equation system, but this did not affect the correctness of the final solution. This indicates that students' conceptual understanding of the material has developed adequately through problem modeling. Meanwhile, in terms of local cultural integration, the Blitar region was not only presented as a visual element but also treated in a real economic context, including estimating material costs, product selling prices, and profit calculations. This indicates that students associate mathematical variables with real components, such as the amount of materials and unit prices. One of the group reflection quotes states, "We determine the three variable linear equation system from the price of the main materials, then create three equations based on different sales package combinations." This quote shows a conceptual ization process grounded in contextual experience rather than merely an illustrative presentation.

In terms of visual creativity, the posters showed a structured layout, systematic division of information between the cultural context and mathematical process sections, and the use of cultural symbols to support arguments. However, some groups used text that was quite dense, which reduced visual readability. Overall, the aesthetics and visual communication were excellent. Finally, regarding presentation clarity, classroom observations and discussion transcripts show that groups negotiated solution strategies. One recorded piece of discussion was, "If we eliminate the second equation first with the first, we will find the value of variable x faster." This dialogue reflects a strategic, collaborative thought process for choosing an efficient solution method. Overall, this poster project not only produced a product but also demonstrated the depth of conceptual understanding, cultural contextualization skills, visual creativity, and collaborative dynamics in problem-solving among students learning mathematics on three-variable linear equation systems.

Figure 8. Students are working on evaluation questions and response questionnaires

Students completed evaluation questions and filled out response questionnaires after the learning activity. This process aimed to assess the extent to which students' understanding of the SPLTV concept had been achieved and to review feedback from the use of "Uno Math Culture." The practicality of the Uno Math Culture media was measured through the results of the student response questionnaires. The aspects assessed included learning design, operations, and visual communication. Based on the results of the student response questionnaire, the media obtained a practicality score of 85.32%, which, according to the classification criteria, falls into the "Very Practical" category.

Based on the practicality questionnaire responses analyzed using a Likert scale, the bar chart shows that ratings at scale 4 (excellent)

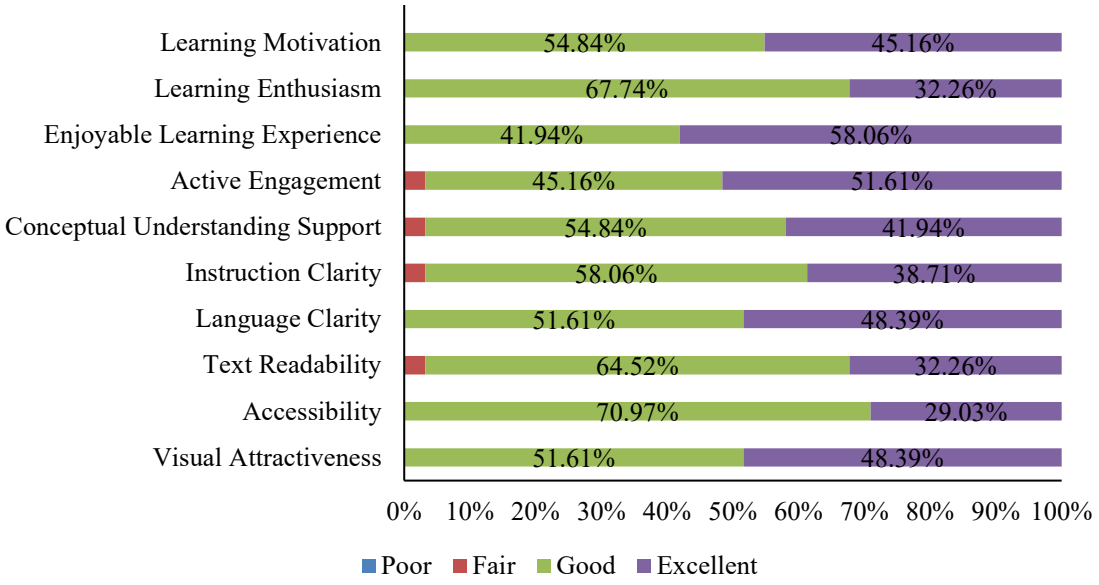


Figure 9. Questionnaire practicality results

dominate across most aspects, indicating that the learning media is perceived as highly practical by users. Ratings at scale 3 (good) also appear in substantial proportions, while ratings at scales 1

and 2 are minimal, suggesting that usability issues are limited and do not significantly hinder implementation. This aspect-based visualization provides a clear depiction of the media's strengths and minor areas for improvement. These results indicate that, in general, students responded positively to the use of the media, both in terms of ease of use, clarity of display, and relevance of the material content to real life. The media were considered easy to use, visually appealing, and capable of supporting students' active involvement in learning mathematics, which had previously been considered abstract. Descriptive analysis of student statements shows that students consider game-based learning media to be visually appealing, easily accessible, and supported by clear language and instructions, making them easy to use during learning activities and facilitating active engagement during play and learning, which provides an enjoyable learning experience. This is reflected in student statements such as "this game is easy to play and visually appealing, so I feel happier to understand mathematics." These findings support the questionnaire results, which show that this learning media is considered practical and easy to use.

The pretest and posttest scores from 31 students in class X4 at SMAN 1 Ponggok, before and after the implementation of PjBL-based educational games that integrate mathematics and local culture, were used as a benchmark for the implementation's effectiveness. The effectiveness of the developed product was analyzed using a paired-samples t-test on the learning outcome test scores of 31 students, with a significance level of 5%.

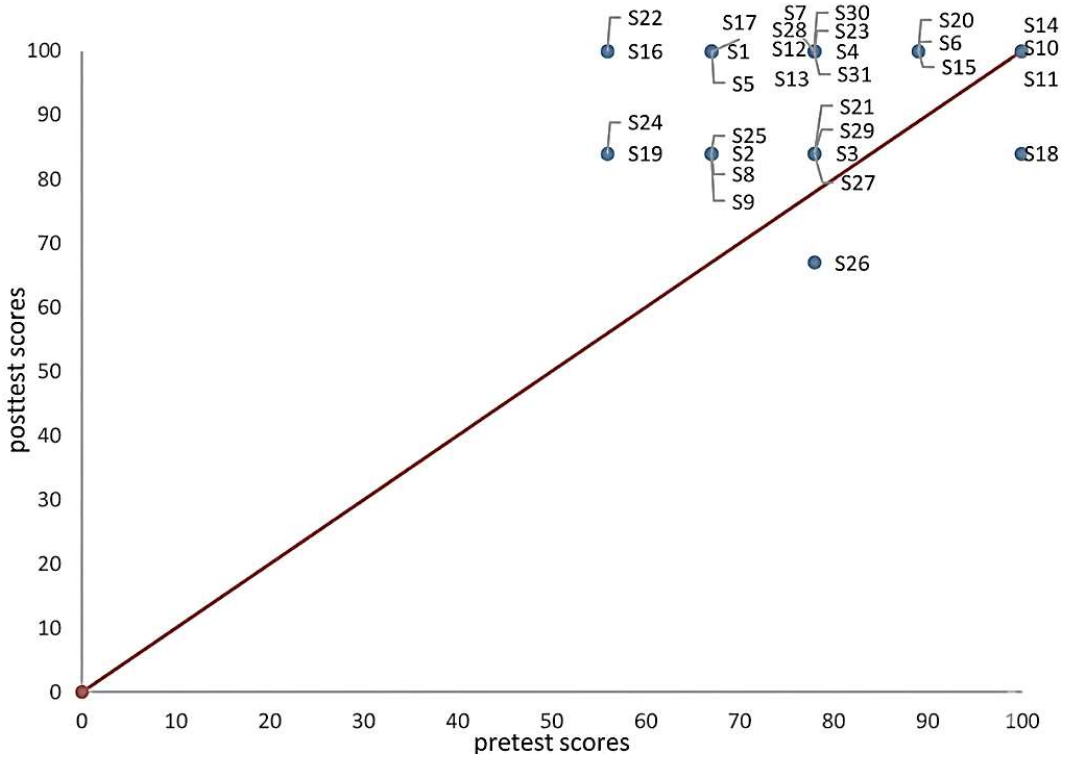


Figure 10. Distribution of pre-test and post-test scores of students

Based on the scatter graph comparing pre-test and post-test scores, most data points are above the diagonal line ($y = x$), indicating that most students experienced an increase in scores after the implementation of the PjBL-based Educational Game that Integrates Mathematics

and Local Culture Learning, namely "Uno Math Culture". This distribution shows that Project-Based Learning combined with educational games and local cultural contexts has a positive impact on students' overall learning outcomes. Thus, this data distribution shows that the learning provided is effective, given the significant improvement in overall learning outcomes after implementation. In the scatter plot, the number of points shown appears to be fewer than the actual number of participants analyzed because some participants had identical pre-test and post-test scores. Thus, these identical score pairs are represented at the same coordinates on the graph, overlap in the data, and visually appear as a single point, even though they represent more than one participant.

Table 5. Results of the paired sample t-test effectiveness

Paired Sample Test									
		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% confidence interval of the difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Pre test Post test	-16.677	14.734	2.646	-22.081	-11.273	-6.568	30	.000

Based on the results of the paired sample t-test in Table 5, a significance value (2-tailed) of 0.000 was obtained, which is less than the significance level of 0.05 ($p < 0.05$). This indicates a statistically significant difference between the students' pre-test and post-test results. The mean difference of -16.677 indicates that post-test scores are significantly higher than pre-test scores. The negative sign appears because the calculation was done by subtracting the pre-test score from the post-test score (pre-test minus post-test), so that the negative difference indicates an increase in learning outcomes after the treatment was given. The standard deviation of 14.734 indicates variation in the increase in scores among students, while the standard error of the mean of 2.646 indicates that the estimated average difference is quite stable. In addition, the 95% confidence interval ranges from -22.081 to -11.273. Since the entire interval range does not cross zero, it can be ascertained that the increase that occurred was not caused by mere coincidence but truly reflected the effect of the treatment. The t-value of -6.568, with 30 degrees of freedom (df), further reinforces that the difference is significant. In addition to statistical significance, an effect size analysis was conducted using Cohen's d to determine the magnitude of the intervention's impact. The Cohen's d value obtained was 1.13, which falls into the large effect category (Cohen, 1988). Thus, it can be concluded that the use of PjBL-based educational games to integrate mathematics learning with local culture in senior high schools has been statistically shown to be effective in improving student learning outcomes.

Evaluation

After the learning process, an evaluation was conducted to assess the suitability of the Uno Math Culture educational game as a PjBL-based learning medium that integrates mathematics and learning about local culture in senior high schools. Uno Math Culture learning begins with the presentation of contextual cultural issues embedded in Uno cards that students must analyze and solve. The teacher introduces cards featuring problems related to local Blitar products, particularly traditional food packaging familiar to students' daily lives. In addition, students are directed to work collaboratively in groups to

explore the information on each card, identify variables, and formulate mathematical models that represent the context. Group discussions are intended to allow students to express ideas, test strategies such as elimination or substitution, and experiment with different approaches to solving the system. The mechanism of matching cards, collecting points, and strategically responding to challenge cards encourages active participation and the negotiation of meaning among group members. After completing the game phase, students present their findings as structured worksheets or project posters, representing the product stage in PjBL.

A series of learning activities, ranging from contextual problem identification and collaborative modeling to solution verification and project presentation, is arranged in accordance with the stages of Project-Based Learning. Cultural context cards trigger the essential questioning stage, challenge cards guide students in project planning, collaborative modeling represents the investigation stage, poster creation reflects project development, and worksheet-based reflection serves as evaluation and revision, so that students are repeatedly involved in identifying variables, constructing equations, validating solutions, and interpreting results in a meaningful context.

The local cultural elements used in the game, namely familiar Blitar food products, proved effective in attracting students' interest by creating cognitive proximity between abstract algebraic symbols and real-life situations. When learning is contextualized to students' lives, this material is easier to visualize and relate to the surrounding environment. The validation results from three academics and one practitioner showed a validity level of 86.40%, categorized as "highly valid." In contrast, the student response questionnaire showed a practicality level of 85.32%, categorized as "highly practical." In terms of effectiveness, this product significantly improves student learning outcomes ($t(30) = -6.568, p < 0.05$) with a large effect size. Overall, the development of PjBL-based educational games that integrate mathematics with learning about local culture is valid, practical, and effective for learning.

The unique features of Uno Math Culture support the development of mathematical literacy. Modeling-based challenge cards require students to translate contextual information into algebraic formulations. The use of color and symbol systems helps students classify problem types and organize solution strategies. The economic-cultural scenarios require interpretation and validation of results, strengthening argumentation and decision-making skills. Reflection through structured worksheets encourages students to communicate mathematical arguments clearly. Through this process, students develop the ability to formulate, apply, and interpret mathematics, which are core components of mathematical literacy. During implementation, some students made procedural errors, such as eliminating variables simultaneously, inconsistently defining variables, or applying substitutions too early without analyzing the system's structure. However, the PjBL framework provided opportunities for conceptual clarification. Group discussions required students to justify their reasoning, compare alternative strategies, and revise incorrect procedures before presenting their final results. This collaborative reflection process allowed misunderstandings to be identified and corrected systematically. Therefore, the effectiveness of this intervention can be explained not only by the presence of games but also by the placement of game mechanisms within a structured pedagogical cycle that encourages reasoning, reflection, and conceptual validation.

Research by Yumova, Yumov, Bulgatova, & Garmaeva (2024) supports the general effectiveness of educational games in enhancing motivation and logical thinking; however, the

present study contributes by explaining how these improvements occur through a structured learning mechanism. In this study, integrating Project-Based Learning (PjBL) into game design required students to collaboratively analyze contextual problems, formulate systems of three-variable linear equations, and justify their solution strategies through tangible project outputs. The use of local cultural contexts, such as Blitar's distinctive products, functioned not merely as visual decoration but as meaningful problem scenarios that demanded mathematical modeling and interpretation. Through iterative gameplay and project completion, students repeatedly engaged in identifying variables, constructing equations, and evaluating solution validity, thereby strengthening conceptual understanding of SPLTV rather than relying on procedural memorization. This finding aligns with Putri, Astawa, & Suharta (2025), who argue that culturally contextualized mathematics learning enhances students' sense-making processes and deepens conceptual comprehension.

From a pedagogical perspective, the application of the Project-Based Learning (PjBL) approach in Uno Math Culture has been shown to encourage students to think critically and actively throughout the learning process. This is in line with studies conducted by Effendi et al. (2023), which found that project-based learning increases student engagement and responsibility in understanding mathematical concepts. Additionally, Gokhool et al. (2022) add that incorporating real-world project contexts into mathematics learning can strengthen problem-solving skills. Therefore, Uno Math Culture makes an innovative contribution by harmoniously integrating PjBL contexts and local cultural contexts, which have not been comprehensively examined in previous studies. From an operational perspective, the survey results show that students find it easy to access this game and understand its instructions. These findings are consistent with the results of a study on educational games that can create focus and time efficiency in the learning process. Thus, the user experience aspect of Uno Math Culture is optimal because it successfully combines technical ease and aesthetic value in a single medium.

Thus, the novelty of this study lies in combining educational games with the Project-Based Learning (PjBL) approach and the local cultural context in mathematics learning, thereby simultaneously increasing motivation, activity, and mathematical thinking skills. The integration of educational games, Project-Based Learning (PjBL), and local cultural contexts in this study shows that learning innovation is effective when content, teaching methodology, and contextual relevance operate synergistically. Unlike previous studies that primarily used educational games to increase motivation or treated PjBL separately from contextual game mechanisms, this study shows that the deliberate alignment of game structure with PjBL stages serves as cognitive scaffolding for mathematical modeling. The large effect sizes obtained in this study indicate that the intervention successfully improved not only procedural competence but also conceptual understanding and active engagement. Overall, the development of Uno Math Culture demonstrates that combining educational games, Project-Based Learning (PjBL), and local cultural context can support the implementation of learning innovation while also fostering students' appreciation of local wisdom. This confirms that mathematics learning not only focuses on cognitive abilities but also serves as a means of character building and strengthening national cultural identity.

However, this study was conducted with a relatively small sample from a single class and did not include a control group, which constitutes a significant limitation. As a result, the findings primarily reflect the specific characteristics, learning habits, and classroom dynamics of this

particular group of students, and may not accurately represent the broader population of high school students. Consequently, the interpretation of the results should be approached with caution, as factors such as differences in prior knowledge, motivation, cultural background, or school resources in other settings could influence the effectiveness of educational games integrated with PjBL and local cultural contexts. In practical terms, while the study provides useful insights into implementing the learning model in this context, further research with larger, more diverse samples and comparative designs is necessary to confirm whether similar outcomes would be achieved across different student populations and educational environments.

CONCLUSION

This study aims to develop and evaluate PjBL-based educational games that integrate mathematics learning with local culture in senior high schools. The findings indicate that Uno Math Culture meets validity criteria based on expert judgment, demonstrates high practicality, as reflected in positive student responses, and shows strong effectiveness in supporting students' understanding of the three-variable linear equation system. However, further development is required, given the limitations of this study, particularly the restricted research subject group, which comprised students from a single school context. Future studies are therefore recommended to implement the media across more diverse student populations and school settings to examine their adaptability, scalability, and relevance in broader learning environments. Thus, this research is expected to provide implications both theoretically and practically. Theoretically, this study contributes to the development of educational games based on Project-Based Learning (PjBL) that integrate mathematics learning with local culture, particularly on three-variable linear equation systems at the senior high school level. The findings of this study enrich theoretical discussions by showing how culturally contextual project-based games can support the understanding of mathematical concepts. In practice, the results of this study provide an alternative learning medium for educators that is cooperative, engaging, and effective in fostering motivation to learn and deepening students' understanding of mathematical concepts, while also serving as a valuable reference for researchers developing innovative learning media in future studies.

DECLARATION OF GENERATIVE AI USAGE IN THE WRITING PROCESS

During the drafting of this manuscript, the author(s) utilized generative artificial intelligence tools (ChatGPT, OpenAI) for the purpose of refining sentence structure, improving academic language clarity, and assisting in bilingual translation (Indonesian–English). Following the use of this tool, the author(s) reviewed and revised the content as necessary and accept full responsibility for the final content of the article.

REFERENCES

Ababil, D., Purwasi, L. A., & Nugroho, K. U. Z. (2025). Systematic literature review: design of mathematics modules based on ethnomathematics. *Global Education Journal*, *3*(2).

Acquah, E. O., Szelei, N., & Katz, H. T. (2020). Using modelling to make culturally responsive pedagogy explicit in preservice teacher education in Finland. *British Educational Research Journal*, *46*(1), 122-139.

Akbar, S. (2013). *Instrumen perangkat pembelajaran [Teaching instruments]*. PT Remaja Rosdakarya.

Al Khateeb, M. A. (2019). Effect of mobile gaming on mathematical achievement

among 4th graders. *International Journal of Emerging Technologies in Learning*, *14*(7).

Andang, S, & Hadi, A. M. (2025). Integrating ethnomathematics into digital learning materials to enhance junior high school students' geometry problem solving skills. *Multidisciplinary Science Journal*, *8*(5).

Andriani, D., Widada, W., Herawaty, D., Ardy, H., Nugroho, K. U. Z., Ma'rifah, N., … Anggoro, A. F. D. (2020). Understanding the number concepts through learning Connected Mathematics (CM): A local cultural approach. *Universal Journal of Educational Research*, *8*(3), 1055-1061.

Arianti, A. S., Pamungkas, G. Z., Hambali, Y. A., Anisyah, A., & Supriadi, O. A. (2024). Designing RPG-Based education game with discovery learning model for vocational high school. *Journal of Engineering Science and Technology*, *19*(3), 911-925.

Baog., I. W., Bartolome., J. L. D., Hayo., M. A. D., Agbon., A. J. N., & Roferos, G. V. M. (2024). Unlocking mathematical success: a qualitative case study on grade 10 learners' challenges and triumphs with the DAMATH Strategy. *International Journal of Research and Innovation in Social Science*, *VIII*(VI), 1124-1133.

Bernini, M. A. M., Carvalho, A. L., & Carlos-Bender, J. (2019). Project-based learning: video game development as a tool to integrate ecology, genetics, evolution and informatics. *Revista Saúde & Diversidade*, *3*(2), 82-87.

Branch, R. M. (2010). Instructional design: The ADDIE approach. In *Instructional Design: The ADDIE Approach*. https://doi.org/10.1007/978-0-387-09506-6

Chi, D. N. (2023). Benefits of implementing project-based learning in an english for business course. *Journal of Ethnic and Cultural Studies*, *10*(3), 55-71.

Cicchetti, D. V. (1994). Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology. *Psychological Assessment*, *6*(4), 284.

Darmayanti, R., Baiduri, B., & Inganah, S. (2022). Moodle-Based learning media development of flex model in improving mathematical hard skills of high school students. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *11*(4), 2649-2665

Delport, D. H. (2019). Numeracy students' perspectives on a new digital learning tool at a South African university. *South African Journal of Higher Education*, *33*(5).

Dewi, I. L. K., Zaenuri, Dwijanto, & Mulyono. (2020). Identification of mathematics prospective teachers' conceptual understanding in determining solutions of linear equation systems. *European Journal of Educational Research*, *10*(3), 1157-1170.

Dewi, P., Razak, M., Asrul, B. E. W., & Wahyuningsih, P. (2022). *Perancangan game edukasi labirin matematika dengan algoritma linear congruent method berbasis android* [designing an educational math maze game using the linear congruent method algorithm based on android]. *Jurnal It*, *13*(1), 44–49.

Djubaedi, D., Rohadi, T., Hidayat, A., & Kodama, Y. (2024). Analysis of entrepreneurship core competency and curriculum integrated with local culture and products. *International Journal of Evaluation and Research in Education*, *13*(5), 3526-3534.

Effendi, M. M., Ummah, S. K., & Cahyono, H. (2023). Teacher perspective and performance in curriculum prototype

implementation through the development of innovative project-based learning modules. *Mosharafa: Jurnal Pendidikan Matematika*, *12*(1), 47–58.

Fang, M., Liu, Y., Hu, C., Huang, J., & Wu, L. (2024). An entrepreneurial education game for effectively Tracing the knowledge structure of college students - based on adaptive algorithms. *Entertainment Computing*, *49,* 100632.

Fisher, D., Kusumah, Y. S., & Dahlan, J. A. (2020, October). Project-based learning in mathematics: A literature review. In *Journal of Physics: Conference Series* (Vol. 1657, No. 1, p. 012032). IOP Publishing.

Gokhool, F., Lawson, D., Hodds, M., & Aslam, F. (2022). Exploring differential engagement with mathematics support from an engineering student focus. *Teaching Mathematics and Its Applications*, *41*(4), 292-304.

Hsieh, W., & Donahue, M. (2010). Risk and resilience frameworks in understanding special education. *International Encyclopedia of Education (3rd ed.)*.

Ke, F., Dai, C. P., & West, L. (2024). Mathematical experience in game-based problem-solving. *Journal of Computer Assisted Learning*, *40*(3), 1083-1097.

Kuncoro, K., Hidayat, A., Nadzeri, M. B., Juandi, D., Hendriyanto, A., & Meirani, F. (2025). Thinking beyond the equations: a deep dive into reflective thinking for mathematics learning. *Participatory Educational Research*, *12*(5), 310-334.

Lee, J., & Paul, N. (2023). A review of pedagogical approaches for improved engagement and learning outcomes in mathematics. *Journal of Student Research*, *12*(3), 1-9.

Long, C. S., Subramaniam, K., Harrell, P. E., Harris, M., & Thompson, R. (2025). Novice secondary teachers' developing beliefs on implementing project-based learning. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*(6), em2652.

Maros, M., Korenkova, M., Fila, M., Levicky, M., & Schoberova, M. (2023). Project-based learning and its effectiveness: evidence from Slovakia. *Interactive Learning Environments*, *31*(7), 4147-4155.

Matthew, G., Pelser-Carstens, V., Bunt, L., & Bunt, B. (2025, October). Enhancing student engagement and knowledge retention through game-based learning: a comprehensive framework integrating game design and learning theories. In *Proceedings of the 18th European Conference on Game-Based Learning*. Academic Conferences and Publishing Limited.

Myers, C., Piccolo, L., & Collins, T. (2023). Democratising the design of educational games for social change: an approach based on critical pedagogy. *Journal of Learning for Development*, *10*(1), 55–74.

Nagamalla, L., Geedipally, V. R., Bandu, U., & Suryadevara, G. (2024). Impact of project based learning (pjbl) on creativity, communication, and adaptability among engineering students: a journey from classroom to community for sustainable solutions. *Journal of Engineering Education Transformations*, *38*(Special Issue 1).

Nurhuda, A., Al Khoiron, M. F., Azami, Y. S. I., & Ni'mah, S. J. (2023). Constructivism learning theory in education: characteristics, steps and learning models. *Research in Education and Rehabilitation*, *6*(2), 234-242.

Putri, P. E. W., Astawa, I. W. P., & Suharta, I.

G. P. (2025). Integrating PjBL-STEAM with balinese meru architecture to enhance students' mathematical conceptual understanding. *International Journal of Education, Management, and Technology*, *3*(2), 516-524.

Ratri, D. P., Rachmajanti, S., Anugerahwati, M., Laksmi, E. D., & Gozali, A. (2025). Fostering cultural competence: developing an English syllabus for young learners in the Indonesian EFL context with emphasis on local culture to maintain students' identity. *Cogent Education*, *12*(1), 2440177.

Rosyadi, A. A. P., Wardani, S. S., & Cholily, Y. M. (2025). Development of mathematical monopoly game to improve mathematical communication ability. *Al-Jabar/ : Jurnal Pendidikan Matematika*, *16*(1), 391–408.

Sarkar, D. (2025). Redefining quality education in the 21st century: a holistic approach to learning. *International Journal For Multidisciplinary Research*, *7*(2).

Sharma, L. R. (2025). Culture as a reflection of heritage and identity: a thematic analysis. *Journal of Foreign Languages Cultures and Civilizations*, *13*, 124–132.

Videnovik, M., Trajkovik, V., Kiønig, L. V., & Vold, T. (2020). Increasing quality of learning experience using augmented reality educational games. *Multimedia Tools and Applications*, *79*(33–34).

Wesley Nero, S., & Donley, K. (2024). Culturally and linguistically responsive pedagogy: Examining teachers' conceptualizations of affirmative instructional practices for multilingual learners. *TESOL Journal*, *15*(4), e881.

Yumova, T. Z., Yumov, I. B., Bulgatova, E. N., & Garmaeva, T. I. (2024). Enhancing students' motivation in studying mathematics disciplines: The effectiveness of applying contextual and gaming technologies. *Science for Education Today*, *14*(2).

Zhao, L., Zhao, B., & Li, C. (2023). Alignment analysis of teaching–learning-assessment within the classroom: how teachers implement project-based learning under the curriculum standards. *Disciplinary and Interdisciplinary Science Education Research*, *5*(1).