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Development of Augmented Reality (AR) Learning Media Based on Ethnomathematics for MSME Business: Improving Students' Numeracy and Entrepreneurial Character

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ABSTRACT

The gap between formal mathematics learning and real business practices results in the low relevance of learning materials in improving numeracy skills and shaping entrepreneurial character in students. Responding to this urgency, this study aims to identify content components and compile initial design specifications (Blueprint) for Ethnomathematics-based Augmented Reality (AR) Learning Media for Doormat Craft MSMEs in Karangrejo, Pasuruan. The method applied is Research and Development (R&D) at the ADDIE (Need Assessment) model analysis stage. Data collection was conducted through interviews with teachers and Systematic Literature Studies (for needs and context analysis), as well as documentation of phenomenological studies (available data) on doormat craft MSMEs (for authentic content analysis). The instruments used include interview guidelines and an Ethnomathematics concept mapping matrix. The main findings indicate a significant need for AR media that can contextualize relevant mathematical concepts—such as calculating raw material ratios and determining price margins—into interactive business scenarios. This in-depth analysis resulted in an AR application Blueprint, which details the content flow and digital interaction model, while ensuring that the Ethnomathematics content explored can be transformed into 3D AR interactive objects. This design specification makes a substantial contribution to this research, by providing a strong empirical foundation for the further development of learning technologies that are effective in improving business numeracy literacy and entrepreneurial behavior in students.

Keywords: Augmented Reality, Entrepreneurial Character, Ethnomathematics, MSME Business, Numeracy.

INTRODUCTION

Contemporary labor market dynamics and global transformation have shifted the educational paradigm, with 21st-century competencies becoming the primary foundation for individual success. Two critical competencies currently in demand are numeracy literacy and entrepreneurial character. (Inganah et al., 2023; Istiningsih et al., 2022). Numerical literacy goes beyond formal calculations and involves the ability to apply mathematical concepts to analyze, solve problems, and make decisions in everyday life (Munthahana et al., 2023). Furthermore, entrepreneurial character, which includes creativity, courage to take risks, and the ability to overcome business challenges, is very important to face international competition and meet human resource development needs (Kusuma et al., 2022). However, empirical evidence suggests a substantial gap between these competencies and traditional school learning. Mathematics education, which is generally abstract and poorly connected to real-world

contexts, results in poor numeracy skills and limited entrepreneurial character development in students (Darmayanti & Sugianto, 2022). Therefore, fundamental innovation is needed in learning media that can integrate mathematical material interactively and meaningfully.

To address the gap between current curricula and practical competency needs, the application of educational technology offers a potential alternative (Baharuddin & Hatta, 2024; Kusumawati et al., 2025). Augmented Reality (AR) is an innovative technology that has proven effective in providing immersive, visual, and contextual learning experiences (Lubis et al., 2021; Sutarto et al., 2022). Augmented Reality (AR) is an innovative technology that has proven effective in providing immersive, visual, and contextual learning experiences (Fajria Septiani, 2024; Inganah et al., 2023; Susanto, 2024). Previous studies have shown that digital learning media can significantly improve students' critical thinking skills and learning motivation (Aldora Pratama et al., 2025; Darmayanti & Sugianto, 2022; Putri, 2024). Through the use of AR, student participation in the learning process can be significantly increased, encouraging critical thinking, and supporting a comprehensive understanding of mathematical concepts through authentic problem-solving situations (Handayani et al., 2025; Umam et al., 2024). Thus, AR serves as an effective learning ecosystem in mimicking real-world challenges in the classroom, thereby preparing students for practical applications.

The effectiveness of augmented reality (AR) is largely determined by the quality and relevance of the content delivered. Therefore, an ethnomematics approach is applied as a pedagogical framework to optimize the impact of AR media (BIN FRANS RESI et al., 2024; Munthahana et al., 2023; Nurniyati et al., 2024). Ethnomematics refers to studies that recognize that mathematics is not simply a collection of formal rules, but rather a cultural practice that emerges from everyday activities and local communities (Munthahana et al., 2023). The application of ethnomematics has been proven effective in improving students' numeracy literacy because it can connect abstract mathematical concepts with contexts that are meaningful and familiar to students, so that learning becomes more relevant and related to aspects of everyday life (Lubis et al., 2021; Sutarto et al., 2022). Through the integration of AR and ethnomathematics, learning media has the potential to create authentic educational experiences, transforming cultural or local phenomena into interactive mathematical objects for students to explore. This innovative combination successfully combines advanced technology with local wisdom to create a more immersive educational experience (Trisna, 2019).

To produce substantial Ethnomathematics content closely related to entrepreneurial character development, this research focuses on the Micro, Small, and Medium Enterprises (MSMEs) sector. The handicraft sector is an example of a labor-intensive business, with significant added value (high percentage of value added) and great potential for job creation (Mahasamudram et al., 2024). The specific research location is a doormat craft MSME in Karangrejo Village, Purwosari District, Pasuruan Regency, East Java Province, which has been recognized as a center for doormat craftsmen. The business practices of this MSME intrinsically include "Business Calculation Logic" which has a strong link to Formal Mathematics concepts, including

the calculation of raw material ratios, profit margin percentages, linear production cost functions, and resource optimization. Thus, the exploration of Business Ethnomathematics of this MSME through a phenomenological study approach will serve as an important primary empirical data source for the development of Augmented Reality (AR) media content.

Initial analysis revealed the need for authentic and contextual learning media. Although numerical literacy and entrepreneurial character development are recognized as important elements, available learning resources have not been able to establish direct links between mathematical concepts and business practices in real-world contexts. This learning problem stems from the abstract presentation of mathematical concepts, when they should be applied to business logic, such as calculating break-even points or profit percentages. This research positions a phenomenological study (an exploration of Business Ethnomathematics) as an integral component in the Analysis Phase (A) of the ADDIE Research and Development (R&D) model, specifically as a Content Analysis. This comprehensive analysis, supported by interviews with teachers and observations of MSME locations, aims to formulate the identified gap: Authentic Augmented Reality (AR) media is needed to hone Business Logic through the local context of doormat crafts.

Previous research has shown the effectiveness of Augmented Reality (AR) in mathematics learning and the contribution of Ethnomathematics to improving numeracy skills (Munthahana et al., 2023; Sutarto et al., 2022). Examples include the development of an Ethnomathematics-based electronic module for three-dimensional geometry (Astrianingsih et al., 2024; Sutarto et al., 2022) and Ethnomathematic analysis of historic building architecture (Sulistiawati et al., 2022). However, a substantial gap in the analysis has been identified: the development of AR media that explicitly incorporates in-depth exploration of the Business Calculation Logic (Business Ethnomathematics) of certain Micro, Small, and Medium Enterprises (MSMEs), specifically doormat crafts in Karangrejo, to simultaneously train numeracy skills and entrepreneurial values, has not been adequately optimized. Most research related to AR and Ethnomathematics focuses more on the aspects of form and pattern, rather than the dimensions of accounting and financial decision-making processes. Thus, the novelty or scientific innovation of this research lies in the application of **MSME Business Ethnomathematics as the main element of content to produce authentic AR Media Design Specifications and provide a dual impact on numeracy skills and entrepreneurial competencies.**

This research is designed as an initial phase of Research and Development (R&D) by applying the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model (Astrianingsih et al., 2024; Cahyadi, 2019; Inganah et al., 2023; Spatioti et al., 2022). The justification for study limitations in the Analysis Phase aims to ensure that the resulting augmented reality (AR) media has a strong empirical basis and is in accordance with user needs. This problem-solving approach begins with an in-depth analysis that includes four main aspects: 1) Identification of learning problems, 2) Analysis of student and environmental characteristics, 3) Analysis of the ethnomematic

content of MSME businesses through phenomenological studies, and 4) Analysis of the feasibility of AR technology. This rigorous framework ensures that the results in the form of Initial Design Specifications (Blueprint) are based on practical needs in the field, not solely on theoretical aspects.

This Analysis phase essentially encompasses Content Analysis and Technology Analysis. Content Analysis, which focuses on Business Ethnomathematics, involves mapping the Business Calculation Logic of the Karangrejo Doormat MSME to Formal Mathematics concepts. This activity produces an Authentic Content Module, which is a list of mathematical concepts that will be realized as Augmented Reality (AR) objects, such as calculating margin percentages and applying linear functions in the context of production costs. Next, Technology Analysis, related to AR Feasibility, includes an in-depth documentation review of educational AR media and similar development platforms, such as Unity and ARCore. The ultimate goal is the development of an Initial Design Specification, or Blueprint, detailing the content framework, user interaction flows, and minimum technology requirements for AR media development. This Blueprint serves as a direct solution from the analysis phase to facilitate the transition to the Design phase of the R&D process.

Based on the context of the problem background, gap analysis, and research and development justification, the main objective of this research is to produce a valid and adequate Initial Design Specification (Blueprint) for Ethnomathematics-Based Augmented Reality Learning Media for MSME Doormat Craft Businesses as an empirical basis for the Design Phase (D) in the ADDIE model. Specifically, this research aims to: (1) identify needs and gaps in learning numeracy skills and entrepreneurial character; (2) explore and map the Calculation Logic of MSME Doormats as authentic ethnomathematics materials; and (3) determine the appropriate Augmented Reality technical specifications for the visualization of these materials. The proposed research hypothesis states that the Initial Design Specification (Blueprint) for Ethnomathematics-Based Augmented Reality Learning Media for MSME Businesses produced through the ADDIE Analysis Phase meets the standards of validity and technical feasibility as a basis for developing innovative learning media that can effectively improve students' numeracy skills and entrepreneurial character (Kusuma et al., 2022; Munthahana et al., 2023).

METHOD

This research design is a component of Research and Development (R&D) that applies the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). However, this research is specifically limited to the Analysis Phase (A) of the ADDIE model to ensure that the developed Augmented Reality (AR) media has a strong empirical basis and is on target in meeting user needs (needs assessment). This Analysis Phase is comprehensive, including: 1) Identification of learning problems (Needs Assessment) through teacher interviews and a systematic literature review, 2) Analysis of student characteristics and learning contexts, 3) Analysis of ethnomematic content of MSME businesses through phenomenological studies, and 4) Analysis of AR

technology feasibility (Technology Analysis). The specific outcome of this design is the Initial Design Specification (Blueprint) for AR media, which serves as a solution for the analysis phase leading to the Design Phase (D). This design strictly ensures that the Blueprint is based on practical needs in the field, connecting abstract mathematical concepts with the real-world business logic of MSMEs in the doormat craft sector. The type of research applied is Research and Development (R&D), which aims to produce Initial Design Specifications for innovative learning media. The R&D model adopted is ADDIE (Analysis, Design, Development, Implementation, and Evaluation). This study focuses exclusively on the Analysis Stage of the ADDIE model, which serves as a Needs Assessment. This stage was chosen to bridge the substantial gap between the demands of numeracy and entrepreneurial competencies and the quality of conventional mathematics learning, which tends to be abstract and lacking in context. This research specifically aims to produce a Blueprint detailing the content flow and digital interaction model, as an empirical prerequisite for proceeding to the Design (D) stage. Therefore, this research is a formative R&D study in the early stages that serves as the foundation for the entire product development process.

The research approach used is Comprehensive Analysis within the ADDIE Analysis Stage framework. The core of this approach is an Ethnomathematics Content Analysis of MSME Businesses through a phenomenological study of MSME doormat craftsmen. This phenomenological study aims to explore the "Business Calculation Logic" inherent in MSME practices, such as raw material ratio calculations, profit margin percentages, and linear production cost functions. This approach specifically maps business calculation logic to Formal Mathematics concepts, which are then processed into interactive 3D AR objects. This approach ensures authentic and relevant AR media content, addressing analytical gaps by focusing on the accounting and financial decision-making aspects of MSMEs, rather than just geometric shapes and patterns.

The specific research location for exploring business ethnomematics content is a doormat craft MSME in Karangrejo Village, Purwosari District, Pasuruan Regency, East Java Province. This location was identified as a center for doormat craftsmen whose business practices are labor-intensive and have significant potential for job creation. Research subjects included Mathematics teachers (for interviews regarding learning needs and gaps) and doormat craft MSME operators (as key informants for the phenomenological study/authentic content analysis). MSME operators served as the primary subjects because they possess empirical data on Business Calculation Logic, which is essential for developing AR media content. This selection of location and subjects ensured the relevance and authenticity of the local context, which is a key element in the effectiveness of ethnomematics in improving numeracy literacy.

Data collection was conducted using three main techniques: 1) Interviews, 2) Systematic Literature Review, and 3) Phenomenological Study Documentation. Structured interviews were conducted with teachers to identify the needs and gaps in numeracy learning and students' entrepreneurial character. Systematic Literature Review was applied for needs and context analysis, including the feasibility evaluation of AR technology and development platforms (such as Unity, ARCore). The main technique

used was Phenomenological Study Documentation on doormat craft MSMEs, which serves as Authentic Content Analysis. The documented data are existing data from MSMEs' business practices, such as production cost data and profit margins, which are crucial for mapping their Business Calculation Logic to Formal Mathematical concepts.

Table 1 presents a summary of Data Collection Techniques, Subjects, and Objectives.

Table 1. Summary of Data Collection Techniques and Their Objectives

No	Data collection technique	Subject/Data Source	Purpose of Data Collection
1.	Interview	Math teacher	Identifying needs and gaps in numeracy and entrepreneurship learning.
2.	Systematic Literature Study	Journal, Curriculum, AR Technical Report	Analysis of context needs and feasibility of AR technology (development platform).
3.	Documentation of Phenomenological Studies	MSMEs in the doormat craft industry	Authentic content analysis and excavation of Business Calculation Logic (Business Ethnomathematics).

Table 1. Summary of Data Collection Techniques and Their Objectives This table details the three main data collection methods used in the Analysis Phase (A) of the R&D: Interviews with teachers for needs, Literature Study for context and technology, and Phenomenological Documentation on MSMEs for authentic content of Business Ethnomathematics.

Applied data analysis techniques focused on interpreting qualitative data from the needs and context analysis phases. Data from teacher interviews and a literature review were analyzed to identify learning gaps and determine appropriate AR technical specifications. The core of the data analysis was a Business Ethnomathematics Content Analysis. This analysis involved mapping the Business Calculation Logic of the Keset Karangrejo MSME (e.g., raw material ratio data and profit percentage) to Formal Mathematics concepts (e.g., Ratio Calculation, Margin Percentage, Linear Function of Production Cost). This activity substantially resulted in an Authentic Content Module, a specific list of mathematical concepts that can be visualized as interactive 3D AR objects. This analysis was supported by observations of the MSME's location and aimed to conclude the need for authentic AR Media to train Business Logic through a local context. As an integral component of this analysis phase, a Technology Analysis (AR Feasibility) was conducted through an in-depth documentation review of educational AR media and similar development platforms (e.g., Unity, ARCore). This comprehensive analysis of Business Ethnomathematics Content and AR Technology Feasibility directly guided the formulation of the Initial Design Specification (Blueprint), ensuring that

authentic content could be transformed into a technically feasible 3D AR interactive object. Thus, the Blueprint formulation is an integrative result of content and technology analysis.

The primary instruments used in this study were an interview guide and an ethnomathematics concept mapping matrix. The interview guide was used to collect data from teachers regarding learning needs and gaps, particularly regarding the low relevance of mathematics materials in improving students' numeracy skills and entrepreneurial character. The ethnomathematics concept mapping matrix was a key instrument designed to process and organize data obtained from the Phenomenological Study of MSMEs producing doormats. This matrix served to systematically identify and map authentic MSME Business Calculation Logic (such as calculating the break-even point or profit percentage) to Formal Mathematical concepts. The result of this mapping was an Authentic Content Module, which served as the basis for formulating the Initial Design Specification (Blueprint) for the AR media, detailing the content framework and user interaction flow.

Although this study focused solely on the R&D Analysis Phase, the validity and accuracy of the data were established through triangulation of sources and methods. The validity of the primary data was supported by a Phenomenological Study of MSMEs and in-depth interviews with teachers, ensuring that the data used as ethnomathematics content (Business Calculation Logic) was empirical and authentic from the local context. The validity of the Blueprint content is supported by a systematic Content Analysis, which explicitly maps MSME business practices to relevant formal mathematical concepts (e.g., Raw Material Ratio, Price Margin Percentage). Furthermore, the technical feasibility of the Initial Design Specification (Blueprint) is ensured through an in-depth Technology Analysis of similar AR media and optimal development platforms (e.g., Unity, ARCore). The results of this analysis produce an Initial Design Specification that serves as a solid empirical foundation for further development, meeting the validity criteria as a basis for the Design Phase (D) of the ADDIE model.

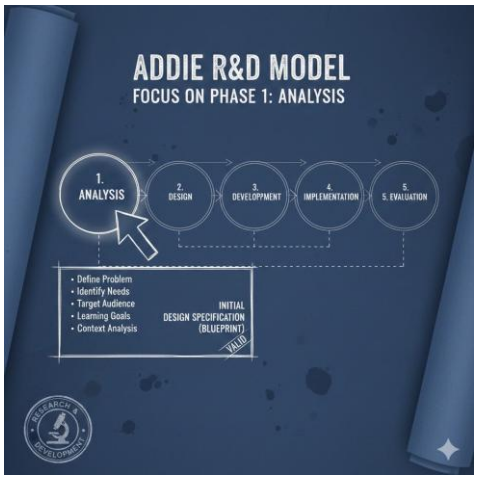

Figure 1. Illustration of the ADDIE Research and Development (R&D)

Figure . represents the five-step model used in research and development (R&D). This research focuses exclusively on the first step, Analysis, to produce a valid Initial Design Specification (Blueprint) before proceeding to the Design, Development, Implementation, and Evaluation. The main limitation of this research is its limited scope in the Analysis Phase (A) of the ADDIE model. This means that the research results only consist of an Initial Design Specification (Blueprint) and an Authentic Content Module, without producing an AR media product that is ready for implementation and evaluation. This limitation is deliberate (rationalization) to ensure that the AR media to be developed in the next stage has a strong empirical foundation and accurately meets user needs (needs assessment), avoiding the development of irrelevant products. In addition, the ethnomematics content explored is limited to the business context of doormat craft MSMEs in Karangrejo, Pasuruan, and specifically focuses on Business Calculation Logic (Financial Logic), which may not cover all aspects of ethnomematics (e.g., geometric patterns). This limitation opens up opportunities for further research, where the resulting Blueprint will be used as an empirical basis to proceed to the Design Phase (D) and beyond.

RESULTS AND DISCUSSION

Result

1. Analysis Results

   The results of the needs and context analysis are presented to identify gaps and the urgency of developing learning media.

   1.1 Presentation of Current Learning

   Interviews with third-grade elementary school mathematics teachers indicate that current learning tends to be text-centered and utilizes conventional methods such as lectures and practice exercises. The learning process generally begins with the presentation of material, followed by feedback, and then moves on to the core material using teacher handbooks, student worksheets, and student books.

   These findings are visually demonstrated in Figure 2. Teacher Handbook. This figure demonstrates a focus on text-dominated material delivery and one-way interaction, which directly hinders contextual and interactive learning experiences.

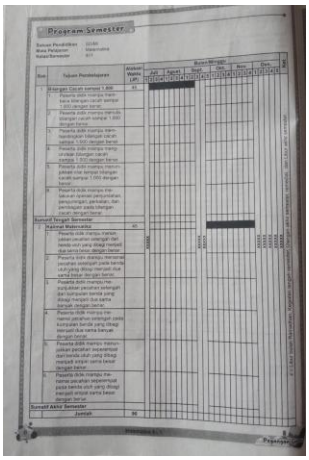

Figure 2. Teacher's Handbook

1.2 Use of Learning Media and Need Gap

Although teachers have used visual media such as scales, rulers, and measuring tapes (meters) for the material on units of weight and length, these media are limited to physical measuring tools and do not yet connect the mathematics material to real-life contexts or local businesses.

The main gap (need gap) identified is between the mathematics material in schools and authentic mathematics practices in the students' environment. This is despite the fact that some students' parents own businesses, such as doormat crafts, chip making, and mushroom cultivation. This gap reinforces the urgency of developing more contextual, interactive, and relevant media for local businesses to improve students' numeracy and entrepreneurial character.

2. Results of Local Business Context (Business Ethnomathematics)

Context analysis was conducted through observation and phenomenological studies on the Doormat Craft MSME in Karangrejo Village, Pasuruan, which is known as a center for doormat craftsmen.

Figure 3. Documentation of Doormat Craft MSMEs in Karangrejo

This authentic MSME activity offers a rich context for ethnomathematics practices. Observation and interview findings indicate that the doormat-making process inherently involves Financial Logic and other formal mathematical concepts:

- Geometry and Measurement: Used to design sizes, shapes, and cut patterns precisely as in Figure 4 and Figure 5. Example: measuring the area/circumference of a doormat.

Figure 4. Knitted Doormat Product

Figure 5. Pearl Doormat Product

- Social/Business Arithmetic: Used routinely in calculating Cost of Goods Sold (COGS), determining profit margins, analyzing profit/loss, and calculating workers' wages.

- Logic of HPP/Authentic Pricing: Based on the practices of MSMEs, the HPP is calculated by entering the details of Raw Materials (2 kg @ Rp. 600.00) = Rp. 1,200.00 and Labor = Rp. 1,000.00, with a total of Rp. 2,200.00, which is then rounded up to an estimated capital of Rp. 3,000.00 per unit of doormat. The selling price is set at Rp. 4,000.00 per unit.
- Ratios and Percentages: Calculations of raw material ratios, profit margin percentages, and waste efficiency are routinely performed.

- Simple Statistics: Used to record and monitor daily/monthly production quantities, manage raw material stock, and summarize sales data.

This authentic practice, especially regarding the calculation of COGS and determination of selling prices, is the primary basis for the AR media content that will be developed.

3. Initial Design Specifications (Blueprint) for AR Media Based on Business Ethnomathematics

Based on the needs and context analysis, the following are the initial design specifications for the AR media to be developed (Blueprint): Based on the needs and context analysis, the following are the initial design specifications for the AR media to be developed (Blueprint):

- Media Goals and Targets

  This media aims to facilitate the understanding of the concepts of Social Arithmetic (COGS, Profit, Loss, Margin) and Geometry (Area and Perimeter) through simulations of the production process and business strategies of doormat craft MSMEs, thereby improving students' Numeracy and Entrepreneurial Character. The target users are 3rd grade Elementary School students, with the potential for developing materials for upper grades.

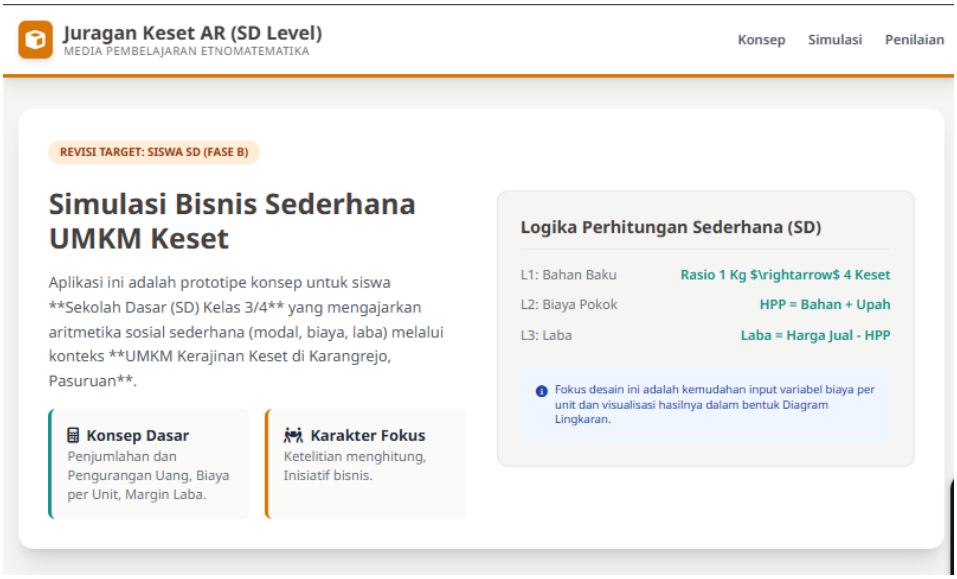

Figure 6. AR Media Design

- Ethnomathematics Content Components
  This content focuses on authentic MSME practices mapped to formal mathematical concepts:
  - Numeracy: Includes calculating the cost of goods sold per unit, determining the selling price with a certain margin, calculating the percentage of product waste/rejects, measuring the area/circumference of the mat, and recording stock.
  - Entrepreneurial Character: Training characters such as Initiative, Accuracy (in calculations and measurements), and Responsibility (waste management).
- AR Content Flow and Interaction Model
  The AR interaction design is designed to explicitly transform the MSME Business Calculation Logic into an interactive and visual learning experience. This interaction is divided into three main stages:
  1) Preliminary Stage: Explanation of the context of the Karangrejo Doormat Home Industry.
  2) AR Interaction Stage: The user will scan a marker/image (e.g., a doormat or waste material image) to reveal a 3D virtual object. The interactions that occur are:
     - Geometry Visualization: A 3D model of the doormat will appear, used to simulate area and perimeter measurements. Students can interact directly with the virtual doormat as if it were in their real environment.
     - Interactive Business Process Simulation (Financial Logic): Students will be presented with a simple and intuitive interface (simulation interface) to input real business variables extracted from MSMEs, such as Raw Material Price per Kg and Labor Wage Cost per unit.
       - Based on student input, the application will automatically calculate the COGS per unit, Selling Price, and Profit Margin Percentage.

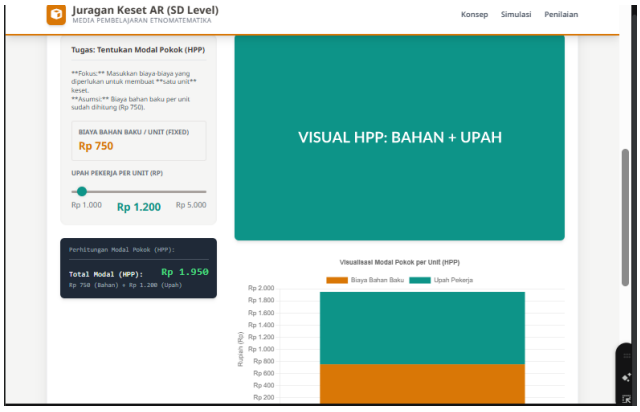

Figure 7. HPP Simulation

- Real-time Visualization: Abstract calculation results (e.g., Profit or Loss) will be visualized into an Interactive 3D Model that changes in real-time in the student's real-world environment. For example, if the student sets a selling price that generates a high profit, a larger stack of money (a profit symbol) and/or a more attractive product display will appear next to the virtual doormat. Conversely, if a loss occurs, the 3D model of the stack of money will decrease or display a "Loss" indicator. This simulation effectively visualizes abstract mathematical calculations.

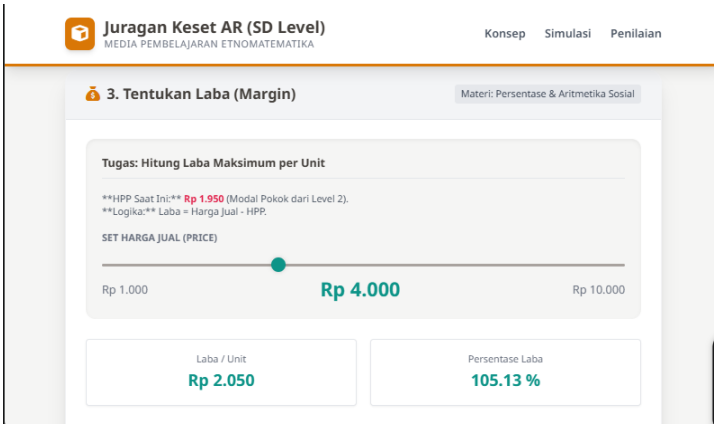

Figure 8. Real-time Visualization

- AR media at this stage can be visualized through Figure 9.

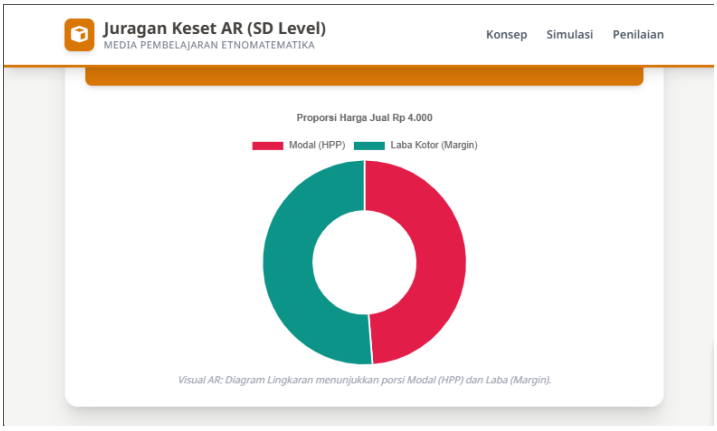

Figure 9. Proportion of Selling Price

- Evaluation Stage: Contains contextual practice questions adapted from real MSME business practices (for example, calculating profits in the event of a loss/product rejection).

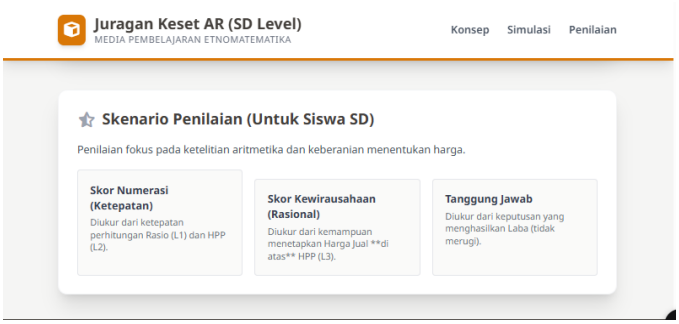

Figure 10. Assessment Scenario

Discussion

1. Interpretation of Development Needs and Solutions

The findings presented in Figure 2 of the Teacher's Handbook indicate that although educators have used visual media such as scales and meters, the learning process has not been fully integrated with students' local resource potential. This situation creates a gap between formal mathematics (abstract concepts) and the business realities of students' environments, potentially reducing numeracy understanding and hindering the development of entrepreneurial character. This limitation of conventional media aligns with previous research. For example, (Munthahana et al., 2023) emphasized in their literature review that Ethnomathematics has been proven effective in improving students' numeracy literacy because it bridges abstract mathematical concepts with contexts that are meaningful and familiar to students, so that learning becomes more relevant and connected to everyday life. Similarly, research by (Wardani et al., 2023) shows that mathematical concepts connected to local wisdom can serve as a basis for designing ethnomathematics-based learning processes that are more interesting, meaningful, and contextual.

The proposed solution involves integrating Business Ethnomathematics by utilizing the context of the Home Doormat Craft Industry in Karangrejo as a learning resource. The identified authentic practices, such as calculating capital, profit, and waste utilization, directly accommodate the concepts of social arithmetic and measurement taught at the elementary school level. The application of this context makes mathematics more meaningful and concrete, which is consistent with constructivist theory in education.

2. The Role of AR Technology

Augmented Reality (AR) technology was chosen because of its unparalleled ability to blend the virtual and real worlds, which is essential for learning Business Ethnomathematics. AR overcomes the fundamental limitations of conventional visual media (such as physical scales, meters, or static diagrams) currently used by teachers. Conventional tools are only able to represent data or objects in a limited and discrete manner, and fail to visualize abstract mathematical concepts in a dynamic and immersive manner.

The Advantages of AR in Learning

- Abstract Calculation Visualization: AR allows virtual objects (e.g., simulated 3D models of raw materials or craft products) and business calculation data (such as Cost of Goods Sold/COGS and Profit Margin) to be overlaid directly onto students' physical environments. This transforms abstract mathematical calculations into concrete, interactive simulations, making it easier for students to understand

how each variable (weight, size, cost) contributes to the final calculation result.
    - Example: Students can scan raw materials, and AR immediately displays a dynamic COGS calculation based on quantity, replacing the need for static and less responsive physical scales/meters.
- Immersive and Interactive Learning Experiences (Numeracy): AR technology explicitly connects Business Ethnomathematics (e.g., COGS and Margin) with Numeracy through interactive simulations. These interactions place students in authentic business scenarios, where they must use their numeracy skills to analyze, process data, and make real-time decisions.
- Enhancing Entrepreneurial Skills: AR-enabled business decision-making scenarios directly facilitate the development of Entrepreneurship. Students can manipulate variables in the simulation (e.g., changing the selling price or production quantity) and immediately see the visual and numerical impact on their Profit Margin, enabling strategic business decision-making practice in a risk-free environment.

Therefore, AR provides a much more immersive and interactive experience, effectively bridging the gap between traditional business practices (Ethnomathematics) and the understanding of abstract Numeracy concepts, as well as fostering Entrepreneurial capabilities.

3. The Relationship between Concepts and Media Characteristics

The resulting Initial Design Specification (Blue Print) explicitly links the three main elements of the research:

- Ethnomathematics → Numeracy: Authentic Business Arithmetic concepts (COGS, Margin, and Profit calculations) used by MSMEs will be transformed into interactive AR simulations. Through these interactive scenarios, students directly practice numeracy skills by calculating business variables. This approach makes abstract mathematical concepts such as ratios and percentages more realistic and contextual. This aligns with literature findings that confirm that *Ethnomathematics has been proven to play a significant role in improving students' numeracy literacy* (Munthahana et al., 2023; Simamora et al., 2023; Sudarso et al., 2023) because it makes learning more meaningful and contextual.
- Ethnomathematics → Entrepreneurship: Focusing on innovation (such as waste utilization) and out-of-town marketing reach will be integrated as case studies in AR media. By simulating the business decision-making process and managing production variables, this media implicitly trains entrepreneurial character traits such as initiative, accuracy (in calculations), and responsibility (resource management)—prominent characteristics possessed by successful entrepreneurs in Karangrejo. Developing entrepreneurial character through online learning media (including digital technology) has proven crucial for facing global competition and the demands of human resource development (Ambarwati et al., 2023; Kusuma et al., 2022; Silvester et al., 2021).

Overall, this AR media is designed to address the gap between school mathematics and business realities. The integration of Augmented Reality technology significantly overcomes the limitations of conventional visual media (scales/meters) by providing a more immersive and interactive experience in visualizing abstract mathematical calculations (such as COGS and Margin). This approach aligns with recommendations from similar studies that suggest integrating local culture and technology to improve the quality of mathematics learning.

4. Limitations and Implications of the Analysis Stage

This comprehensive analysis phase has successfully validated the urgency of media development (Needs Analysis) and identified rich ethnomathematics resources (Context Analysis) in MSME business practices. These findings confirm the significant gap between conventional, abstract mathematics learning and the real needs of 21st-century numeracy and entrepreneurship competencies. Therefore, its main output, the Initial Design Specification (Blueprint), is not merely a technical document, but rather a strong empirical foundation that will directly guide the visual design and programming process in the subsequent Design Phase (D) of the ADDIE model. The importance of this empirical foundation is in line with the view (Reigeluth & An, 2020) which emphasizes the need to align the instructional design process with learner-centered theory, ensuring the developed product is relevant to the needs of real users. In this context, Blue Print ensures that the development of AR media will focus on the Karangrejo MSME Business Calculation Logic, ensuring the authenticity of Ethnomathematics content.

However, the implementation of this analysis phase faced important limitations. Some business owners declined further observations, arguing that it would "not answer the observation questions." This refusal limited the depth of authentic data that could be obtained and indicated potential barriers to the adoption or openness to technology-based educational interventions among MSMEs. This limitation reinforces the recommendation for further research. The implication is the need for more deliberate engagement strategies in the future. Future research should explore barriers to digital technology adoption among MSMEs (including sociocultural aspects) to ensure the successful implementation and adoption of AR media, as suggested by (Al-Azawei & Al-Masoudy, 2020) regarding the importance of considering demographic and behavioral factors in virtual learning environments.

CONCLUSIONS AND SUGGESTIONS

This research demonstrates the urgency and feasibility of developing Augmented Reality (AR)-based learning media for ethnomathematics in doormat-making MSMEs. This is driven by the gap between abstract school mathematics concepts and real-world business practices in the local context. Through the Analysis Phase (A) of the ADDIE model, this phenomenological study of MSMEs in Karangrejo successfully mapped and validated authentic business calculation logic (financial logic), such as determining cost of goods sold (COGS) and profit margins, into formal mathematical concepts. The main outcome of this research is a technically valid Initial Design Specification (Blueprint), which provides a strong empirical foundation for further development of innovative learning technologies, explicitly aimed at improving numeracy skills and instilling entrepreneurial character in students. The focus on MSME financial logic as the core content makes this Blueprint a unique and strong empirical foundation for further development of innovative learning technologies.

Therefore, the next Design stage should clarify the visualization of identified MSME practices through two main focuses: first, designing an effective Augmented Reality (AR) sign, using product images or waste raw materials as triggers to display interactive 3D models that provide an immersive experience; and second, creating a simple and intuitive simulation interface to calculate Cost of Goods Sold (COGS) and Profit, where the design should prioritize ease of use for Elementary School students by making raw material costs and labor wage data the main variables that are easy to input and visualize the results.

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