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# DESIGN OF VIRTUAL REALITY-BASED ELEMENTARY SCHOOL SOCIAL ARITHMETIC LEARNING GAME WITH ETHNOMATHEMATICS APPROACH

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## Abstract

Given the importance of mathematics and students' need for optimal mathematical abilities, alternative solutions are needed to solve these problems. The development of learning resource products in virtual reality-based learning media with an ethnomathematics approach can be used by students to learn an alternative solution to these problems so that learning is based on the latest technological developments. Furthermore, the development of learning media using an ethnomathematics approach has proven to increase students' interest and motivation to learn, which can improve students' mathematics learning outcomes. Social arithmetic is one of the subjects in mathematics that studies the basic operations of a number related to everyday life, which is quite interesting for teachers and students if presented with learning media. The ethnomathematics approach used in this Research focuses on community activities in Riau Islands Province. The cultural product taken from the Riau Islands region is Luti Gendang. This Research designs a virtual reality-based elementary school social arithmetic learning game with an ethnomathematics approach using the research and development method through the ADDIE model. This model consists of five steps: analysis, design, development, implementation, and evaluation. The five stages are summarized into three parts: planning, development, and evaluation. This Research focuses on the first part, namely planning. The planning part consists of two stages: analysis in the form of needs assessment and design. The needs analysis stage involves gathering information to identify problems related to learning media development. This process includes interviews with math teachers to understand the needs of learners through teachers in learning social arithmetic. This analysis also includes an examination of material needs, learning objectives, and learner needs, as well as an analysis of the culture in the Riau Islands (Batam) relevant to the material. In addition, there is also a design stage. The design stage was carried out by developing a plan for the product development process. The initial steps were determining the software that would be used to develop the media, creating image displays to illustrate, and completing the material obtained from various sites.

Keywords: Learning game, ethnomathematics approach, social arithmetic, virtual reality, learning media.

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## 1 INTRODUCTION

Students are expected to have five abilities outlined by the *National Council of Teachers of* Mathematics (NCTM, 2000): problem-solving, reasoning, communication, connection, and representation (Hutagaol, 2013). Facts on the ground show that these five standards in learning mathematics at the primary school level in Indonesia still need to be adequately met. The lack of mathematical ability to answer the questions given results from students' inability to understand and remember learning materials, which impacts low learning outcomes (Nurfitriyana, 2021; Oktaviani et al., 2020). These results are reinforced by the results of the *Program for International Student Assessment* (PISA) and *Trends in International Mathematics and Science Study (*TIMSS), which state the low mathematical abilities of Indonesian students at the international level (Alwathoni et al., 2021; Hadi & Novaliyosi, 2019).

Given the importance of mathematics and students' need for optimal mathematical abilities, alternative solutions are needed to solve these problems. One alternative to solving this problem is to create learning resource products in the form of teaching materials that students can use to learn. In addition, it has been proven that developing teaching materials through an ethnomathematics approach can increase student motivation and interest in learning (Rahmawati & Marsigit, 2017; Rizal et al., 2021). Ethnomathematics examines the culture of the surrounding community so that it brings out mathematics in real learning (Setiana et al., 2021). This makes it easier for students to understand math concepts, thus improving their math learning outcomes.

Social arithmetic is a subject in mathematics that examines basic operations on numbers that are relevant to everyday life. This subject is very interesting for teachers and students when presented with educational media (Friantini et al., 2020). Learning social arithmetic provides students with an experience related to financial literacy. Social arithmetic is an area of mathematics that focuses on the basics of addition, subtraction, multiplication, and division to enable students to apply these concepts in everyday life (Harahap, 2010). The ethnomathematics approach used in this Research focuses on community activities in Riau Islands Province. The cultural product taken from the Riau Islands region is Luti Gendang. Luti Gendang is a savory pastry filled with shredded fish or fried chicken. In Riau Islands Province, Luti Gendang originates from the border area of the Anambas Islands. Wheat flour, milk, eggs, butter, and sugar are used to make this bread. The inside is shredded tuna fish seasoned with

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shallots, chili, and traditional Malay spices. The oval shape of the bread is meant to highlight its unique character and delicious savory taste.

Several researchers have conducted several related studies. Zaenuri and Dwidayati (2018) have started the analysis of EthnomathematicsEthnomathematics and obtained the results of the concept of social arithmetic, which can be found as a cultural product from Semarang City. Wulandari (2020) conducted an ethnomathematics analysis on Jambi's specialties to obtain learning instruments for social arithmetic material. The same findings were presented by Pramesti and Rasmanto (2021), who mentioned that the mathematical concept that can be integrated into the activities of the coastal community of Wonokerto, Pekalongan Regency, is social arithmetic. The findings show that social arithmetic can be found in several buying and selling activities, so further Research is needed.

Along with the rapid advancement of technology, various kinds of technology-based learning media are currently available. One of the learning media that is currently being developed and can be implemented in the learning process is *Virtual Reality* (VR) media. According to Zulmaulida et al. (2021), VR is a technology that allows users to engage with a three-dimensional (3D) environment that is as similar as possible to the real world. Users (in this case, students) can experience different experiences by being taken to another world through VR media.

Ariatama et al. (2021) also stated in their article that VR technology is a method of presenting learning images in three-dimensional media, commonly called 3D. This procedure is carried out with the help of computer components to ensure the results look more realistic and with the help of several other essential devices. This will create the illusion that users (students) are physically present in a predetermined environment. VR can create an interactive learning environment and offer learning experiences that encouraging students' abstract thinking and communication. This is one of its advantages (Fernandez, 2017). Learning mathematics with VR can be a means to achieve mathematics education's goals because of its many benefits. The low proficiency of Indonesian students in mathematics, as evidenced by the PISA 2022 study, is expected to be overcome by VR, which is expected to be an innovation and a solution to the challenges of mathematics education.

A positive innovation in education is using *games* as a teaching method. Various models and types of *games* are used as learning media to increase student motivation, understanding, and learning outcomes (Hermawan et al., 2017). Pramuditya et al. (2018) reinforces this opinion(Pramuditya, S. A., Noto, M. S., & Purwono, 2018). Educational games are one of the innovative learning media solutions available. Educational games can be created as learning media that are interesting, fun, have a storyline, and are expected to improve students' math comprehension skills.

The formulation of this research problem relates to optimizing the application of Ethnomathematics in learning social arithmetic through *virtual reality* media at the primary school level in Indonesia. Although Ethnomathematics has been recognized to increase students' mathematical interest and understanding by integrating local cultural elements, *virtual reality* technology as a mathematics learning medium still needs to be improved, especially in incorporating relevant cultural aspects. Therefore, this study intends to develop and evaluate the effectiveness of a virtual reality game based on Ethnomathematics to improve students' understanding and engagement in social arithmetic. As such, this Research will explore how the design of EthnomathematicsEthnomathematics in a VR context can facilitate a more immersive and multicultural learning experience in mathematics.

This study aimed to design a *virtual reality game* using Ethnomathematics to improve students' understanding of social arithmetic. The game was designed to improve math skills and give students a deeper understanding of how math is related to their daily lives and culture. Despite its great potential as a learning medium, *virtual reality* needs to integrate cultural aspects into mathematics learning. Most mathematics learning content development still ignores the influence of culture on the way students understand and absorb mathematics knowledge. This study fills that gap by incorporating Ethnomathematics as a cultural framework in virtual reality game design to enhance students' understanding and engagement in learning social arithmetic. By integrating Ethnomathematics in mathematics learning through virtual reality, this Research has the potential to offer a more effective and enjoyable approach to the acquisition of social arithmetic mathematics materials at the primary school level. This improves mathematical skills and fosters and recognizes cultural diversity in education. The study is also anticipated to provide new insights for curriculum and educational technology developers on how technology can support inclusive and multicultural learning.

## 2 METHODOLOGY

*Research and Development* (R&D) is the methodology used to develop this VR educational game. According to Sugiyono (2017), Research and development is a methodology used to produce products and evaluate their efficacy. The ADDIE paradigm, a systematic learning

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design model, was used in this development. Romiszowski (in Ma'ruf, 2021) reveals the procedural aspects of the systems approach; systematics has been applied in various methodological practices for the design and development of computer-based learning materials, audiovisual materials, and texts at the level of learning materials design and development.

The steps in making this mobile learning application were adapted from the ADDIE development model. The ADDIE model was organized in a systematic sequence of activities to address learning challenges related to learning resources that meet the needs and characteristics of learners. This paradigm was chosen for its systematic development and theoretical foundation in learning design. It consists of five stages: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. The five stages are summarized into three components: planning, development, and evaluation.

This investigation will last for two years. The planning and development part will be placed 2024 for the first year. Planning is the initial part of this investigation. The evaluation segment will be carried out in the following year. The planning part consists of two stages*: analysis in the* form of a *needs assessment* and *design*. The needs analysis stage entails gathering information to identify problems related to learning media development. This process includes interviews with math teachers to understand the needs of learners through teachers in learning social arithmetic. This analysis also included an examination of material needs, learning objectives, and learner needs, including an analysis of the culture in the Riau Islands (Batam) that is relevant to the material. In addition, there was also a *design* stage, which was a continuation of the analysis stage. The analysis results from the previous stage were used to design and develop VR media. In the product development process, the design stage involves preparing a plan. The initial stage was determining the software that would be used to create the media. Then, an image display was created to complement and illustrate the material content sourced from various websites. The images include *backgrounds*, buttons, and supporting images made using Corel-Draw x7 and Canva software (Sugiyono, 2017).

Based on the needs analysis of teachers and students, data collection was carried out through questionnaires and needs analysis by experts through interviews. The data collection results in needs analysis were used in the next stage, namely planning. In addition, at this early stage, a literature review was conducted. This aimed to identify theoretical concepts in determining the appropriate stages in the product development process (Sukmadinata, 2006).

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## 3 FINDINGS AND DISCUSSION

The findings of this study are the design of a VR-based elementary school social arithmetic learning game application named "SIVIRA: Social Arithmetic *Virtual Reality* Application". The learning game that has been designed must use VR devices. The content of this media includes VR simulations, materials, learning videos, exams, and media and developer information aligned with the findings of the student and teacher needs analysis. The following description of the research procedure will be conducted in the first year, with particular emphasis on planning.

### 3.1 Teacher Need Analysis

The student needs analysis stage was carried out on 45 teachers and students of the PGSD FKIP UT Study Program who filled out the questionnaire. The data collection stage occurred at UT Batam between June 11 and 24, 2024. Questionnaire responses showed that all teachers felt they understood social arithmetic material well. In addition, 85% also know the variety of social arithmetic taught at the elementary school level. There were 15% of teachers who did not know the variety, indicating a need for additional training or learning resources. Responses showed that all teachers felt they could teach this material well, although 10% needed more understanding of related aspects, such as discounts, selling prices, and interest.

Despite this high level of understanding, there needs to be more between understanding the material and effective teaching practices, as reflected in the difficulties encountered in teaching the material. This shows that theoretical understanding only sometimes goes hand in hand with the ability to communicate these concepts to students effectively. This is shown through the results of the questionnaire, where 70% of teachers use discussions, 30% use lectures, 50% use presentations, and 80% use practice problems. In reviewing the teaching approaches used, teachers generally place a strong emphasis on practice problems to deepen students' understanding. One factor that hinders students' ability to understand the material is the number of practice questions and monotonous discussions that they consider less attractive.

80% of teachers have used technology in teaching, with tools such as whiteboards and markers used by all respondents and PowerPoint or ICT used by 60%. However, 20% of teachers still need to integrate technology in their teaching. Although most teachers already use some form of technology, such as ICT and PowerPoint, responses show these technologies have yet to be fully effective in overcoming the problem of students' aversion to the material. This suggests that it is essential to use technology and integrate it into the teaching strategy.

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All teachers experienced obstacles in teaching with the main issues, including difficulty applying concepts (30%), students' difficulty in calculating multiplication by large numbers (30%), and the need for more exciting and interactive learning media (40%). These difficulties highlight the importance of developing more interactive and supportive learning resources that overcome these barriers and enrich students' learning experiences. Introducing more interactive and innovative learning methods, such as educational *games* and *virtual reality*, can provide a more immersive and engaging learning experience. Mastery of mathematics is a dynamic and active process involving constructing concepts and principles, not just static and passive learning (Rusnandi et al., 2016).

To overcome these difficulties, 40% of teachers have tried to make educational games for social arithmetic, 60% have increased practice problems, and 20% have used learning videos. It shows creative efforts in adopting more interactive and exciting methods to improve student understanding. Turmudi (2008) argues that students are not yet to be actively involved in mathematics acquisition. Furthermore, he emphasized that mathematics learning has been done in an informative way, which means that students are only given information by the teacher. As a result, the level of "engagement" is also considered minimal. In this type of learning, students need to be more involved in identifying the lesson concepts they must understand. This causes the given concepts not to be embedded in the students' memory, so they quickly forget the material and often need clarification when trying to solve problems different from those demonstrated by their instructor. Consequently, it is imperative to develop and distribute learning materials that allow students to be actively and dynamically involved in the learning process and understand mathematical concepts, thus enabling them to recognize the relationship between mathematics and other concepts.

Most students find math boring (Nuraini & Edy, 2017). Because math concepts are abstract, learning becomes more abstract. Educators must be able to facilitate engaging, innovative, and inventive math learning activities. Learning media is one of the factors that can increase fun and interest in learning math. In the learning process, *virtual reality media* is one of the options. Innovative *mobile learning* media facilitates the learning process by making it more exciting and straightforward, thus increasing its effectiveness (Huang et al., 2016).

The overwhelmingly positive response to using educational games, with 100% of teachers agreeing that educational games for social arithmetic should be used as learning media, shows excellent potential for adopting game-based learning tools. These teachers were also

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unanimously (100%) interested in using educational games in the learning process, signaling their readiness to integrate this innovative approach into their teaching. Nowadays, the utilization of technological media significantly influences the learning process (Sakat et al., 2012). As a result, advanced technology can create more innovative and inventive learning media. Teachers also agreed that features such as learning videos and practice questions in educational games would be helpful. In addition, integrating social arithmetic material in the game with an ethnopedagogical approach - using elements of local culture - was seen as an innovative way to make the material more relevant and exciting for students.

The integration of Ethno pedagogy in teaching social arithmetic offers an opportunity to enrich students' learning experiences by considering their cultural background and local context. Using this method, social arithmetic is not only taught as an abstract concept but as an integral part of students' lives and culture. If implemented effectively, ethnopedagogy can facilitate the connection between theory and practice and between school and community. The responses showed that most teachers agreed with integrating social arithmetic materials into local culture or traditions through educational games. Almost all respondents agreed that the ethnopedagogical approach in educational games can facilitate understanding of the material and increase students' interest in learning. It shows strong support for adopting this method more widely in the curriculum. It has been proven that Ethnomathematics examines the culture of the surrounding community to bring mathematics to life in learning (Setiana et al., 2021). It makes it easier for students to understand math concepts, thus improving their math learning outcomes.

Teachers' strong support for using educational games that integrate ethnopedagogy suggests the potential for further development in this area. Creating educational games that focus on aspects of local culture and economy could be an effective way to facilitate more immersive and enjoyable learning of social arithmetic. Technology like *virtual reality* (VR) could also be expanded to provide a richer and more engaging immersive experience.

### 3.2 Expert Need Analysis

Based on interviews conducted with experts, learning social arithmetic material is considered quite tricky because it depends on numeracy and language comprehension factors.

*"Arithmetic learning in elementary schools today is generally still abstract and still uses some kind of illustration, so it requires more concrete learning. Moreover, it requires numeracy skills and understanding of the soil well. If there is no such thing, it will be difficult for students to*

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*understand the material. Moreover, social arithmetic in learning in elementary school is math in everyday life. This is very important to teach because there are many benefits, one of which is to facilitate transactions in buying and selling activities."*

This statement is consistent with Research that shows students' challenges in social arithmetic are exacerbated by their lack of language skills, which include the inability to understand or interpret questions and retell them in their native language. Secondly, students faced challenges in the prerequisite aspects, particularly in the language aspect. This resulted in a lack of concept understanding, an inability to record what was known and required, and difficulty determining formulas. Lastly, students need help with applied aspects, particularly in the calculation process, which prevents them from concluding the responses to the questions (Dila & Zanthy, 2020). This requires the utilization of effective learning media to understand social arithmetic material. Incorporating engaging learning media into the educational process can inspire students to develop new interests and desires, increase their motivation to learn, and even have beneficial psychological effects (Azhar, 2017).

Experts have stated that the capacity to understand and execute arithmetic operations to answer the questions presented is critical to learning social arithmetic materials.

*"There are several skills needed in learning arithmetic material, namely literacy and numeracy skills, analytical skills (critical thinking), problem solving skills."*

Numeracy literacy is essential for students because it can help them understand social arithmetic material. Numeracy literacy is a valuable skill that is essential for students to excel in various fields and compete on a global scale. Numeracy literacy applies to *Science, Technology, Engineering, and Mathematics* (STEM). The *Program for International Student Assessment* (PISA) is one of the international standards that can be used to assess or measure numeracy literacy (Lane et al., 2019). The latest results for 2023 were released by the *Organization for Economic Cooperation and Development* (OECD), the institution that organizes the PISA program. Regarding scores, Indonesia did move up five places in math and numeracy literacy skills; however, there was a 13-point drop from the 2018 results. Indonesia's math score was 366, 106 points lower than the global average. Math literacy and numeracy were the areas with limited skills below level two. The percentage is *82%* (OECD, 2022). This shows that there is still a significant need for improvements in numeracy literacy and mathematics education, as numeracy literacy is an essential skill that all individuals in the contemporary era need. Numeracy literacy enables individuals to acquire, describe, analyze, utilize, and communicate

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mathematical symbols. These mathematical symbols can solve problems, make judgments, and make decisions (Perdana & Suswandari, 2021; Rakhmawati & Mustadi, 2022; Sari et al., 2021). The learning process is then evaluated against the completed building materials. For example, an expert statement:

*"The main evaluation is that most learning processes are still guided by printed books and lecture methods...Learning is also not creative because it does not utilize media or technological developments."*

Printed book content is considered less than optimal because of the need for concrete examples to understand social arithmetic material, which cannot be achieved only through text and images. VR technology supplements and media in the form of books can help educators deliver creative 3D visualizations in printed books, thus facilitating understanding and interest (Abdillah et al., 2020). VR technology has the potential to significantly improve the quality of learning during the educational process and support learning activities by integrating the real world with the virtual world, thus solving this problem (Nincarean et al., 2013).

The interview process conducted with informants (experts) gave opinions related to learning interesting social arithmetic material, namely, the exploration process through concrete things to reduce learning boredom.

*"Using media following technological developments*

*"Interesting social arithmetic learning is by applying directly in real life reinforced with interesting props."*

*"Making learning interesting and meaningful for students can be done with something that is close and remembered by them, namely by utilizing gadgets in the application of social arithmetic ... Because the times in this technological era are very supportive of that."*

*"Arithmetic learning will be more interesting if done by utilizing interesting media that can provide illustrations to students so that learning looks more concrete."*

*"Constructivist, Reality-based (problem-solving) learning."*

The constructivist perspective is consistent with the concept of meaningful learning in mathematics education. Students are said to understand if they generate meaning from their experiences by establishing cognitive connections between new experiences and prior mathematical knowledge rather than simply memorizing formulas and theorems (Gazali, 2016). Z.P. Dienes (in Bossé et al.) underlined the importance of manipulating objects in mathematics

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learning, as any mathematical concept or principle can only be fully understood when initially introduced to students in concrete form.

In addition, informants (experts) argue that further consideration is needed in using the ethnomathematics approach in designing materials on the learning media made.

*"This is very good because through the Ethnomathematics approach it can teach local wisdom to students. Besides, by promoting culture, it can also give appreciation to community members in the area."*

*"Learning with ethnomatics using cultural products is also very important, but of course you have to pay attention to the suitability of the material with these cultural products. For social arithmetic material, there are several subs that can be related to cultural products and this can make learning more concrete."*

This is in line with the statement that EthnomathematicsEthnomathematics plays an essential role in the integration of technological progress and the preservation of local wisdom through the application of science (Nur et al., 2020; Nuryadi et al., 2020; Permata et al., 2021). According to Putra and Mahmudah (2021), Ethnomathematics-based learning is essential in advancing science, especially for students. Using EthnomathematicsEthnomathematics in mathematics learning will facilitate abstraction, idealization, and generalization of mathematical concepts (Widada et al., 2018). Ethnomathematics is the right choice for mathematics instructors because it integrates local culture to ensure that mathematics education can be applied in a cultural context (Ilyyana & Rochmad, 2018; Irawan et al., 2018; Manoy & Purbaningrum, 2021).

The features that are needed to learn space-building material in *mobile learning* are good visualization features.

*"Good visualization features will be very useful in learning and understanding students. Menus or tools that are easy to understand and supporting designs can also attract students' interest in using them."*

Zulmaulida et al. (2021) wrote that VR is a technology that allows *users* to engage with three-dimensional (3D) environments that are as similar as possible to the real world. VR media allows *users* (in this case, students) to experience different visual experiences by taking them to different environments.

After conducting the data collection stage through needs analysis from teachers and experts, the process was continued to the planning stage. The planning stage shows the need for

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educational game applications for social arithmetic material based on *virtual reality* for learning support. These applications can improve students' mathematical abilities and facilitate the exploration of abstract concepts presented in an interesting way.

### 3.3 Application Development Planning

The learning game media to be developed is *Virtual Reality-based* and in the form of an application. Students are allowed to choose a place and time that suits their level of preparation for learning. It aligns with the principle of enjoyable learning, as the game media offers students an alternative time and location to learn without external pressure. It is an advantage of virtual applications regarding time and location, as it allows students to access materials and information at any time and from any location (Ally, 2009). Researchers are interested in developing *Virtual Reality-based* educational games on social arithmetic material. Because educational games are technology-based learning media, students can easily access information and educational materials anytime and anywhere.

One of the benefits of VR is its capacity to create interactive learning environments and offer learning experiences that enhance students' abstract thinking and communication (Fernandez, 2017). Learning mathematics with VR can be a means to achieve mathematics education's goals because of its many benefits. VR is expected to be an innovation and a solution to the challenges associated with mathematics education in Indonesia, as evidenced by the less-than-optimal performance of students in the 2022 PISA study. The utilization of *games* as an educational tool is also a constructive innovation in the field of education. Learning media aims to increase student motivation, understanding, and learning outcomes by applying various models and forms of activity (Hermawan et al., 2017). Strengthened by the opinion of Pramuditya et al. (2018), educational games are one of the solutions offered as innovative learning media. Educational games can be developed as learning media that are interesting and fun and have a series that is expected to support students' math comprehension skills. The *virtual reality-based* educational game media developed is expected to be a learning support media that can improve students' mathematics skills in social arithmetic material to make it easier to explore abstract concepts projected in an exciting form.

## 4 CONCLUSION

The Research found that most mathematics learning content still needs more attention to the influence of culture on students' mathematical understanding. Therefore, this Research seeks to fill this gap by incorporating ethnomathematics elements that allow students to understand mathematics in a broad cultural context relevant to their daily lives. Preliminary results show that integrating Ethnomathematics in mathematics learning through VR can provide a more effective and enjoyable methodology, especially in improving students' mathematical engagement and understanding. This Research also offers insights for curriculum and educational technology developers on the importance of incorporating cultural aspects in mathematics learning to create a more inclusive and multicultural learning experience.

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