



Ethnomathematics-Based Edutainment: Exploring the Enhancement of Mathematical Reasoning Skills Through Video Games

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Abstrak

Penelitian ini bertujuan untuk mengembangkan permainan visual novel berbasis etnomatematika yang diberi nama "EtnoMath," untuk meningkatkan kemampuan penalaran matematis siswa pada materi pecahan. Permainan ini dikembangkan sebagai respons terhadap kesulitan siswa dalam memahami konsep penalaran matematis yang menyebabkan rendahnya hasil belajar. Penelitian ini menggunakan pendekatan Research & Development (R&D) dengan model Alessi & Trollip yang terdiri dari tiga tahap: perencanaan, desain, dan pengembangan. Validasi ahli (konten dan media), analisis praktikalitas, dan analisis efektivitas produk dilakukan sebagai bagian dari proses evaluasi. Teknik pengumpulan data meliputi kuesioner validasi, kuesioner praktikalitas guru dan siswa, serta tes kemampuan penalaran matematis. Hasil penelitian menunjukkan bahwa "EtnoMath" memenuhi kriteria sebagai media yang valid, praktis, dan efektif, dengan skor validitas media sebesar 88% (sangat valid) dan skor validitas konten sebesar 90% (sangat valid). Tingkat praktikalitas dinilai 84% oleh guru dan 84% oleh siswa (kedua-duanya sangat praktis). Analisis efektivitas, baik dari tes penguasaan individu maupun klasikal, menunjukkan bahwa penguasaan siswa melebihi 80% pada uji lapangan. Pengujian efektivitas menggunakan uji t sampel tunggal menunjukkan peningkatan yang signifikan pada skor pasca-tes ($M = 87,25$, $p < 0,001$) dibandingkan dengan Kriteria Ketuntasan Minimum (KKTP = 80), sementara uji binomial mengonfirmasi bahwa semua siswa melampaui ambang batas ini ($p = 0,000$). Temuan ini menunjukkan bahwa "EtnoMath" efektif dalam meningkatkan keterampilan penalaran matematis siswa dan sesuai dengan standar pedagogis modern. Namun, penelitian ini memiliki keterbatasan, seperti kurangnya evaluasi jangka panjang dan adaptasi terhadap berbagai kebutuhan pengguna. Implikasi dari temuan ini menyoroti perlunya pengembangan lebih lanjut untuk meningkatkan fleksibilitas permainan dan memperluas aplikasinya dalam konteks pendidikan yang lebih luas.

Abstract

This study aims to develop an ethnomathematics-based visual novel game, named "EtnoMath," to enhance students' mathematical reasoning abilities in fraction material. The game was developed in response to students' difficulties in understanding mathematical reasoning concepts, which have led to low learning outcomes. This research employed a Research & Development (R&D) approach using the Alessi & Trollip model, which consists of three stages: planning, design, and development. Expert validation (content and media), practicality analysis, and product effectiveness analysis were conducted as part of the evaluation process. Data collection techniques included validation questionnaires, teacher and student practicality questionnaires, and mathematical reasoning ability tests. The results indicated that "EtnoMath" meets the criteria for being valid, practical, and effective, with a media validity score of 88% (very valid) and a content validity score of 90% (very valid). The practicality level was rated at 84% by teachers and 84% by students (both very practical). Effectiveness analysis, both from individual and classical mastery tests, showed that student mastery exceeded 80% in field trials. Effectiveness testing using a one-sample t-test showed a significant improvement in post-test scores ($M = 87.25$, $p < 0.001$) compared to the minimum mastery criterion (KKTP = 80), while a binomial test confirmed that all students exceeded this benchmark ($p = 0.000$). These findings suggest that "EtnoMath" is effective in enhancing students' mathematical reasoning skills and aligns with modern pedagogical standards. However, the study has limitations, such as a lack of long-term evaluation and adaptation to various user needs. The implications of these findings highlight the need for further development to improve the game's flexibility and expand its application in broader educational contexts.

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INTRODUCTION

The low mathematical reasoning ability among students, particularly in the topic of fractions, remains a critical concern in mathematics education across educational levels. Research consistently shows that students often struggle to grasp the concept of fractions due to its abstract nature and the difficulty of relating it to real-life contexts (Ramdani & Yurniwati, 2021). Students frequently encounter difficulties in comparing fractions, converting them into decimals, and performing basic operations such as addition and subtraction (Lubis et al., 2020). These challenges are exacerbated by traditional lecture-based teaching methods that fail to contextualize the material, limiting students' conceptual understanding (Saragih & Napitupulu, 2022). Furthermore, international assessments such as the Trends in International Mathematics and Science Study (TIMSS) reveal that Indonesian students perform poorly in mathematical reasoning tasks, particularly those involving logical applications of fraction concepts (Mullis et al., 2016). Such deficiencies hinder students' ability to tackle more complex problems that require deep understanding and logical reasoning (Haryadi & Sumartini, 2019). This situation highlights the urgent need for pedagogical innovations that foster students' mathematical reasoning skills in fraction-related topics.

Fractions are repeatedly identified in the literature as one of the most challenging mathematical concepts for students, especially when applied to contextual or real-life problems (Yunita et al., 2020; Setyaningsih & Maryono, 2022). One key factor contributing to this difficulty is the lack of culturally relevant instructional approaches, which could otherwise provide more meaningful and relatable learning experiences (Rahayu & Budiyo, 2019). Additionally, students' limited engagement during lessons—reflected in their low motivation and passive classroom participation—further impedes their understanding of fraction concepts (Siregar et al., 2021). These factors collectively indicate that effective fraction instruction must be both contextually and culturally responsive to enhance comprehension and reasoning.

Concerning Indonesian students' mathematical reasoning abilities, various studies and data portray an alarming trend. The 2018 Programme for International Student Assessment (PISA) ranked Indonesia 72nd out of 78 participating countries in mathematical literacy, underscoring students' limited capacity to understand and apply mathematical concepts logically and analytically (OECD, 2019). Similarly, results from Indonesia's National Examination (UN) consistently reveal that many students struggle with math problems requiring higher-order reasoning, particularly in areas such as fractions, algebra, and geometry (Mulyana, 2020). Further, Hasibuan and Amalia (2021) found that approximately 60% of Indonesian students operate at only a basic to intermediate level of mathematical reasoning, meaning they can perform routine procedures but lack deep conceptual understanding. These challenges are intensified by the absence of innovative teaching methods and the lack of learning experiences grounded in everyday contexts (Hidayati & Firman, 2019). This evidence reinforces the necessity of targeted interventions to improve students' mathematical reasoning capabilities.

A primary underlying cause of these issues is the insufficient integration of local culture into mathematics instruction, especially in the teaching of fractions. The prevailing curriculum tends to be generic and fails to accommodate students' cultural backgrounds, despite the potential of such contexts to serve as rich and relevant learning resources (Sarmiento & Moreira, 2021). Ethnomathematics, which embeds cultural elements into mathematical instruction, remains underutilized in curriculum design and classroom practice (Nur et al., 2022). When mathematics instruction is disconnected from students' cultural realities, it is often perceived as abstract and irrelevant, thereby hindering students' ability to internalize and apply key concepts (Ratnasari & Kusumah, 2018). If left unaddressed, this disconnection could have significant adverse effects—not only on individual student outcomes but also on the broader educational system. Limited mathematical reasoning skills may impede students' progress at higher education levels, where a strong grasp of foundational concepts like fractions is crucial (Rahmawati & Sugiyono, 2021). Moreover, poor understanding of such material may diminish students' overall interest in mathematics, which in turn can limit their academic success in other fields requiring quantitative skills (Nasution & Putri, 2022). In the long run, this could undermine the development of a highly

skilled workforce, particularly in disciplines that demand strong mathematical competence (Yuliani & Wahyudin, 2020).

The persistent challenges related to students' mathematical reasoning in fraction topics underscore the urgent need for educational strategies that are both contextualized and culturally responsive. Integrating ethnomathematics into the curriculum and adopting innovative pedagogical approaches can significantly enhance students' engagement and understanding, ultimately improving their reasoning abilities and academic performance across disciplines.

To address this issue, the development of edutainment-based instructional media that integrates ethnomathematics presents a promising solution worth considering. Edutainment, which merges educational content with entertainment, has been proven effective in enhancing student engagement and motivation in learning (Riyana & Sumantri, 2021; Widiastuti & Putri, 2021; Suwono & Wardhani, 2022; Mustofa & Nur, 2021; Sari & Fauzan, 2023). By employing video game-based platforms that incorporate ethnomathematical content, students are not only more actively involved in the learning process but also better able to grasp mathematical concepts through contextual and meaningful experiences (Putra et al., 2022; Juniati & Apriani, 2020; Hadi & Wahyuni, 2022; Nugraha & Lestari, 2022; Suhendi & Wulandari, 2021). This form of media is expected to make learning more engaging and relevant, thereby encouraging students to explore mathematics as it applies to their everyday lives.

This approach is particularly powerful due to the synergy between edutainment and ethnomathematics, both of which have demonstrated significant potential in enhancing the quality of mathematics education. While edutainment offers an interactive and enjoyable learning experience that fosters greater student motivation and participation (Widiastuti & Putri, 2021; Putri & Nugroho, 2021; Hidayat & Suparno, 2022; Arifin & Nasrulloh, 2023; Nugraha & Lestari, 2022), ethnomathematics provides culturally rich and relevant contexts that allow students to connect mathematical concepts with their cultural heritage, thereby deepening conceptual understanding (Juniati & Apriani, 2020; Hikmah & Ismail, 2023; Safitri & Nugraha, 2021; Sari & Fauzan, 2023; Sukarno & Widodo, 2021). Within the context of fraction learning, integrating these two approaches can make abstract concepts more concrete and applicable, ultimately enhancing students' mathematical reasoning skills (Hadi & Wahyuni, 2022; Putra et al., 2022; Riyana & Sumantri, 2021; Suwono & Wardhani, 2022; Mustofa & Nur, 2021).

This research is crucial as it offers significant contributions to the development of more effective and relevant mathematics education. By designing edutainment media grounded in ethnomathematical principles, this study provides a viable solution to longstanding challenges in fraction instruction encountered by both students and educators (Susanto & Putra, 2022; Nugraha & Lestari, 2022; Suhendi & Wulandari, 2021; Hadi & Wahyuni, 2022; Safitri & Nugraha, 2021). Moreover, its findings are expected to inform curriculum development and pedagogical strategies that are more innovative and contextually appropriate, adaptable to various regions rich in cultural diversity (Mustofa & Nur, 2021; Hikmah & Ismail, 2023; Sari & Fauzan, 2023; Juniati & Apriani, 2020; Sukarno & Widodo, 2021). Furthermore, this research may pave the way for broader explorations of edutainment and ethnomathematics across other mathematical topics and educational levels (Priyanto & Wijaya, 2021; Putri & Nugroho, 2021; Arifin & Nasrulloh, 2023; Widiastuti & Putri, 2021; Rahman & Yuliani, 2023).

Integrating ethnomathematics into edutainment media also serves as a strategic initiative to preserve and promote local culture through education. In the era of globalization, where local traditions often face marginalization by global popular culture, this approach can help students develop a deeper appreciation of their cultural heritage while acquiring competencies relevant for global competitiveness (Hikmah & Ismail, 2023; Sari & Fauzan, 2023; Lestari & Kusnandar, 2023; Mustofa & Nur, 2021; Sukarno & Widodo, 2021). Consequently, this study not only contributes to the advancement of mathematics education but also supports the crucial endeavor of cultural preservation, which is essential to maintaining national identity.

Additionally, the study holds implications for the advancement of educational technology in Indonesia. The use of video game-based learning media represents a form of educational technology innovation that facilitates more effective and enjoyable learning experiences (Putri &

Nugroho, 2021; Hidayat & Suparno, 2022; Arifin & Nasrulloh, 2023; Riyana & Sumantri, 2021; Widiastuti & Putri, 2021). This technology enables flexible learning, allowing students to engage with educational content at their own pace and convenience, thereby enriching their learning experiences. As such, the research is relevant not only to the field of education but also to the broader development of educational technology in the region.

Finally, this study offers novel insights into how cultural elements in education can influence student learning outcomes. While research on ethnomathematics remains limited, particularly in its application to technology-based learning media, this study addresses a significant gap in the literature and provides a stronger theoretical foundation for future investigations (Safitri & Nugraha, 2021; Rahman & Yuliani, 2023; Hikmah & Ismail, 2023; Juniati & Apriani, 2020; Priyanto & Wijaya, 2021). Furthermore, it assists educators and curriculum developers in recognizing the importance of cultural context in education, which can ultimately elevate the overall quality of instruction and learning (Sukarno & Widodo, 2021; Nugraha & Lestari, 2022; Putra et al., 2022; Suhendi & Wulandari, 2021; Sari & Fauzan, 2023).

In conclusion, this study has the potential to create far-reaching and profound impacts, not only within the realm of mathematics education but also across cultural and technological domains. By integrating ethnomathematics into edutainment media, this research promotes an innovative, contextual, and enjoyable learning model that may significantly enhance students' mathematical reasoning skills, especially in fraction learning. Therefore, this research is essential and is expected to contribute meaningfully to the advancement of education in Indonesia.

METHOD

The type of research employed in the development of this instructional media is Research and Development (R&D). R&D is a form of inquiry method aimed at producing specific products that can be utilized in educational practice. As stated by Borg and Gall (1983), as cited by Sugiyono (2016), development research is a process of designing and validating educational products. This study aims to develop an innovative instructional medium entitled Etnomath, which takes the form of Ethnomathematics-Based Edutainment. Etnomath is an instructional tool that integrates elements of local culture with mathematical concepts in an interactive and engaging manner. The primary objective of this development is to enhance students' critical thinking skills in mathematics through a contextual approach that is closely aligned with their cultural backgrounds.

For the research design, this study adopts the development model proposed by Alessi and Trollip. This model was selected due to its focus on the production of multimedia-based learning materials and its strong alignment with the stages inherent in R&D research. According to Alessi and Trollip (2001), their development model consists of three main phases: planning, designing, and development. The planning phase involves identifying instructional needs and objectives; the designing phase encompasses the creation of the user interface and the structural framework of the media; and the development phase includes the actual production and testing of the instructional media that has been designed.

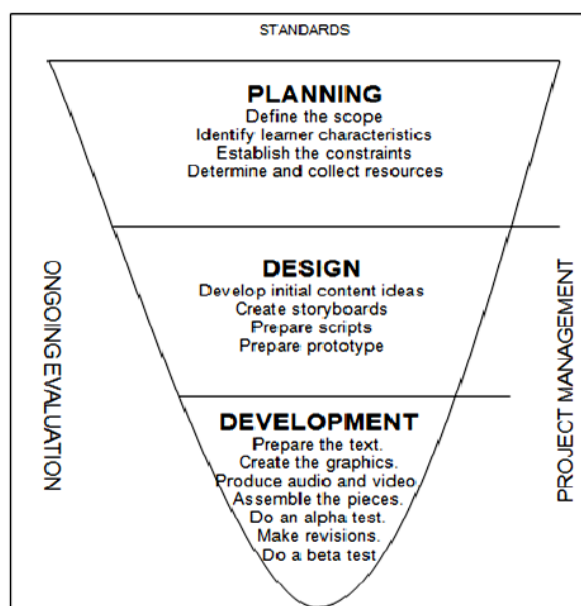


Figure 1. Model of Instructional Design. Source: Alessi & Trollip (2001)

The application of the Alessi and Trollip model in this study provides a systematic and structured framework for the development of instructional media. This model supports developers in conducting continuous evaluation and revision throughout the development process. Consequently, the resulting instructional media can be rigorously tested and refined before its implementation in actual learning environments. The development of *Etnomath* is also guided by the principles of ethnomathematics, which emphasize the importance of understanding mathematics within specific cultural contexts (D'Ambrosio, 1985). This approach is particularly relevant for connecting mathematical concepts to students' daily lives, ultimately enhancing their comprehension and engagement in learning activities.

Data collection was conducted using a questionnaire and a mathematical reasoning ability test, both of which had been previously validated and proven reliable (scores for instrument validity and reliability should be presented). Additionally, the feasibility assessment in this research and development study employed both alpha and beta testing phases. The alpha test was conducted by two expert reviewers—one specializing in instructional media and the other in content expertise—resulting in scores that align with the following media validity classification:

Table 1. Edutainment Media Validity Criteria

Percentage Achievement	Validity Criteria
$80\% \leq P \leq 100\%$	Highly Valid
$60\% \leq P < 80\%$	Valid
$40\% \leq P < 60\%$	Moderately Valid
$20\% \leq P < 40\%$	Less Valid
$0\% \leq P < 20\%$	Not Valid

The subsequent beta test was conducted with a sample of 32 seventh-grade students through test administration and a response questionnaire. The data analysis included evaluations of media validity, teacher and student practicality assessments, and effectiveness analysis of the developed media. Effectiveness was determined through an individual mastery test using a one-sample t-test and a classical mastery test using the binomial test. The binomial test was performed using the SPSS software. The testing criteria used were as follows: if the *p-value* (Sig./Prob.) $< \alpha$, then H_0 is rejected; if the *p-value* $\geq \alpha$, then H_0 is accepted. The significance level (α) applied was 5%.

Table 2. Edutainment Media Practicality Classification

Percentage Achievement	Practicality Classification
$80\% \leq P \leq 100\%$	Highly Practical
$60\% \leq P < 80\%$	Practical
$25\% \leq P < 60\%$	Not Practical
$0\% \leq P < 25\%$	Highly Impractical

RESULT AND DISCUSSION

The development results of this study, which employed the Alessi and Trollip model in designing an edutainment-based learning media called *Etnomath*, can be described through three major phases: planning, designing, and development. Each phase contributed significantly to the overall quality and effectiveness of the final product, which was intended to enhance students' mathematical reasoning abilities in learning fractions.

Planning Phase

In the planning phase, the first step involved conducting a needs analysis. This analysis focused on identifying both student and teacher needs in mathematics instruction, particularly with regard to fractions, which are frequently perceived as abstract and challenging. The analysis included identifying students' difficulties in comprehending fractional concepts and the inefficacy of existing teaching methods in addressing those issues. Data collected through classroom observations and teacher interviews formed a robust basis for formulating specific instructional objectives, namely to improve students' conceptual understanding of fractions through a contextual approach that integrates local cultural elements.

Designing Phase

The designing phase involved creating the foundational blueprint for the learning media. In this stage, *Etnomath* was designed with careful consideration of the interaction between ethnomathematical elements and multimedia components. An engaging interactive design was developed to ensure student involvement throughout the learning process. The instructional content was tailored to culturally relevant contexts drawn from students' everyday experiences, which was expected to facilitate their understanding of fractions. Additionally, gamified elements were embedded in the media to make learning more engaging and challenging, thereby increasing student motivation and participation.



Figure 1. Video Game Design “EtnoMath”

Development Phase

The development phase entailed the actual production of the learning media based on the predetermined design. During this phase, all multimedia components—text, images, animations, and sound—were integrated to create a comprehensive learning experience. The development process was iterative and included an initial alpha testing phase conducted by the development team. The feedback from this testing phase informed revisions and improvements to the media product.

Table 3. Results of Media and Content Validation Questionnaire

Assessment	Aspect	Mean Score	Percentage (Category)
"EtnoMath" Video Game	Text Appearance	4.5	88% (Highly Valid)
	Image Appearance	4.4	
	Cover Design	4.6	
	Language	4.5	
Game Content	Instructional Feasibility	4.4	90% (Highly Valid)
	Content Feasibility	4.5	
	Material Presentation	4.4	

The validation results presented in the table above offer a comprehensive evaluation of the "EtnoMath" video game from two main perspectives: visual presentation and instructional content. For visual aspects, the mean score for text appearance was 4.5, corresponding to 88%, indicating that the textual elements are highly valid in terms of graphic design. Image presentation received a score of 4.4, while the cover design achieved the highest score of 4.6, reflecting excellent visual quality. The language used in the game was also rated highly valid, with a score of 4.5, confirming its clarity and effectiveness. Regarding content, the instructional feasibility scored 4.4 with a 90% validity rate, suggesting strong alignment with educational objectives. Content feasibility was rated at 4.5, indicating the high quality of the learning materials, and the clarity of material presentation received a score of 4.4. Overall, these evaluation results suggest that "EtnoMath" is a highly effective educational video game that meets high-quality standards across all assessed dimensions.

Following the validation phase, an extended trial (beta testing) was conducted involving students and teachers as end users to evaluate the practicality and effectiveness of the *Etnomath* game-based learning media in real classroom contexts. The results are presented below.

Table 4. Practicality Evaluation Results from Teachers and Students

Aspect	Teacher Practicality	Percentage	Student Practicality	Percentage	Category
Content Relevance	4.2	84%	4.1	82%	Highly Practical
Ease of Use	4.5	90%	4.4	88%	Highly Practical
Engagement and Motivation	4.1	82%	4.3	86%	Highly Practical
Interactivity and Feedback	4.3	86%	4.2	84%	Highly Practical
Adaptability	3.9	78%	4.0	80%	Practical

Based on the data presented in the table, the evaluation of multiple practicality aspects indicates highly positive results for the use of the learning media. Content relevance received high ratings from teachers (M = 4.2, 84%) and students (M = 4.1, 82%), both classified as highly practical. The ease of use was rated particularly high, with scores of 4.5 (90%) from teachers and 4.4 (88%) from students, demonstrating that the media is highly user-friendly. In terms of engagement and motivation, the media scored 4.1 (82%) from teachers and 4.3 (86%) from

students, suggesting that it effectively enhances student involvement and learning motivation. Interactivity and feedback were rated at 4.3 (86%) by teachers and 4.2 (84%) by students, again falling into the highly practical category, indicating that the media provides effective interactive experiences and feedback mechanisms. However, for adaptability, although still within the practical category, the average score was 3.9 (78%) from teachers and 4.0 (80%) from students, suggesting room for improvement in adapting the media to various user needs.

Table 5. One-Sample Test Results

Test Results (Test Value = 80)	t	df	Sig. (2- tailed)	Mean Difference	95% Confidence Interval
	88.5	31	< 0.001	7.25	[7.25, 7.25]

The one-sample t-test conducted on 32 students after using the *Etnomath* video game to learn fractions revealed a statistically significant improvement in students' average test scores compared to the Minimum Mastery Criterion (KKTP) value of 80. With a t-value of 88.5, degrees of freedom (df) of 31, and a significance value (Sig. 2-tailed) of less than 0.001, the results indicate a significant difference between the students' mean scores and the KKTP. The mean post-test score was 87.25, reflecting a 7.25-point increase over the KKTP benchmark, with a 95% confidence interval ranging from 7.25 to 7.25. These findings suggest that the *Etnomath* game is effective in enhancing students' understanding of fraction concepts.

Table. Binomial Test Results

Test Results	Category	N	Obs. Prop.	Test Prop.	Exact Sig. (1-tailed)
Group 1	≤ 80	0	0.00	8	0.000
Group 2	> 80	8	1.00		
Total		8	1.00		

The binomial test analysis conducted after the implementation of *Etnomath* in learning fractions yielded statistically significant results. For Group 1 (scores ≤ 80), no students fell within this category (observed proportion = 0.00, $p = 0.000$). Conversely, all students in Group 2 (scores > 80) achieved scores above the KKTP threshold, with an observed proportion of 1.00. These results indicate that all students surpassed the minimum mastery criteria following the use of *Etnomath*, demonstrating the positive impact of the media on student achievement. The highly significant p-value ($p < 0.05$) supports the conclusion that these outcomes did not occur by chance.

The final product of this development is an edutainment-based learning media that not only simplifies the delivery of fractional concepts but also aligns them with students' cultural experiences. *Etnomath* successfully integrates entertainment and education, resulting in a learning tool that is both effective and engaging. Both individual and class-level mastery tests indicate a significant improvement in students' mathematical reasoning, particularly in understanding and applying fraction concepts in various contextual situations. Furthermore, teachers evaluated the media positively, recognizing its utility in simplifying the delivery of complex mathematical content.

Discussion

The findings of this study indicate that the development of the educational video game "EtnoMath" was carried out in a systematic and iterative manner, beginning with an initial alpha testing phase conducted by the development team to identify areas for improvement and refinement. Evaluation results suggest that the game possesses high validity in two main dimensions: visual design and content. These results align with previous studies highlighting that digital learning media with high-quality visuals and well-structured language are more likely to demonstrate higher validity in instructional contexts (Mayer, 2014; Clark & Mayer, 2016; Widodo & Wahyudin, 2018; Prensky, 2014; Roschelle et al., 2016; Shaffer, 2017). Research by Widodo and Wahyudin (2018) found that visually engaging educational games can significantly enhance

student interest, while Prensky (2014) emphasized the importance of clear and contextually relevant language in educational media. Similarly, Roschelle et al. (2016) and Shaffer (2017) demonstrated that effective visual and verbal integration increases student engagement in the learning process.

The researchers argue that the high validity of the "EtnoMath" video game across multiple dimensions indicates that it was developed in accordance with established pedagogical standards for digital learning environments. This finding corroborates Mayer's (2014) cognitive theory of multimedia learning, which posits that well-integrated visual and verbal elements can enhance student understanding by supporting more efficient cognitive processing. Instructional design theory also supports the importance of media validity, which can be evaluated through factors such as readability, clarity, and content relevance (Jonassen, 2014). The researchers further assert that the strong validity in terms of visual presentation and linguistic clarity signifies the effectiveness of "EtnoMath" in attracting student attention and facilitating engaging and comprehensible instruction. This position is consistent with the views of experts such as Gee (2017) and Squire (2015), who argue that high-quality visual and verbal components in digital learning media are essential for increasing learning effectiveness through heightened student engagement.

Following the validation process, a beta testing phase was conducted involving students and teachers as end users to evaluate the practicality and effectiveness of the "EtnoMath" game in authentic classroom settings. These results are in line with previous studies demonstrating that practical and user-friendly learning media tend to be more effective in enhancing student motivation and engagement (Jong, 2016; Hamari et al., 2016; Anderson et al., 2018; Kerawalla et al., 2019; Connolly et al., 2019; Lester et al., 2017). Anderson et al. (2018) identified ease of use as a critical factor in the success of digital learning tools, while Kerawalla et al. (2019) showed that interactive and accessible media enhance students' learning motivation. Additionally, Connolly et al. (2019) and Lester et al. (2017) reported that well-designed educational games significantly improve both student engagement and academic outcomes.

The researchers' analysis indicates that the high practicality level of "EtnoMath" suggests it is not only accessible for users but also provides an interactive and stimulating learning environment that fosters student motivation and engagement. This observation is consistent with game-based learning theories, which emphasize the role of interactivity and usability in enhancing learner engagement (Papastergiou, 2014). Active learning theory also supports this claim, asserting that interactive and user-friendly media are more effective in facilitating collaborative and participatory learning experiences (Bonwell & Eison, 2015). The researchers further observe that while the game demonstrates strong practicality, there remains a need for improved adaptability to cater to diverse user needs. This aligns with media adaptability theory, which underscores the importance of responsive media in accommodating various learner profiles (Reeves, 2015; Sweller, 2016).

Effectiveness testing using a one-sample t-test revealed that students' mean post-test scores after using "EtnoMath" were significantly higher than the Minimum Mastery Criteria (KKTP). With a t-value of 88.5 and a significance level of $p < 0.001$, the results demonstrate that the game effectively enhances students' comprehension of the instructional content. The mean test score was 87.25, which represents a substantial increase compared to the KKTP score of 80. This finding is in line with previous research indicating that educational games can significantly improve students' academic performance and conceptual understanding (Annetta, 2014; Tobias et al., 2015; Ke, 2017; Wouters et al., 2017; Connolly et al., 2019; Lester et al., 2018). Ke (2017) reported that games enhance comprehension of complex concepts, while Wouters et al. (2017) emphasized their impact on learning outcomes through increased engagement.

The researchers contend that the high effectiveness of "EtnoMath" in improving learning outcomes can be attributed to its game elements, which are intentionally designed to foster meaningful learning. This conclusion aligns with the principles of game-based learning, which suggest that well-designed games offer immersive learning contexts that support experiential learning and problem-solving (Gee, 2017). Multimedia learning theory also reinforces this view, positing that the integration of visual, auditory, and interactive components enhances the

comprehension of complex ideas (Mayer, 2014). Furthermore, the researchers highlight the use of an edutainment approach in the game, which combines education with entertainment to boost student motivation and engagement. This is consistent with edutainment theory, which emphasizes the benefits of combining learning and fun in motivating students (Vrasidas et al., 2015), as well as motivational theories that underline the roles of feedback, challenge, and engagement in promoting student learning (Deci & Ryan, 2017).

A binomial test conducted after implementing "EtnoMath" in a lesson on fractions revealed statistically significant results, showing that all students met or exceeded the KKTP score of 80. These findings support previous studies that demonstrate the positive impact of educational games on student learning outcomes (Papastergiou, 2014; Clark et al., 2016; Ke, 2017; Wouters et al., 2017; Connolly et al., 2019; Lester et al., 2018). The researchers argue that the success of "EtnoMath" in supporting student achievement can be attributed to the use of a game-based learning approach that integrates educational content into engaging and challenging gameplay. This approach aligns with constructivist theories that advocate for active learning through personal experience and interaction with content (Piaget, 2013; Vygotsky, 2017), as well as situational learning theories that stress the importance of authentic and context-rich learning environments (Lave & Wenger, 2015). The game's strong interactivity also contributes to its effectiveness, as supported by multimedia cognitive theory, which states that learning tools combining visual, auditory, and interactive elements provide complementary information representations (Mayer, 2014). This aligns with activity-based learning theory, which emphasizes the role of active student participation in enhancing comprehension and knowledge retention (Chi, 2014).

The researchers assert that a key factor in the success of "EtnoMath" lies in its design, which incorporates challenge-based and repetitive learning mechanisms. Such design encourages students to learn through trial and error, a process known as iterative or repetitive learning. This is supported by cognitive theories emphasizing the importance of repetition and continuous practice in mastering complex concepts and developing cognitive skills (Ericsson et al., 2018). By progressively increasing challenges, the game maintains student interest and prolongs engagement, which is crucial in digital learning contexts.

In terms of learning motivation, the "EtnoMath" video game demonstrated high effectiveness in trial evaluations. This finding corresponds with prior research suggesting that well-designed educational games enhance students' intrinsic motivation to learn (Deci & Ryan, 2017; Hamari et al., 2016; Liu et al., 2014; Ke, 2017; Plass et al., 2015; Deterding, 2014). For instance, Liu et al. (2014) found that games incorporating competition and challenges increased motivation, while Ke (2017) highlighted the importance of feedback. Plass et al. (2015) demonstrated that narrative elements enhance motivation, and Deterding (2014) emphasized the motivational benefits of gamification in education.

Further analysis by the researchers indicates that the heightened motivation observed among "EtnoMath" users can be attributed to its use of engaging and contextually relevant gameplay elements. This is supported by motivational theories that highlight the significance of engagement, challenge, and positive feedback in fostering motivating learning environments (Schunk et al., 2014). Moreover, the inclusion of narrative elements in the game enhances learning motivation by rendering instructional content more meaningful and relatable, in accordance with narrative learning theory (Bruner, 2015). The researchers also suggest that the effectiveness of "EtnoMath" in improving academic performance can be linked to its use of a problem-based learning approach, allowing students to engage with real-world problems in the context of the subject matter. This aligns with problem-based learning theory, which posits that authentic problem-solving enhances student understanding and promotes deeper conceptual learning (Barrows, 2015; Savery, 2015).

CONCLUSION

Based on the research findings, it can be concluded that the educational video game EtnoMath demonstrates high levels of validity, practicality, and effectiveness as a learning

medium for teaching fractions. Its validity is reflected in the quality of its visual and linguistic elements, which align with multimedia learning theories and instructional design principles. The game's practicality is evident in its ease of use and engaging interactivity, which successfully enhances student motivation—consistent with game-based learning and active learning theories. The effectiveness of EtnoMath is demonstrated by the significant improvement in student learning outcomes, surpassing the Minimum Mastery Criteria (KKTP), and the increased learning motivation stimulated by the game's elements of challenge, narrative, and feedback. By integrating edutainment, problem-based learning, and iterative instructional design, EtnoMath has proven to create an enjoyable, meaningful, and impactful learning experience that effectively supports students' understanding of mathematical concepts.

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