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Interactive math comics: An analysis of Indonesian and Spanish students' responses

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Abstract

This study investigates the responses of Indonesian and Spanish students to the use of interactive mathematics comics in their education. The research aims to see the practicality of these comics on student engagement, comprehension, and retention of mathematical concepts across different cultural contexts. Using a quantitative approach, the study analyzes data through normality and homogeneity tests to ensure the reliability and consistency of responses. Results show that Indonesian and Spanish students respond positively to interactive mathematics comics, demonstrating increased motivation and interest. However, cultural differences significantly influence the perception of specific indicators such as content quality, technical quality, and language usage. Indonesian students, who are generally accustomed to traditional teaching methods, found the comics engaging and helpful in understanding complex concepts. On the other hand, Spanish students, who are more familiar with interactive and student-centered learning, showed mixed responses depending on their educational experiences and expectations. Despite these differences, both groups recognized the value of interactive comics as a supplementary educational tool. Future research could explore a larger and more diverse sample size, including longitudinal studies to assess the sustained impact of such tools and further investigate the integration of other multimedia elements like augmented reality to enhance interactivity. From these results, the Mathematics Comic on Cartesian coordinates material developed is practical and can be used in mathematics learning. This is because the Mathematics Comic on Cartesian coordinates material received a good response, and students hope that learning mathematics will be more fun and effective.

Keywords:
Augmented reality, Cultural contexts, Interactive mathematics comic, Learning mathematics, Students responses

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1. INTRODUCTION

Education is a humanization process, which means that without education humans will not become humans in the true sense (Lafer, 2014). Through education, individuals can develop and shape the character and civilization of a dignified nation to make the nation's life more intelligent. Education also develops the students' potential to become human knowledgeable, capable, creative, independent and become a democratic and responsible citizen in accordance with its objectives as stated in the National Education System Law Number 20 of 2003. This national education goal is a formulation of human qualities that must be developed in every educational unit (Reimers & Chung, 2019). It is hoped that this formulation can improve the quality of education, which requires serious attention not only from the government, but also from education administrators and the community (Gbenu, 2012). As one of the educational providers, schools basically have the aim of preparing students who can solve problems by developing their potential (Levine, 2006). Problem solving is one of the abilities that students must have to train students to face various increasingly complex problems, especially in mathematics (Wüstenberg et al., 2016). Mathematics is a field of study that has an important role in the world of education (Hidayat & Aripin, 2019; Hidayat & Husnussalam, 2019; Hutajulu et al., 2019; Pertiwi et al., 2021; Sari & Hidayat, 2019; Valero, 2010). Mathematics is a formal science that uses symbolic language to study concepts such as number, structure, variation and shape (Asmara et al., 2024; Hutajulu et al., 2022; Kusmaryono et al., 2024; Lee, 2017; Setambah et al., 2021).

In the era of the fourth revolution, or 4.0, known as the digital revolution, all information can be obtained in real-time and quickly anywhere and at any time (Skilton & Hovsepian, 2017). Education 4.0 refers to how the education community directly adjusts or analyses directly to or analyses the digitalisation of education. At the institutional level, the inputs for Education 4.0 recommended by UNESCO should be: (a) reasoning for complexity, (b) access with open platforms, (c) digital support, (d) new creations and (e) solidarity. In this era, digital literacy is one of the skills that every educator must master (Supianti et al., 2022; Wijaya et al., 2024). Digital literacy is the ability to obtain, understand and use information originating from various sources in digital form (Spante et al., 2018). Digital literacy as stated by Gilster is the ability to understand and use information from various digital sources and consider it only as literacy in the digital era (Gilster, 1997). Therefore, it is a traditional form of the notion of literacy (media literacy), such as the ability to read, write and deal with information using technology and time formats, as well as an essential life skill. Gilster (1997) further emphasized that digital literacy is about mastering ideas, not just pressing buttons, as well as knowledge about what we see on a computer screen when we use network media. Hague and Payton in "Digital Literacy Across the Curriculum", explain the eight components of digital literacy, namely: Functional Skills and Beyond, Creativity, Collaboration, Communication, The Ability to find and select Information, Critical Thinking and Evaluation, Cultural and Social Understanding, and E-Safety (Hague & Payton, 2010). In addition, Miranda et al. (2021) proposes four central components of Education 4.0 that will serve as a reference for the design of new educational innovation projects: competences, learning methods, information and communication technologies, and infrastructure. In mathematics education, teaching digital literacy is also

an important thing to teach students (Fauzan et al., 2024; Hidayat & Aripin, 2023; Riwanto & Budiarti, 2021; Wijaya et al., 2024), one of which is through teaching materials that integrate digital technology such as digital mathematics comics.

Comics are a learning media as a tool to convey instructional messages with visual communication (Ntobuo et al., 2018). Comics tend to be liked more by students than school textbooks because they are entertaining and light (Akcanca, 2020; Matuk et al., 2021). In addition, comics are also educational because they can increase interest in reading and develop vocabulary (Golding & Verrier, 2021). Over time, comics are not only entertainment but also a means of learning communication and a medium for socialization (Akcanca, 2020; Şahin & Kara, 2022). Thus, the use of comics attracts students' attention to read the material because the storyline and image arrangement are designed to be attractive in order to increase students' imagination (Wati, 2022). Therefore, learning mathematics using comics can be easier because it is presented in the form of everyday conversation (Saputri & Qohar, 2020).

Along with technological developments, comics can now be displayed electronically as e-comics or digital comics (Andarukmi et al., 2024; Linardatos & Apostolou, 2023). This also adapts to students' world development because they are used to using technology in the form of devices to play, communicate with other people and social media (Angela et al., 2021). One innovation in digital comics is the use of an interactive story concept so that it can involve students directly (Damopolii et al., 2021). Platforms that can be used to turn teaching materials into interactive ones is live worksheets (Marhaeni et al., 2023), which allow teachers to create effective and enjoyable teaching materials (Fitriyah et al., 2024; Pepkolaj et al., 2024). Creating interactive comics with the help of live worksheets has not been widely done (Fitriyah et al., 2024; Lestari et al., 2023; Sutarni et al., 2024). Even though several studies on mathematics comics considered them effective in improving student learning outcomes (Chu & Toh, 2020; Lestari et al., 2021; Saputri & Qohar, 2020), several previous studies have shown that the use of digital mathematics comics is effective in supporting students' digital literacy skills (Karlimah et al., 2021; Riwanto & Budiarti, 2021).

For all the above reasons, the aim of this research is to find out the response of Indonesian and Spanish students in using math comics. Understanding this comparison is crucial for several reasons. By comparing responses from different cultural backgrounds, educators and curriculum developers can design more effective, tailored educational strategies that cater to the specific needs and preferences of students from diverse regions. Knowing how different student groups respond to interactive comics can help in creating content that maximizes engagement and learning outcomes. Recognizing cultural nuances ensures that educational tools are both relevant and appealing to all students. This comparison provides valuable cross-cultural insights that can inform international educational practices. It helps in understanding universal elements of effective teaching tools and identifying aspects that need cultural adaptation.

Exploring varied responses encourages innovation in teaching methods. It highlights the importance of incorporating diverse perspectives and interactive elements to make learning more dynamic and inclusive. And the last, by identifying and addressing the different responses, educators can work towards achieving educational equity. Ensuring that

all students, regardless of their cultural background, have access to engaging and effective learning resources is essential for fostering an inclusive educational environment.

In conclusion, understanding the comparative responses of Indonesian and Spanish students to interactive mathematics comics is essential for developing culturally sensitive, engaging, and effective educational tools that can enhance learning experiences across diverse student populations.

2. METHOD

The type of research used is research and development with the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). This research focuses only on the implementation aspect to assess the quality of the product, specifically its practicality, which aims to determine students' responses to the use of mathematics comics in mathematics learning. In the case of Spain, the students were 13 years old and in their first year of Secondary Education in a public school. The mathematical content included in the comic book had not been presented in the classroom before, so their first contact with it was precisely through the comic book. In the case of Indonesia, the students are 13-14 years old and in their second year of Secondary Education in state schools. The mathematical content contained in comics had never been presented in class before, so their first contact was through comics. The students were selected through a stratified random sampling method to ensure a representative sample from each country. In Spain, the comic used was in English, while in Indonesia, it was in Indonesian. Therefore, the comics used only differed in language but had the same content.

This study employs a quantitative research design to analyze the responses of Indonesian and Spanish students to interactive mathematics comics. Data was collected and analyzed using standardized response questionnaires and statistical tests to ensure the reliability and validity of the findings. The primary material used in this study is an interactive mathematics comic designed to teach cartesian coordinate materials. The comic includes vibrant illustrations, engaging storylines, and interactive elements such as puzzles and problem-solving activities. Data was collected using a structured response questionnaire. The instrument used in this research is a student response questionnaire, which has five indicators: quality of content and objectives; engineering quality; quality of learning; use of language; and interest. Data analysis will be carried out using a Likert scale to make it easier to interpret the data used. The data categories used in this research can be seen in Table 1.

Table 1. Data categories

Score Intervals	Category
$x \leq 20$	Very Less
$20 < x \leq 40$	Less
$40 < x \leq 60$	Enough
$60 < x \leq 80$	Good
$80 < x$	Very Good

Based on Table 1, if the group gets a minimum percentage of 61%, then it can be said that the use of mathematics comics in mathematics learning is said to be practical and can be used in mathematics learning. Each indicator was measured using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). A neutral response (3) on a Likert scale can be seen positively, as it indicates that respondents are open to various viewpoints, show flexibility, are ready to receive new information, remain objective, and help reduce bias in data analysis. The questionnaire was administered to the students after they used the interactive mathematics comic.

This research begins with a pre-study orientation. The purpose of starting with a pre-study orientation is to familiarize researchers with the study's context, participants, and relevant background information. This initial phase helps to clarify objectives, refine research questions, and identify any potential challenges, ensuring a more focused and effective research process. It also provides an opportunity to establish rapport with participants and set clear expectations, which can contribute to more accurate and meaningful data collection. An orientation session was held for Indonesian and Spanish students by distributing preliminary study questionnaires. After that, students were given access to the interactive math comics and allowed to use them for two weeks during their regular math classes. After the two-week period, students completed a response questionnaire. The teacher assisted in administering the questionnaire to ensure correct understanding and completion.

To obtain more detailed results for each indicator, analysis will be carried out using the independent sample t-test and one sample t-test. To carry out the independent sample t-test and one sample t-test, the data must be normally distributed and homogeneous. To find out whether the data is normally distributed and homogeneous, prerequisite tests will be carried out, namely the normality test and homogeneity test. A normality test was conducted on the collected data to determine if it followed a normal distribution. The test was performed for all indicators across both student groups Indonesian Students' (SI) and Spanish Students' (SS). The significance value (Sig.) for each indicator was checked, with a value ≥ 0.05 indicating normal distribution. A homogeneity test was conducted to assess the consistency of the responses across both groups. By employing this method, the study aims to provide a comprehensive analysis of how interactive mathematics comics are received by students from different cultural backgrounds, thereby informing future educational strategies and tool development.

To find out more detailed results for each indicator, the study uses the following statistical analyses independent sample t-test. This test uset to compare the means of two independent groups (Indonesian and Spanish students) and determine if there are statistically significant differences between their responses for each indicator. This test will help identify specific areas where Indonesian and Spanish students' perceptions diverge, providing insights into cultural influences on the reception of interactive mathematics comics. After that, used the one sample t-test. This test aims to compare the mean response for each indicator within a single group to a known value or average (e.g., the overall average response or a neutral value like the midpoint of the Likert scale). This test will help determine if the responses for each indicator are significantly different from the expected average

response within each cultural group. It provides a deeper understanding of how each group uniquely perceives the various aspects of the interactive comics.

By employing these analytical methods, the study aims to provide a comprehensive and detailed analysis of student responses, uncovering specific differences and similarities between Indonesian and Spanish students. This will inform educators and curriculum developers about the effectiveness of interactive mathematics comics and guide the development of culturally sensitive educational tools.

3. RESULTS AND DISCUSSION

3.1. Results

In the dynamic realm of mathematics education, eighth-grade students in Indonesia and Spain embark on a unique journey guided by mathematics comics centered around cartesian coordinates. Figure 1 provides a glimpse into the immersive world of Indonesian mathematics comics, where complex mathematical concepts come to life through captivating visuals and interactive narratives. These comics not only serve as educational tools but also as catalysts for sparking curiosity and deepening understanding. As we delve into this study, we explore how these innovative resources resonate with students across cultural and educational contexts, paving the way for enriched learning experiences and broader insights into effective pedagogical practices.

Figure 1. Indonesian mathematics comic display

To facilitate the internationalisation of the study, researchers also created English Mathematics Comics which are expected to help students in Spain use Mathematics Comics in learning mathematics. Several displays of English mathematics comics used in mathematics learning are shown in Figure 2.

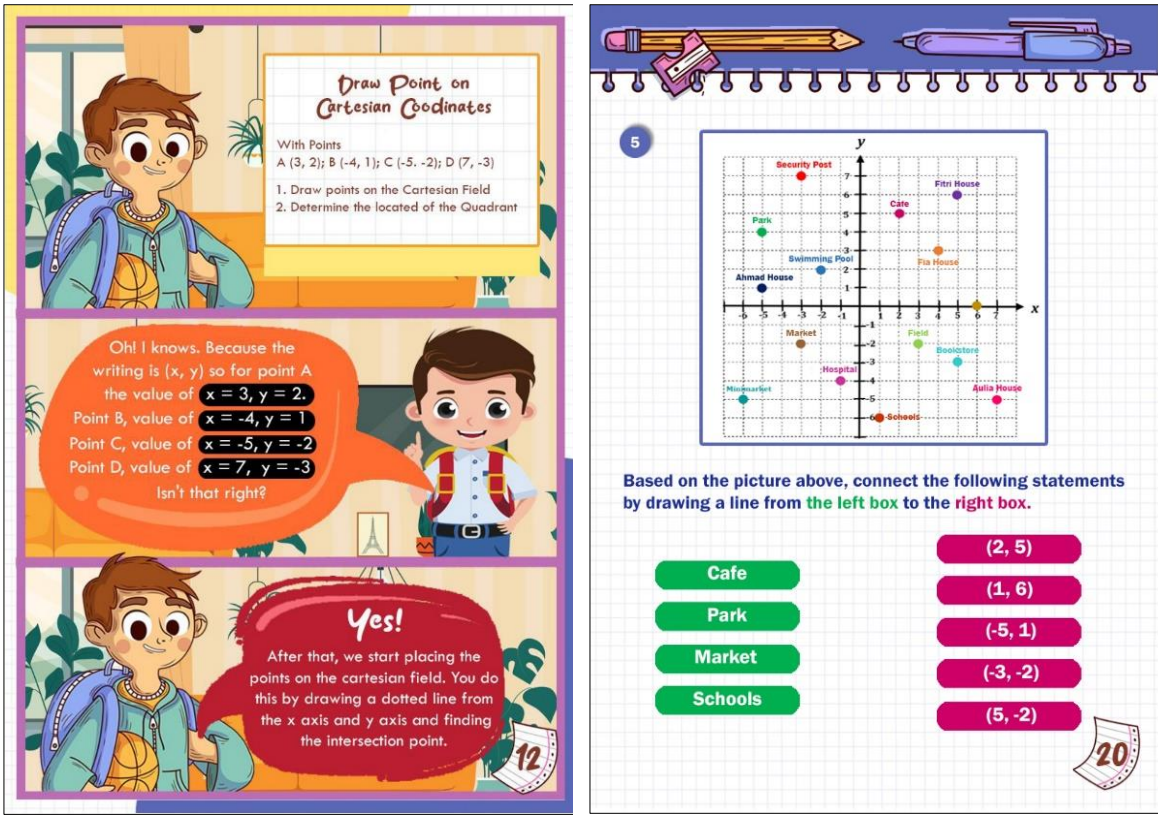

Figure 2. English mathematics comic display

After students are given mathematics lessons using mathematics comics with cartesian coordinate material, then students fill out response questionnaires via the Google Form that has been created. The procedure of administering a response questionnaire after students have completed mathematics lessons using comics on cartesian coordinates is essential for evaluating the instructional approach. By using a Google Form, the questionnaire is efficiently distributed, ensuring easy access and standardization of responses. The subsequent analysis of the responses allows educators to understand the effectiveness and reception of the comics-based learning method, highlighting areas of engagement or potential improvement. Presenting the data in both Figure 2 and Table 2, with clear percentages and qualifications, enhances the clarity and comprehensibility of the findings. This dual presentation supports a more in-depth and visually accessible interpretation of student responses, allowing educators and researchers to make data-driven decisions to optimize teaching methods.

Table 2. Results of student response analysis

Indicators	Description	Indonesia	Spain	Overall
Content Quality and Goals	Percentage	89.55%	80%	87.24%
	Qualifications	Very Good	Good	Very Good
Technique Quality	Percentage	90%	70.95%	85.40%
	Qualifications	Very Good	Good	Very Good
Learning Quality	Percentage	85.61%	61%	79.66%
	Qualifications	Very Good	Good	Very Good
Language Use	Percentage	88.18%	78.10%	85.75%
	Qualifications	Very Good	Good	Very Good
Interest	Percentage	87.73%	62.86%	81.72%
	Qualifications	Very Good	Good	Very Good

Based on Table 2, it is known that the Indonesian student group (SI) stated that the mathematics comics developed in terms of the quality of content and objectives, technical quality, learning quality, use and interest were very good. Meanwhile, the Spanish student group (SS) stated that the mathematics comics developed had good quality content and objectives, technical quality, learning quality, use of language and interest. Therefore, mathematics comics is declared practical for use in mathematics learning because each indicator has a percentage above 61%.

For all indicators the SI gave a more positive response compared to the SS. This shows that the SI is more accepting and welcoming of mathematics comics than the SS. To find out more detailed results for each indicator, analysis will be carried out using the independent sample t-test and one sample t-test. To carry out the independent sample t-test and one sample t-test, the data must be normally distributed and homogeneous. To find out whether the data is normally distributed and homogeneous, prerequisite tests will be carried out, namely the normality test and homogeneity test. The test was carried out using SPSS software. The results of the normality test are presented in Table 3.

Table 3. Normality test results

Indicator	Data	Shapiro-Wilk	
		Statistic	Sig.
Content Quality and Goals	Indonesia	0.858	0.144
	Spain	0.976	0.078
Technique Quality	Indonesia	0.891	0.231
	Spain	0.912	0.065
Learning Quality	Indonesia	0.923	0.459
	Spain	0.871	0.156
Language Use	Indonesia	0.856	0.178
	Spain	0.903	0.145
Interest	Indonesia	0.887	0.241
	Spain	0.954	0.376

Based on the results of the normality test presented in Table 3 for all indicators, namely content and purpose quality, technical quality, learning quality, language usage, and

interest across all groups SI and SS, the Sig. value is ≥ 0.05. This indicates that the data tested are normally distributed. Next, a homogeneity test will be conducted. The results of the homogeneity test are presented in Table 4.

Table 4. Test of homogeneity

Indicator		Levene Statistic	Sig.
Content quality and goal	Based on Mean	0.345	0.545
Technique Quality	Based on Mean	0.111	0.741
Learning Quality	Based on Mean	0.225	0.687
Languages Quality	Based on Mean	0.287	0.621
Interest	Based on Mean	0.198	0.755

Based on the homogeneity test results presented in Table 4, the content and objective quality indicators have a value of Sig. 0.545, the technical quality indicator has a Sig value. 0.741, the learning quality indicator has a value of Sig. 0.687, the language use indicator has a value of Sig. 0.621, and the interest indicator has a Sig. 0.755. These results have a Sig value. ≥ 0.05 which means that the data tested is homogeneous. After knowing that the data is normally distributed and homogeneous, it will be continued with the independent sample t-test. The results of the independent sample t-test are presented in Table 5.

Table 5. Independent sample t-test results

Indicator	Sig. (2-tailed)	Significance Level 5%	
		Lower	Upper
Content quality and goal	0.030	0.099	1.811
Technique Quality	0.000	3.419	8.101
Learning Quality	0.000	4.590	10.202
Languages Quality	0.009	0.412	2.614
Interest	0.000	1.236	3.738

Based on the results of the independent sample t-test which are presented in Table 5, the content and objective quality indicators have a value of Sig. 0.030, the technical quality indicator has a Sig value. 0.000, the learning quality indicator has a value of Sig. 0.000, the language use indicator has a Sig value. 0.009, and the interest indicator has a Sig value. 0.000. These results have a Sig value. ≤ 0.05 which means there are significant differences between the SI and the SS in all indicators. These findings indicate varying perceptions and evaluations of interactive mathematics comics between the two cultural groups. The significant differences suggest that Indonesian and Spanish students have distinct views on the effectiveness, technical aspects, language suitability, and overall appeal of the comics as educational tools. These insights underscore the importance of considering cultural contexts when designing and implementing educational resources to better meet the diverse needs and expectations of students from different backgrounds. The one sample t-test will be performed next, with the results presented in Table 6. This test will determine if the average responses for each indicator within each group differ significantly from a known value or the overall average response, providing further insights into each group's perceptions.

Table 6. One sample t-test results

Indicator	Data	Sig. (2-tailed)	Significance Level 5%	
			Lower	Upper
Content Quality and Goals	Indonesia	0.000	2.51	3.40
	Spain	0.001	1.24	2.74
Technique Quality	Indonesia	0.000	7.91	10.09
	Spain	0.025	0.58	5.99
Learning Quality	Indonesia	0.000	6.61	8.75
	Spain	0.883	-4.27	4.84
Language Use	Indonesia	0.000	3.65	4.81
	Spain	0.000	1.83	3.59
Interest	Indonesia	0.000	2.34	3.20
	Spain	0.760	-1.90	2.47

Based on the results of the one sample t-test presented in Table 6, significant differences were observed in how Indonesian and Spanish students perceive various aspects of interactive mathematics comics. For the I, all indicators—quality of content and objectives, quality of techniques, quality of learning, use of language, and interest—showed Sig. values ≤ 0.05, indicating that their responses differed significantly from the average response for each indicator in the questionnaire. This suggests that Indonesian students have distinct perspectives on the content clarity, technical execution, educational effectiveness, language suitability, and personal engagement with the comics compared to the average perception within their group.

In contrast, among the SS, significant differences were found in the indicators of quality of content and objectives, technical quality, and language quality, with Sig. values ≤ 0.05. This indicates that Spanish students perceive these aspects differently from their group's average responses, reflecting varying expectations or evaluations regarding these specific dimensions of the interactive comics. However, for the indicators of learning quality and interest, the Sig. values were ≥ 0.05, indicating that the responses from Spanish students aligned closely with the average perceptions within their group. This suggests a consistent view among Spanish students regarding the educational effectiveness and personal interest elicited by the comics. These findings underscore the importance of understanding cultural and individual differences in educational tool perception to effectively tailor and enhance learning experiences across diverse student populations.

3.2. Discussion

The results from both the independent sample t-test and one sample t-test reveal significant differences in how Indonesian and Spanish students perceive interactive mathematics comics. The independent sample t-test showed that SI and SS differed significantly across all measured indicators—content and objective quality, technical quality, learning quality, language use, and interest. These findings underscore the impact of cultural backgrounds and educational contexts on student perceptions of educational tools. Indonesian students, potentially less exposed to interactive learning methods, may have found the comics particularly engaging and effective in enhancing their understanding of

mathematical concepts (Lestari et al., 2021). In contrast, Spanish students, who might have higher expectations regarding technical and linguistic aspects, showed varying responses in these dimensions, highlighting different cultural and educational priorities (Rodríguez-Izquierdo et al., 2020).

The one sample t-test further detailed these differences within each group. Indonesian students demonstrated significant deviations from their group averages across all indicators, suggesting diverse individual perspectives on the effectiveness and appeal of the comics (Lestari et al., 2021). This variability indicates a need for tailored educational approaches that cater to diverse learning preferences and cultural contexts (Strekalova-Hughes et al., 2021). Conversely, Spanish students exhibited significant deviations in specific indicators like content quality, technical execution, and language usage, reflecting nuanced evaluations within the group. However, their alignment with group averages in learning quality and interest suggests a shared perception of these aspects (Umar & Ko, 2022).

These findings emphasize the importance of culturally sensitive educational strategies and personalized learning experiences. Educators and curriculum developers should consider these insights to optimize the design and implementation of interactive educational tools, ensuring they resonate effectively across different cultural and educational settings (Kim et al., 2023). Future research could further explore the long-term impacts of such tools and delve deeper into specific cultural factors influencing educational technology adoption and effectiveness.

The study on Indonesian and Spanish student responses to interactive mathematics comics offers insightful perspectives into how different educational tools impact student engagement and understanding across diverse cultural contexts (Lidinillah et al., 2022). By focusing on these two distinct groups, the research aims to explore the universal and culture-specific factors influencing the effectiveness of interactive comics in mathematics education. One of the key findings of the study is the high level of engagement and motivation among students from both countries when using interactive mathematics comics. This suggests that the visual and interactive nature of comics can be a powerful tool in capturing student interest and making abstract mathematical concepts more relatable. For Indonesian students, the vibrant illustrations and storyline appear to bridge the gap between traditional learning and modern educational tools. Spanish students similarly reported increased motivation, particularly enjoying the interactive elements that allowed for a more hands-on learning experience.

The study highlights the importance of cultural contexts in shaping student responses. Indonesian students, who are often accustomed to rote learning and teacher-centered instruction, found the interactive comics refreshing and more engaging. This shift from passive to active learning was significant in enhancing their conceptual understanding and retention of mathematical concepts. In contrast, Spanish students, who are generally more exposed to interactive and student-centered learning environments, appreciated the novelty of integrating comics into their study routine but did not find the shift as dramatic. They valued the interactivity and the narrative as a reinforcement of their existing learning methods rather than a complete paradigm shift (Baker et al., 2021; Orakcı, 2020).

Overall, the mathematics comic on cartesian coordinates received a very good response from SI and a good response from SS. This can be seen from the results of the analysis carried out showing that SI obtained a percentage above 80%. This shows that this percentage has very good qualifications. Meanwhile, the percentage for the Spanish student group is above 60%. This shows that this percentage has good qualifications. After that, other tests were carried out, namely the independent sample t-test and one sample t-test. The results of the independent sample t-test show that there is a significant difference in response between SI and SS. Meanwhile, the results of the one sample t-test show that the SI has a response that is not the same as the average of each indicator in the response questionnaire. Then in SS, three indicators, namely quality of content and objectives, technical quality, and language quality, had responses that were not the same as the average of each indicator in the response questionnaire.

First, the quality of the content and objectives includes instructions for use, the material provided is complete and discussed clearly. Students in Indonesia and Spain certainly have different experiences in using comics during mathematics learning. The way interactive comics are introduced and used in the classroom can vary, impacting student responses. Differences in teacher facilitation, context of use, and additional materials may influence how students view various aspects of comics. A consistent learning approach may result in more uniform responses for certain indicators, while variability may result in different evaluations. Second, technical qualities include color selection, use of images and illustrations, sound and video control. If students in Spain were more familiar with interactive comics as a learning tool, they might have higher expectations regarding this specific indicator. This familiarity can lead to a more critical assessment of content quality, technical execution, and language accuracy. In contrast, media novelty may produce more enthusiastic and consistent responses to indicators related to overall learning quality and interest, which are perceived as more positive and in line with the average. Third, language quality, their previous exposure to different teaching methods and educational content can shape their perceptions and evaluations. If they are accustomed to high-quality technical standards and appropriate use of language, their expectations may be higher, resulting in responses that deviate from the average.

Both groups showed improved comprehension and retention of mathematical concepts after using the interactive comics. The narrative structure and visual aids helped break down complex ideas into more manageable parts, facilitating better understanding. Indonesian students particularly benefited from the visual storytelling aspect, which helped demystify abstract concepts that are typically taught in a more rigid and theoretical manner. Spanish students, on the other hand, noted that the comics helped them see practical applications of mathematical theories, making the subject matter more relevant to their everyday lives. This contextualization of mathematics through stories and characters was a key factor in enhancing their learning experience.

The results of interviews with mathematics subject teachers also show that teachers strongly support the use of mathematics comics in learning. This approach can make learning more interesting and easier to understand for students, especially those who may have difficulty understanding conventional mathematical concepts. This is also supported by

students' responses to the use of mathematics comics which are very positive. They are more enthusiastic and actively involved in learning so that participation in class increases and their interest in mathematics increases. There was even a significant change in students' understanding after using mathematics comics. They tend to absorb difficult concepts more easily through the narrative and images presented in the comic. Students who previously experienced difficulties are now more confident in dealing with mathematics material.

The study noted that while interactive comics were effective in engaging students, they were not a substitute for traditional teaching methods (Akcanca, 2020; Damopolii et al., 2021). The comics worked best as a supplementary tool rather than the primary method of instruction. Teachers needed to integrate these comics into their lesson plans thoughtfully to maximize their effectiveness (Fitriani & Leton, 2024; Smyth, 2022). The findings of this study have several implications for educators and curriculum developers. Firstly, it underscores the potential of interactive comics as a valuable supplementary resource in mathematics education. By incorporating elements of storytelling, interactivity, and visual aids, educators can create a more dynamic and engaging learning environment (Azizah et al., 2022).

For Indonesian educators, this study suggests a need to gradually integrate more interactive and student-centered learning tools to complement traditional teaching methods (Kerimbayev et al., 2023). For Spanish educators, the focus could be on further enhancing the interactivity and practical application of mathematical concepts through such innovative tools. The study opens avenues for further research into the long-term impact of interactive comics on mathematical learning and other subjects. Future research could explore a larger and more diverse sample size, include longitudinal studies to assess the sustained impact of such tools, and investigate the integration of other multimedia elements like augmented reality to further enhance interactivity. From these results, it can be said that the mathematics comic on cartesian coordinates material developed is stated to be practical and can be used in mathematics learning. This is because the mathematics comic on cartesian coordinates material received a good response, and students hope that learning mathematics will be more fun and effective.

4. CONCLUSION

This research has provided valuable insights into the responses of Indonesian and Spanish students towards interactive mathematics comics, highlighting significant differences influenced by cultural backgrounds and educational contexts. The findings from both the independent sample t-test and one sample t-test underscored distinct perceptions and evaluations among the student groups. Indonesian students, relatively less exposed to interactive educational tools, demonstrated significant differences compared to their Spanish counterparts across all measured indicators—content and objective quality, technical quality, learning quality, language use, and interest. These differences suggest that Indonesian students found the comics engaging and effective in enhancing their understanding of mathematical concepts, potentially benefiting from the novelty and interactive nature of the educational tool. Conversely, Spanish students, with greater familiarity with interactive learning methods, exhibited varying responses particularly in

technical execution and language adaptation within the comics. While they showed alignment with group averages in learning quality and interest, significant deviations in specific indicators indicate nuanced evaluations influenced by their expectations of technical sophistication and linguistic precision. These findings underscore the importance of culturally sensitive educational strategies and personalized learning approaches in enhancing student engagement and comprehension. Educators and curriculum developers can leverage these insights to optimize the design and implementation of interactive mathematics comics, ensuring they effectively cater to diverse cultural and educational settings.

This research has limitations, namely that indicators such as content and objectives, technical quality, and language quality are more subjective and open to personal interpretation. Different students may have varying standards and preferences, which can result in a wider range of responses. Learning qualities and interests may be more easily understood and universally understood, resulting in responses that are more consistent and aligned with the average. Future research could delve deeper into longitudinal impacts and explore additional cultural factors that influence the adoption and effectiveness of interactive educational tools. By continuing to refine and tailor these approaches, educators can foster more inclusive and impactful learning environments for students worldwide.

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Declarations

Author Contribution : NHM: Conceptualization, Writing - Original Draft, Editing and Visualization; MA-P: Collecting data, Review & Editing, Supervision; MI: Writing, editing and Supervision.

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