

EXPLORING STUDENTS' PERSPECTIVES ON LEARNING COORDINATE GEOMETRY THROUGH COMICS: A NOVEL VISUAL APPROACH

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Abstract

Recent years have shown an increasing focus on developing and implementing innovative pedagogical strategies that improve student engagement and understanding of complex mathematical concepts. One such approach involves the use of comics as a learning tool to make abstract topics more accessible and engaging. However, despite potential advantages, research on students' perceptions of the creation and use of comics specifically in mathematics education, particularly in areas such as coordinate geometry, remains limited. Thus, this article aims to examine students' perspectives regarding the creation and use of comics in the classroom for understanding coordinate geometry, a subject under the Foundation Mathematics course taken by students at Universiti Teknologi MARA (UiTM) Shah Alam, Malaysia. This study took a quantitative approach using a survey method. The sample consisted of 100 CDCS240, CDCS253, and CDCS255 students from UiTM Shah Alam, Malaysia. The research data were obtained from questionnaires filled out by students and distributed online. The findings revealed that when students created comics to express their understanding of coordinate geometry, they engaged in a creative and constructive process that promotes the development of problem solving, representation, and communication abilities. These findings highlight the effectiveness of comics as an effective pedagogical tool in mathematics education. Integrating comics into teaching practices may enhance students' conceptual understanding and motivation, pointing to valuable opportunities for curriculum innovation and instructional design within Science, Technology, Engineering, and Mathematics (STEM) fields.

Keywords: comics, mathematics education, teaching tools

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Introduction

Most university curricula include mathematics as a required subject. University students, however sometimes struggle to understand how mathematical theories connect to real-world situations, leading to a loss of interest and disheartenment. Students were unable to apply mathematical principles in a range of settings due to a disconnect between mathematics and the real world. One of the learning methods that can be used to motivate students in learning mathematics is using comics. Comics are one of the visual communication media used in learning. Comics consist of images that depict characters and enact stories to educate and entertain the readers (Manning, 1998). The visual art of the comics enhances and extends the communication provided in the text by facilitating the reader to create their own understanding of the setting of the text after being attracted to the visual (McVicker, 2007). That is, visuals are valuable for directing readers' understanding of spatial relations in the context (Pratt,

2009). Incorporating visuals in comics enhances students' capacity to construct knowledge across various modalities (Bolton-Gary, 2012). Comics is a form of visual communication that has the power to convey information in a popular manner and is easy to understand (Maharsi, 2012). According to Lazarinis et al. (2015), comics are a form of storytelling. They use a series of static images while presenting a story as a tool. Nurfitriyanti & Suhendri (2020) also noted that illustrations in comics serve to deliver clear and concise information to the audience.

Comic-based learning, as proposed by Wibowo (2013), was utilized to convey educational content that is challenging for students to grasp through text alone. This strategy highlights the importance of captivating visuals, merging image representation and animation to improve understanding. Additionally, as stated by Subroto et al. (2020), mathematics comics serve as an engaging method for teaching. According to Nurfitriyanti & Suhendri (2020), comics serve as an effective medium for learning mathematics due to their rich visual elements and their connection to real-life phenomena. Studies have shown that using comics and cartoons can enhance students' motivation and interest in learning mathematics in particular (Cho, 2012; Sparrow et. al, 2010). Furthermore, research by Şengül & Dereli (2010) has demonstrated that incorporating comics in mathematics education can reduce students' anxiety related to the subject.

While comics have gained popularity as educational resources in Western societies, particularly in industrialised nations, their use in Malaysia is still limited and underexplored (Krishnan & Othman, 2016; Rashid et al., 2019). One possible reason is the perception that comic books are mainly for entertainment and have little or no educational value. In addition, limited research has examined students' perceptions of using comics, especially in learning complex mathematical topics such as coordinate geometry. This gap in understanding presents a challenge to effectively integrating comics into the Malaysian mathematics curriculum. Therefore, this study aims to analyse students' perspectives on learning coordinate geometry through comics. The findings may provide useful insights for educators and curriculum designers in adopting innovative and engaging teaching strategies. Ultimately, the research has the potential to improve student motivation, understanding, and success in mathematics, thus fostering a wider initiative for enhanced, innovative and welcoming teaching strategies.

Methods

Study's Sample

This study applies a quantitative approach. An open-ended questionnaire was constructed to gather the appropriate data. This study used a sample of 100 undergraduate students, Universiti Teknologi MARA (UiTM) Shah Alam, Malaysia, who were enrolled in the MAT406 Foundation Mathematics from the CDCS2401B, CDCS2531A, and CDCS2551B courses.

Research Instrument

The instrument of research used in this study was a semi-structured questionnaire, which was adapted from Ellis (2015) and Rashid et al. (2019). The survey was conducted online using Google Survey and has been divided into three separate sections. The first section related to the demographic information of the respondents, containing only two items. The second section explored students' perspectives on using comics in learning mathematics, focusing on seven aspects: motivation, active learning, collaboration, learning opportunity, usefulness, ease of use, and satisfaction with comics. The last section examined students' experiences with the use of comics in learning mathematics.

Research Procedure

Instructors invite the students to join the Padlet provided to collect all information regarding the subject. The instructor has provided several examples of comics that need to be completed by the students. After learning the topic of coordinate geometry in the Foundation Mathematics course, students, working in groups, are required to transfer their knowledge or concepts into a comic template. Students are also encouraged to use their own designs and creativity for the comics. All tasks need to be submitted in the

designated space on the Padlet. Figure 1 below shows an example of the task given to the students, while Figure 2 illustrates an example of comics created by the students.

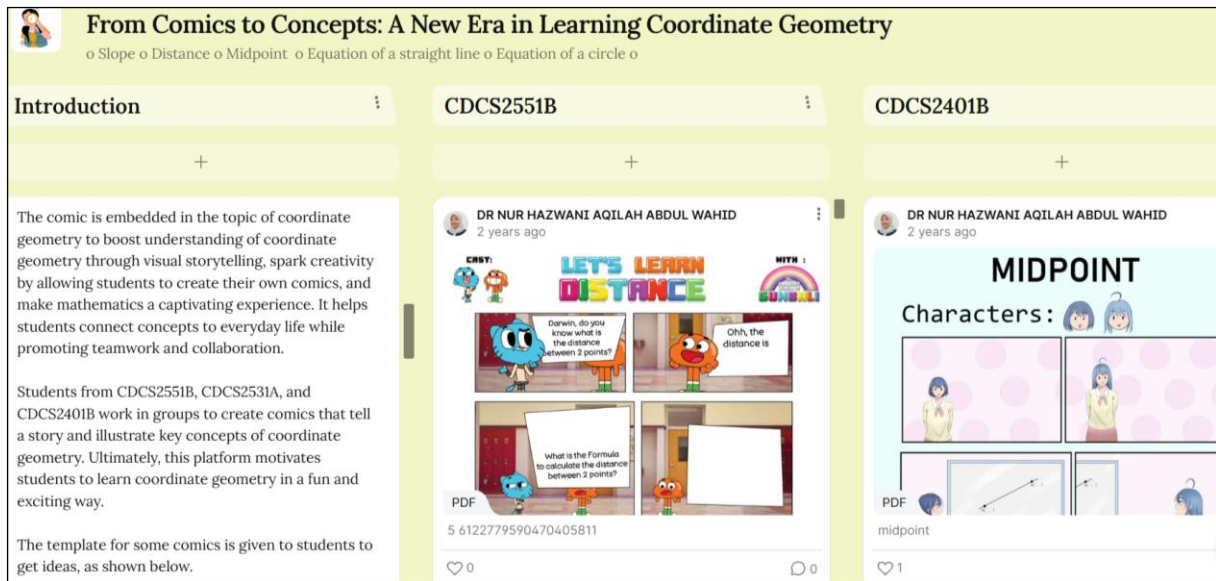


Figure 1. Example of the task given to the students

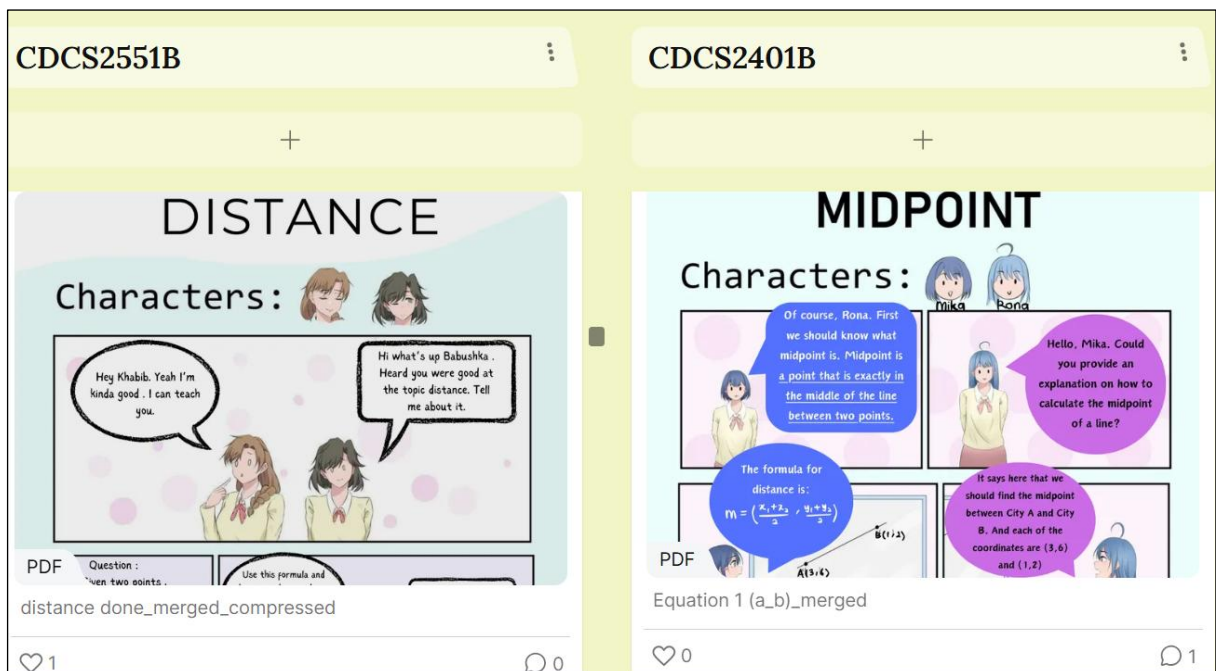


Figure 2. Example of comics done by students

Results and Discussion

Demographic Information

Figure 3 below presents the gender distribution of students in this study who enrolled in three different courses: CDCS2401B, CDCS2531A, and CDCS2551B. In the CDCS2401B course, a significant majority of students are female (73.3%), with males making up only 26.7%. Conversely, in the CDCS2531A course, the gender distribution is more balanced, with females constituting 54.3% and males 45.7%. Similarly, in the CDCS2551B course, the gender split is equal, with both females and

males each comprising 54.3% and 45.7%, respectively. This data indicates a notable gender disparity in CDCS2401B, while the other two courses show a more balanced representation of genders.

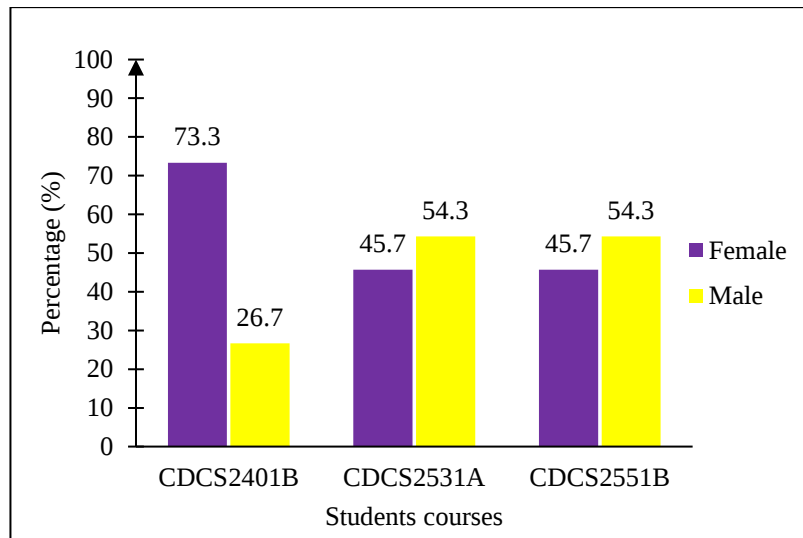


Figure 3. Gender of students based on courses

Students' Perspectives on Using Comics in Learning Mathematics

(a) Motivation

Table 1 shows the analysis of students' perceptions on how comics influence their motivation to complete tasks and collaborate in groups. In response to the statement "Comics motivate me to complete tasks assigned by my instructor," 44% of students "Strongly Agree" and 47% "Agree," reaching an average of 4.31 and a standard deviation of 0.7614. Only 1% "Strongly Disagree" and 2% "Disagree." For the statement "Comics motivate me to interact with my group members outside of class," 40% "Strongly Agree" and 46% "Agree," with an average of 4.24 and a standard deviation of 0.7537. 1% "Strongly Disagree" and no students "Disagree." Regarding "Comics motivate my group to interact and complete tasks together," 44% "Strongly Agree" and 49% "Agree," resulting in an average of 4.37 and a standard deviation of 0.6139, with no negative responses.

Table 1. Analysis of students' responses to motivation with the use of comics

Questions	Percentage (%)					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree		
Comic motivates me to complete tasks assigned by my instructor	1	2	6	47	44	4.31	0.7614
Comic motivates me to interact with my group members outside of class	1	0	13	46	40	4.24	0.7537
Comic motivates my group to interact and complete tasks together	0	0	7	49	44	4.37	0.6139

Figure 4 illustrates the perspectives of female and male students on whether comics encourage participation in learning activities. A substantial majority of both female (98.1%) and male (91.3%) students believe that comics serve as a motivational tool in learning environments. Conversely, a small percent of students, 1.9% of females and 8.7% of males, do not think that comics effectively motivate participation in learning activities.

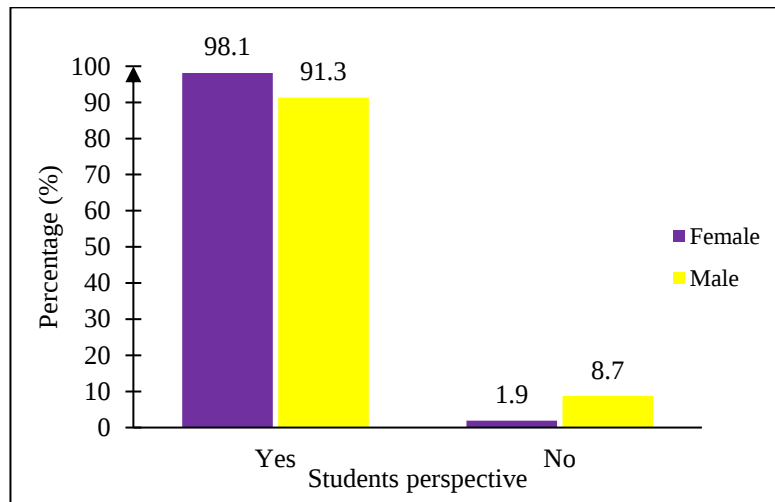


Figure 4. Comics motivate participation in learning activities

(b) Active Learning

Table 2 shows the analysis of students' responses to active learning. It provides insights into students' perceptions of how comics impact their engagement and stress levels during class activities. For the statement "When using comics for class activities, I prefer to do it in a group rather than individually," 50% of students "Strongly Agree" and 38% "Agree," resulting in an average of 4.33 and a standard deviation of 0.8415. Only 2% "Strongly Disagree" and 1% "Disagree." Regarding "When using comics for group activities, I feel less stressed," 41% "Strongly Agree" and 44% "Agree," with an average of 4.22 and a standard deviation of 0.8025. A minimal 4% "Disagree" and no students "Strongly Disagree." For "After using comics, I was more engaged in my learning," 49% "Strongly Agree" and 41% "Agree," resulting in an average of 4.36 and a standard deviation of 0.8027. Only 2% "Strongly Disagree" and no students "Disagree".

Table 2. Analysis of students' responses to active learning with the use of comics

Questions	Percentage (%)					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree		
When using comics for class activities, I prefer to do it in a group rather than individually	2	1	9	38	50	4.33	0.8415
When using comics for group activities, I feel less stressed	0	4	11	44	41	4.22	0.8025
After using comics, I was more engaged in my learning	2	0	8	41	49	4.36	0.8027

Figure 5 shows the perspectives of students, both female and male, on whether comics improve understanding of the course. 96.3% of female students believe that comics effectively enhance understanding of the course content, while 91.3% of male students share this opinion. On the other hand, a minority of students, 3.7% of females and 8.7% of males, do not believe that comics help improve understanding of the course.

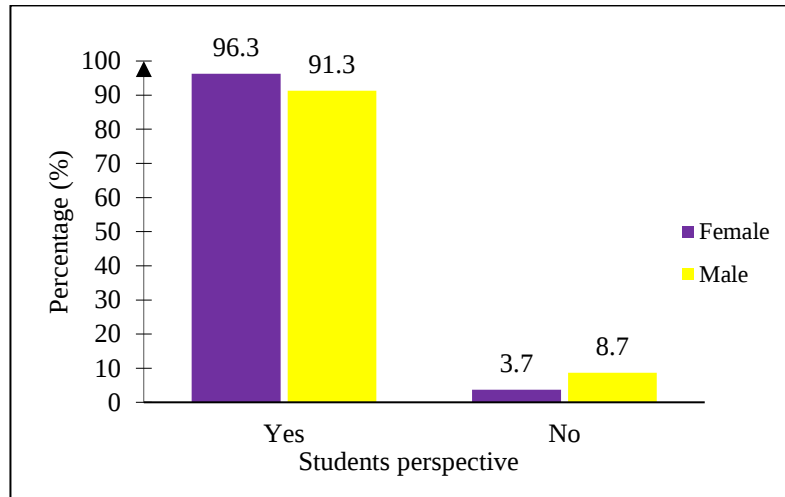


Figure 5. Comics enhance understanding of the course

(c) Collaboration

Table 3 shows students' perceptions of how comics influence their interaction and collaboration within a group. For the statement "The comic motivates me to interact with my group members," 43% of students "Strongly agree" and 44% "Agree," resulting in an average of 4.30 and a standard deviation of 0.6890. No one disagreed or strongly disagreed. In terms of "The comic encourages me to work together on tasks," 41% "Strongly agree" and 49% "Agree," with an average of 4.30 and a standard deviation of 0.6742. Only 1% disagreed. For the statement "Comics help me collaborate with my group members," 47% "Strongly agree" and 45% "Agree," leading to an average of 4.39 and a standard deviation of 0.6340. There were no negative responses.

Table 3. Analysis of students' responses to collaboration with the use of comics

Questions	Percentage (%)					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neither Agree or Disagree	Agree	Strongly Agree		
Comic motivates me to interact with my group members	0	0	13	44	43	4.30	0.6890
Comic encourages me to complete tasks together	0	1	9	49	41	4.30	0.6742
Comics help me collaborate with my group members	0	0	8	45	47	4.39	0.6340

Figure 6 presents the perspectives of female and male students on whether comics aid in group collaboration. A vast majority of both female (98.1%) and male (97.8%) students believe that comics facilitate collaboration among group members. Conversely, only a small fraction of students, 1.9% of females and 2.2% of males, do not think that comics help in collaborative efforts.

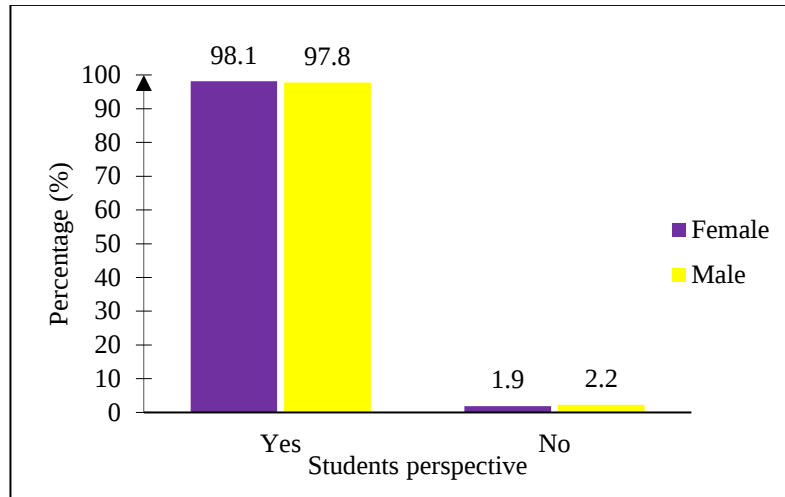


Figure 6. Comic helps to collaborate among group members

(d) Learning Opportunity

Table 4 illustrates the analysis of students' perceptions of how comics contribute to their learning experiences and understanding of subjects. For the statement "Comic allows me to learn from my classmates by reading their posts and comments on our class wall," 43% of students "Strongly Agree" and 47% "Agree," resulting in an average of 4.32 and a standard deviation of 0.6799. Only 1% "Disagree" and no one "Strongly Disagree." Regarding "Comics help me prepare for my independent learning in subjects," 44% "Strongly Agree" and 48% "Agree," with an average of 4.34 and a standard deviation of 0.6995. Only 1% "Strongly Disagree" and no one "Disagree." For the statement "Comics help me learn and understand further about subjects based on the exercise given," 46% "Strongly Agree" and 46% "Agree," leading to an average of 4.36 and a standard deviation of 0.6893. Only 2% "Disagree" and no one "Strongly Disagree".

Table 4. Analysis of students' responses to learning opportunities with the use of comics

Questions	Percentage (%)					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree		
Comic allows me to learn from my classmates by reading their posts and comments on our class wall	0	1	9	47	43	4.32	0.6799
Comics help me prepare for my independent learning in subjects	1	0	7	48	44	4.34	0.6995
Comics help me learn and understand further about subjects based on the exercise given	0	2	6	46	46	4.36	0.6893

(e) Usefulness

Table 5 provides an analysis of students' perceptions of how effective comics are in enhancing their learning experience. For the statement "Comics help me be more effective in learning about subjects,"

44% of students "Strongly Agree" and 46% "Agree," resulting in an average of 4.30 and a standard deviation of 0.7850. Only 2% "Strongly Disagree" and no one "Disagree." Regarding "Comic is useful in understanding further about mathematics," 44% "Strongly Agree" and 46% "Agree," with an average of 4.31 and a standard deviation of 0.7480. Only 1% "Strongly Disagree" and 1% "Disagree." For the statement "Comic meets my expectations," 38% "Strongly Agree" and 49% "Agree," leading to an average of 4.23 and a standard deviation of 0.7366. Only 1% "Strongly Disagree" and no one "Disagree".

Table 5. Analysis of students' responses to usefulness with the use of comics

Questions	Percentage (%)					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree		
Comics help me be more effective in learning about subjects	2	0	8	46	44	4.30	0.7850
Comic is useful in understanding further about mathematics	1	1	8	46	44	4.31	0.7480
Comic meets my expectations	1	0	12	49	38	4.23	0.7366

(f) Ease of Use

Table 6 presents an analysis of students' perceptions regarding the usability of comics. For the statement "Comics are easy to use," 52% of students "Strongly Agree" and 40% "Agree," resulting in an average of 4.42 and a standard deviation of 0.7132. Only 1% "Strongly Disagree." Regarding "Comics are simple to use," 51% of students "Strongly Agree" and 44% "Agree," with an average of 4.46 and a standard deviation of 0.5932. No students "Strongly Disagree" or "Disagree." For the statement "Comics are user-friendly," 50% "Strongly Agree" and 47% "Agree," leading to an average of 4.47 and a standard deviation of 0.5588. No negative responses were recorded. For "Comics can be used without reading instructions," 54% "Strongly Agree" and 41% "Agree," resulting in an average of 4.48 and a standard deviation of 0.6273. Lastly, for "Comics are easy to understand," 52% "Strongly Agree" and 44% "Agree," achieving an average of 4.47 and a standard deviation of 0.6106. Only 1% "Disagree".

Table 6. Analysis of students' responses to ease of use with the use of comics

Questions	Percentage (%)					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree		
Comics are easy to use	1	0	7	40	52	4.42	0.7132
Comics are simple to use	0	0	5	44	51	4.46	0.5932
Comics are user-friendly	0	0	3	47	50	4.47	0.5588
Comics can be used without reading instructions	0	1	4	41	54	4.48	0.6273
Comics are easy to understand	0	1	3	44	52	4.47	0.6106

(g) Satisfaction

Table 7 shows an analysis related to the insights into students' satisfaction with the use of comics in learning mathematics. For the statement "I am satisfied with the use of comics in learning mathematics,"

41% of students "Strongly Agree" and 49% "Agree," resulting in an average of 4.26 and a standard deviation of 0.7992. Only 2% "Strongly Disagree" and 1% "Disagree." Regarding "I would recommend comics to my friends to help them learn mathematics," 45% "Strongly Agree" and 46% "Agree," with an average of 4.29 and a standard deviation of 0.8563. A small 3% "Strongly Disagree" and 1% "Disagree." For the statement "Comics are fun to use," 48% "Strongly Agree" and 47% "Agree," leading to an average of 4.38 and a standard deviation of 0.7625. Only 2% "Strongly Disagree" and 1% "Disagree".

Table 7. Analysis of students' responses to satisfaction with the use of comics

Questions	Percentage (%)					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree		
I am satisfied with the use of comics in learning mathematics	2	1	7	49	41	4.26	0.7992
I would recommend comics to my friends to help them learn mathematics	3	1	5	46	45	4.29	0.8563
Comics are fun to use	2	1	2	47	48	4.38	0.7625

Students' Experience with the Use of Comics in Learning Mathematics

Table 8 summarizes the analysis of students' perceptions regarding the impact of comics on their learning experience. The results show a strong positive attitude towards the use of comics in education. Specifically, 52% of students "Strongly Agree" and 40% "Agree" that comics have inspired them and helped improve their analytical skills, with a mean score of 4.42 and a low standard deviation of 0.6989. Similarly, 48% "Strongly Agree" and 45% "Agree" that comics have increased their knowledge of the topics, resulting in a mean score of 4.40 and a standard deviation of 0.6513. The statement "Comics improve my creativity and enhance my imagination" received the highest mean score of 4.47, with 54% "Strongly Agree" and 40% "Agree," indicating a strong consensus on this benefit. Additionally, 51% "Strongly Agree" and 41% "Agree" that comics should be continued and implemented in the future for other mathematics topics, with a mean score of 4.37 and a standard deviation of 0.8122. Students also indicated that comics helped them understand the topic in better ways (50% "Strongly Agree" and 43% "Agree," mean score of 4.42, standard deviation of 0.6541) and that they are happy to learn mathematics using comics (50% "Strongly Agree," 42% "Agree," mean score of 4.34, standard deviation of 0.8901). The use of comics as an educational tool is also seen as promoting creativity and collaborative learning among students, with a mean score of 4.43 and a low standard deviation of 0.6705. Finally, 53% "Strongly Agree" and 41% "Agree" that comics serve as a valuable learning resource and a great tool for learning, with a mean score of 4.43 and a standard deviation of 0.7555.

Table 8. Analysis of students' responses to the effectiveness of comics

Questions	Percentage (%)					Mean	Standard Deviation
	Strongly Disagree	Disagree	Neither agree or disagree	Agree	Strongly Agree		
Comic has inspired me and helped me improve in analytical skills	0	2	6	40	52	4.42	0.6989
Comic has increased my knowledge of the topic	0	1	6	45	48	4.40	0.6513
Comics improve my creativity and enhance my imagination	0	1	5	40	54	4.47	0.6428

Comics should be continued and implemented in the future for other topics related to mathematics	1	4	3	41	51	4.37	0.8122
Comic has helped me understand the topic in better ways	0	1	6	43	50	4.42	0.6541
I am happy to learn mathematics using comics	4	0	4	42	50	4.34	0.8901
The use of comics as an educational tool promotes creativity and collaborative learning among students	1	0	4	45	50	4.43	0.6705
Comic serves as a valuable learning resource and a great tool for learning	2	0	4	41	53	4.43	0.7555

Figure 7 illustrates the percentage of female and male students who either recommend or do not recommend the use of comics in other subjects. A significant majority of both genders favor the use of comics, with 87% of female students and 91.3% of male students responding "Yes" to recommending comics for other subjects. In contrast, a smaller portion, 13% of female students and 8.7% of male students, do not recommend comics for other subjects.

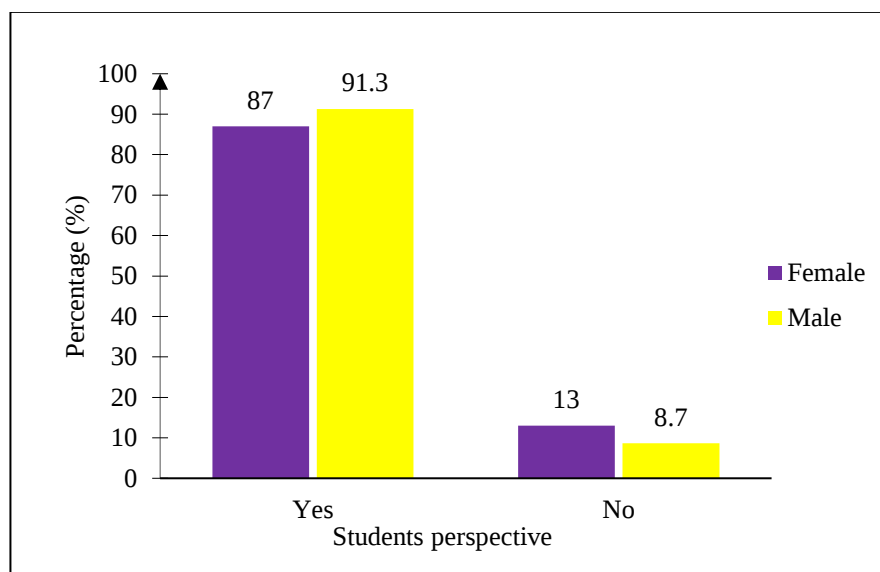


Figure 7. Recommendation of comic to the other subject

Consideration of Potential Bias and Limitations

Although the results across all dimensions, for example, motivation, active learning, collaboration, learning opportunity, usefulness, ease of use, and satisfaction consistently indicate strong positive perceptions of using comics in mathematics learning, several limitations should be noted when interpreting these findings. First, because the activities were part of the coursework, students may have felt pressured to give favourable responses, creating social desirability bias. In addition, the lack of a control group makes it difficult to confirm that the positive responses were due solely to the use of comics rather than other factors such as the novelty of the activity or the instructor's approach. Future studies could reduce these biases by using a control group, anonymous responses, or additional

measures of learning outcomes. Second, the study relied mainly on descriptive statistics such as means, standard deviations and percentages and did not include inferential analyses (e.g., t-tests or ANOVA) to examine potential differences by gender or course. This limitation reflects the exploratory design and the absence of subgroup data required for such tests. Future research should collect and analyse subgroup data to enable more robust inferential comparisons.

Comics have become an effective instructional instrument, especially in mathematics, as they provide a unique combination of visual stimulation and intellectual comprehension. The utilisation of comics in mathematics instruction is becoming acknowledged as an effective approach to enhancing student involvement and understanding. Previous studies indicate that visual narrative in comics assists in explaining intricate mathematical concepts, making them simpler to understand and useful (Muzumdar, 2016). This study shows that using comics in mathematics teaching gained very positive responses from students, especially in terms of motivation and active learning. The findings reveal that comics encourage students to take part in both individual tasks and group activities. The increase in motivation is particularly evident among female students, who reported higher levels of engagement when comics were used as a learning tool. The visual and narrative elements of comics engage students more effectively than traditional methods. This enables a clearer understanding of mathematics and reduces the perception of difficulty. Overall, students feel more motivated because comics explain difficult mathematical ideas in a simpler and clearer way, making the subject easier to understand and the learning process more enjoyable (Mousavi et al., 1995; Putri et al., 2022; Novferma et al., 2023). This outcome can be interpreted through cognitive load theory (Mousavi et al., 1995), which posits that integrating visual and verbal information reduces extraneous cognitive load and makes complex mathematical concepts easier to process. Likewise, dual coding theory (Paivio, 1990) explains how presenting content in both text and image formats enhances comprehension and memory. From a constructivist perspective, the use of comics encourages students to actively construct meaning through discussion and exploration, aligning with the high levels of motivation and engagement reported in this study.

In addition to increasing motivation, comics have a significance for supporting active learning and collaboration among students. The findings show that most students prefer group activities that use comics, as these activities help reduce stress and increase engagement. This preference is especially strong among female students, suggesting that comics can support a more inclusive learning environment and help reduce gender gaps in Science, Technology, Engineering, and Mathematics (STEM) education. The collaborative element in comics encourages student participation by allowing for group discussion, debate, and exploration of mathematical subjects. This improves comprehension of the topic and develops important interpersonal and collaborative abilities (Nugraheni, 2017; Anggara et al., 2019; Suyanto et al., 2019). Furthermore, students responded positively to the use of comics in mathematics and other subjects. This wide acceptance shows that comics are a flexible teaching tool that can improve learning in many different fields. (McCloud & Martin, 1993). Student feedback shows a high level of satisfaction with the use of comics, proving their effectiveness in learning. Students find comics engaging, easy to understand, and accessible, which increases their overall satisfaction with the learning experience. This overall satisfaction is evident in students' frequent suggestions to apply comics in additional academic subjects. The consistent positive responses across various aspects of learning, such as motivation, active learning, collaboration, and overall satisfaction, indicate that comics are not only an effective tool for enhancing mathematical understanding but also hold great potential for broader educational applications. The limited variability in responses indicates a strong acceptance among students, supporting the idea that comics act as a valuable and widely recognised educational resource.

Conclusion

Using comics in mathematics education has been gaining popularity as a creative way to blend visual learning with understanding key concepts. By combining images and text, comics present complex mathematical ideas in a story-like format that can capture the interest of a wide range of students. The students' perspectives towards learning mathematics, in this study, on the topic of coordinate geometry

through comics, were explored. The findings indicate that comics can be employed very effectively in learning a coordinate geometry topic. A majority of students indicated positive feedback, suggesting that comics encourage the elimination of barriers, increase motivation, and encourage active learning and constructive collaboration. The integration of visual and story elements in comics enhances the appeal of learning and decreases persuasion, especially among female students, who exhibit increased motivation and engagement in mathematics. Comics also help ease anxiety related to learning, encourage more interaction, and support the development of teamwork skills, leading to better classroom dynamics and student participation in mathematics. Learning coordinate geometry through comics makes the experience more effective, enjoyable, and satisfying, showing that the benefits of using comics in education go beyond just one subject or topic.

Integrating comics into mathematics education offers significant potential for improving curriculum design, influencing educational policies, and enhancing career preparation. Including comics as part of the mathematics curriculum might lead to more accessible and adaptable learning environments, especially for students who learn concepts more easily in images or storytelling. The approach might also help bridge achievement gaps by introducing innovative approaches to understanding complex mathematical concepts. Thus, the efficacy of using comics in learning other STEM disciplines and for other levels of study would be a research worth undertaking. Besides that, one can also examine the practicality of the augmented reality (AR) technology in an ethnomathematics comic that demonstrates effectiveness in enhancing students' numeracy and literacy skills.

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Author Contribution

NHA Abdul Wahid – conceptualization, data collection, writing – original draft, review & editing; NA Abdul Wahid – data curation, methodology, formal analysis & interpretation of results.

Conflict of Interest

The authors declare no conflicts of interest.

Declaration on the Use of Generative AI

The authors declare no generative AI was used in the manuscript.

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