

Improvement of Students' Mathematical Communication Skills Using Culture-Based Webtoon Digital Comic Learning Media

Nuraini Sri Bina^{1,2}, Dian Armanto¹, Waminton Rajagukguk¹

¹Medan State University, st Willem Iskandar, Medan, 20221, Indonesia

²Potensi Utama University, KL. Yos Sudarso, Medan, Indonesia

Abstract – Digital technology-based learning media is an effective tool in the development of modern education. Despite the potential, several schools have not fully implemented this tool in the learning process. For example, the competence of Indonesian students in mathematics is ranked 68th out of 81 participating countries in PISA 2022. Therefore, this study aimed to develop web-based comic in education for generation z or i-gen students using Indonesian cultural heritage. The study procedures were carried out based on the method proposed by Plomp as well as the development model. The results showed that learning media developed was valid with scores of 4.4 and 4.3 for practicality and effectiveness, respectively. In addition, 86.11% of students achieved Minimum Completeness Criteria (KKM), with 97.7% providing a positive response regarding Webtoon digital comic. The findings also revealed a significant increase in students' mathematical communication skills after the intervention, as evidenced by changes in each indicator. Based on these results, Webtoon digital comic had the potential to be developed for learning different materials and other subjects.

Keywords – Culture, digital comic, mathematical communication, learning media, Webtoon.

1. Introduction

The advancement of a country in the context of technology and world development is largely dependent on the strength of the educational system. Several studies showed that education played an essential role in shaping the character of the future generation, fostering traits, such as civility, knowledgeability, intellect, and the capacity to contribute meaningfully towards nation-building. Therefore, it is essential for the accomplishment of the objectives of any country.

Transforming society by cultivating a populace with positive mindsets and high standards is an objective that can be achieved through educational endeavors [1]. In the education sector, schools play an important role in shaping the future of individuals, communities, and country. This can be achieved through advancement of knowledge and skills, character and ethics development, career and life preparation, social and economic empowerment, life skills acquisition, and the nurturing of responsible citizenship.

Among the primary functions of schools is the cultivation of knowledge and skills, with mathematics holding a significant position. Mathematics has been reported to have the potential to equip students with invaluable soft skills, such as critical thinking, problem-solving abilities, discipline, creativity, and analytical reliability, as stated by Birgili [2]. This indicates that it assumes an essential role in individual development and societal progress. Despite its importance, the performance of Indonesian students in mathematics is still below expectation. In addition, the PISA 2022 results on December 5, 2023, revealed that Indonesian students' mathematical proficiency scoring was 379, ranking 68th out of 81 participating countries [3].

This low performance is further corroborated by Svecova's study [4], indicating that 36.23% of 138 participants struggle with mathematics problem-solving.

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Corresponding author: Nuraini Sri Bina,

¹Medan State University, st Willem Iskandar, Medan, 20221, Indonesia.

²Potensi Utama University, KL. Yos Sudarso, Medan, Indonesia.


Email: rainribi2701@gmail.com

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The persistently low achievement levels in mathematics can largely be attributed to deficient mathematical communication skills. Riswandha and Sumardi [5] also reported the essential role of mathematical communication skills as the foremost factor influencing mathematics learning achievement. This result was in line with the field investigations conducted at SMA Negeri 1 Brastagi, Karo Regency, North Sumatra, Indonesia, which revealed low levels with scores of ≤ 40 [6]. In addition, the examination of mathematical communication skills typically depends on different indicators, such as expressing mathematical ideas scores in the range of 50-65 [7].

In line with previous reports, the deficiency in mathematical communication skills is caused by 2 principal factors, namely technology-based learning media and cultural influences in education. Technology-based learning media has demonstrated the skills to enhance mathematical communication skills, as reported by Bina [8]. Among the media, digital comic is an effective tool for facilitating comprehension of mathematical concepts [9]. Meanwhile, culture-based learning serves as a means of enriching scientific and technological understanding among students. This assertion is supported by a study conducted in countries ranking in the top 7 of PISA, revealing that the integration of traditional cultural elements, such as Chinese music or Korean Tulou architecture, into the curriculum

yield improvements in students' mathematics achievement [10], [11]. Despite the availability of several technology-based learning media in schools, the effectiveness has not been fully realized, as evidenced by Indonesian performance in the 2022 PISA rankings. Addressing this gap necessitates a comprehensive solution that incorporates both factors contributing to low mathematical communication skills. Therefore, this study proposes a novel approach, namely the development of culture-based digital comic learning media. By integrating cultural elements into digital comic platform, this innovative solution aims to optimize students' mathematical communication skills.

2. Methodology

This was a development study, which was carried out based on the procedures proposed by Plomp and the development model. The study procedures were carried out at SMA Negeri 1 Kabanjahe and SMA Negeri 1 Brastagi, with students serving as the target of data collection. In addition, the process for the development of Webtoon digital comic learning media followed the five development steps of the Plomp model, namely preliminary investigation, design, realization/construction, testing, evaluation and revision, and implementation [12]. The research design is shown in Figure 1 below:

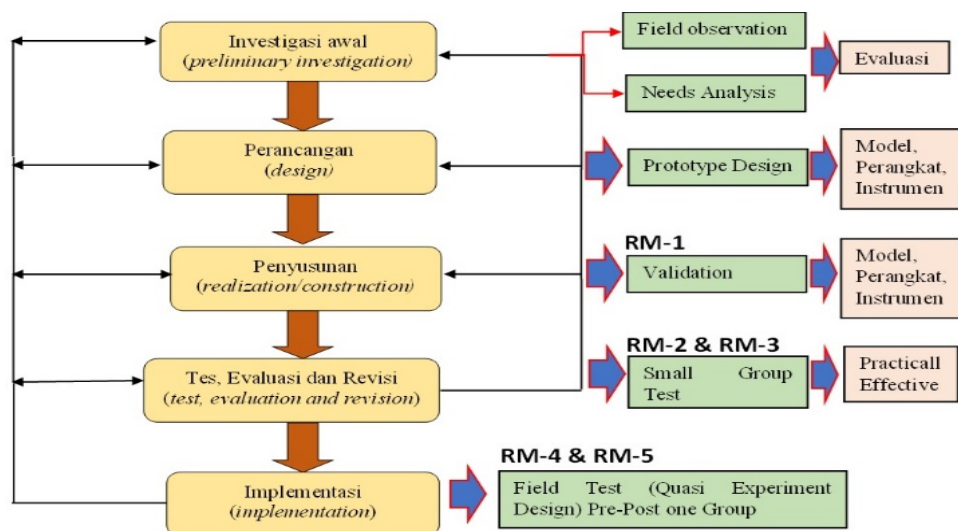


Figure 1. Research design

Figure 1 shows that in the preliminary investigation stage, field observations and needs analysis were conducted; in the design stage, a prototype design of Webtoon was obtained; in the realization stage, validation of Webtoon learning

media was conducted; in the test and evaluation stage, small group field trials were conducted; and in the implementation stage, experiments with quasi-experimental design were conducted.

3. Results

The design results of Webtoon digital comic as a developed prototype are presented in Figure 2.

Figure 2 shows the front view of the Webtoon digital comic learning media prototype design.

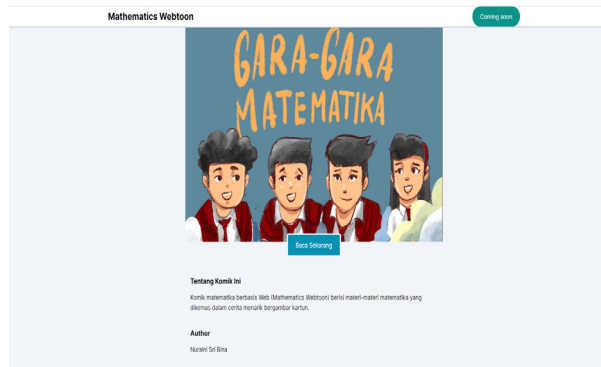


Figure 2. Webtoon digital comic

The realization stage in this study was the validity testing. The testing, evaluation, and revision stages produced practicality and effectiveness.

These three components were the quality standards of a developed product, as reported by Nieveen [13]. The validity of Webtoon digital comic is summarized in Table 1.

Table 1. Webtoon digital comic validation results

No	Assessment Aspect	Validator					Average
		I	II	III	IV	V	
1	Material Component	4.3	4.7	4.1	4.4	4.4	4.38
2	Construction	4.4	4.6	4.4	4.3	4.3	4.4
3	Language Components	4.4	4.2	4	4.4	4.2	4.8
	Average Value	4.4					

Based on Table 1, the average value for each component of all validators was 4.4 in the range of $4 \leq 4.4 < 5$, indicating that digital comic was deemed valid according to Retnawati [14].

The results of the practicality of Webtoon digital comic were outlined in Table 2.

Table 2. Practicality assessment

No	Assessment Aspect	Validator					Average
		I	II	III	IV	V	
1	Effective	4	4	4	4	4	4
2	Interactive	4.3	4.5	4.3	4.3	4.3	4.4
3	Efficient	4.3	4.3	4.5	4.3	4.5	4.38
4	Creative	4	4	4	4	4	4
	Average Value	4.2					

Table 2 showed that the practicality assessment of Webtoon digital comic included effectiveness, interactivity, efficiency, and creativity. The effectiveness aspect indicated that digital comic could be used to explain material, while interactivity ensured images were well presented and clear, and all letters were legible. Efficiency showed that digital comic was easy to carry and use, while creativity was related to the skills to help students become active in learning.

The average score for all components from validators was 4.2, indicating that Webtoon digital comic was practical or had a high level of usability.

The small group testing, evaluation, and revision phases showed practicality and effectiveness. A product was considered to be effective when 80% of students achieved KKM and the responses to the product were positive. Based on the trial, learning outcomes showed a score of 86.11% for KKM and 97.7% of the responses obtained were positive.

Subsequently, Webtoon digital comic was in the effective category as a summary of the percentage of students who achieved KKM and the positive responses was presented in Figure 3.

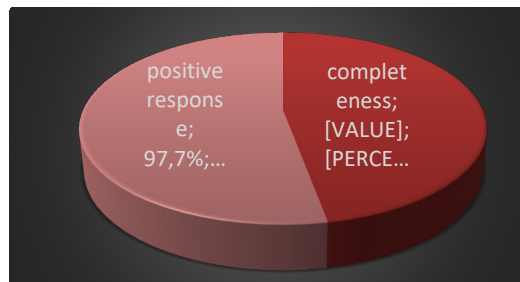


Figure 3. Webtoon digital comic effectiveness percentage

According to the analysis in Figure 3, Webtoon digital comic reached the effective indicator aspect. According to Sinaga [15], the completeness reached $\geq 85\%$ and the positive response was $\geq 80\%$.

The analysis of student response instruments to Webtoon digital comic learning media is shown in the table below:

Table 3. Data on student response results to Webtoon digital comic learning media

Statement	Strongly agree (4)	Agree (3)	Disagree less (2)	Disagree (1)	Amount*Weight
I am interested in digital comics (webtoons) within the context of cartoon culture.	24	11	1	0	131
	66,7%	30,6%	2,8%	0	
I am interested in Digital Comics (webtoons) integrated with Karo Culture because they are new to me.	28	8	0	0	136
	77,7%	22,2%	0	0	
I am interested in participating in further learning activities using WebToon Digital Comics.	26	8	2	0	136
	72,2%	22,2%	5%	0	
Webtoon media uses language that is easy to understand, good writing, pictures and illustrations, so it is useful to help me improve my mathematical communication skills.	25	6	5	0	118
The webtoon-based learning activities I participated in helped me understand cultural values.	30	5	1	0	143
	83,3%	13,9%	2,7%	0	
	69,4%	16,7%	13,9%	0	
Overall	103	33	6	0	523
	78,8%	18,9%	2,3%		
Positive response	97,7%				

Based on the descriptive statistical analysis (Table 3), it was found that the average number of students who had a positive response (strongly agree and agree with weights of 4 and 3) to the learning media for culture-based webtoon digital comics was an average of 34 people, or if the percentage was multiplied by the weight, it was 97.7%. The following are several statements as an explanation of the table above:

- A total of 35 students, or 97.2%, indicated that they were interested in webtoon learning media integrated with the context of Karo culture.
- Additionally, 34 students, or 94.4%, expressed interest in webtoon digital comics integrated with Karo culture.
- Another 97.2% of the students stated that they were interested in participating in further learning with the help of webtoon digital comics.

- Moreover, 94.4% of the students mentioned that the webtoon learning media uses language that is easy to understand, along with good writing, pictures, and illustrations. This helps students to better understand materials that are closely related to in their daily lives.
 - Finally, 35 students, or 97.2%, reported that the learning activities they participated in helped them understand cultural values.
- Meanwhile, those who had a negative response (disagree less and disagree with a weight of 2 and 1) were an average of two people or if the percentage associated with the weight was 2.3%.

The last stage was the implementation, which was carried out after confirming that Webtoon digital comic was valid, practical, and had effective quality standards. The product was then applied in learning, and the results of the application were presented in Figure 4.

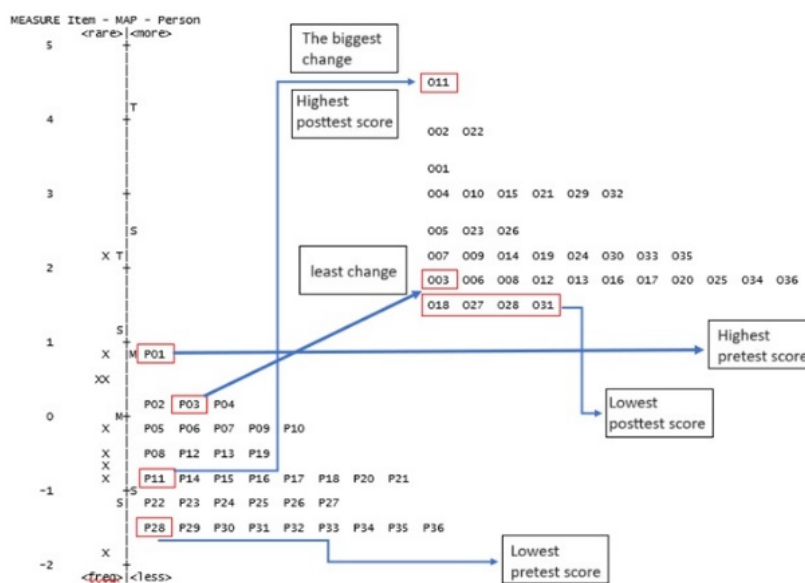


Figure 4. Changes in mathematical communication skills

Based on Figure 4, there was a change in mathematical communication skills before and after learning with Webtoon digital comic. The use of comic in the experimental classroom showed that all students experienced positive changes and were able to complete the items of mathematical communication skills. This was evidenced by the data on changes from the pre-test to the post-test, with the average logit values being positive. The greatest change occurred among participants with code 011, which had a very good difference in answering mathematical communication skills test questions.

The magnitude of this positive change in the logit value indicated that students in the implementation phase of the Plomp development study were able to improve the mathematical communication skills effectively and positively after receiving learning interventions using Webtoon digital comic.

This change was subsequently confirmed by the Wilcoxon test, which indicated a good change or improvement in each indicator item of students' mathematical communication skills. The results of the Wilcoxon signed rank test are presented in Table 4.

Table 4. Wilcoxon signed rank test

		N	Mean Rank	Sum of Ranks
Posttest-Pretest	Negative Ranks	0 ^a	0.00	0.00
	Positive Ranks	36 ^b	18.50	666.00
	Ties	0 ^c		
	Total	36		

Table 4 showed that no student had a lower post-test score compared to the pre-test scores. This could be seen from the negative rank, with the amount of data being 0. The average of the negative rank was 0 as well as the number of ranks. Subsequently, all students had improved, which was indicated by positive ranks, where the post-test score was higher than the pre-test. The number of positive ranks was 36 based on the number of students. The average of the ranks was 18.50 and the number of ranks was 666. Ties indicated that the post-test score was the same as the pre-test, showing the absence of change or improvement in students' mathematical communication skills. The results showed the absence of ties, indicating that all students experienced an increase in mathematical communication skills. The significance test of the differences in mathematical communication skills before and after learning is presented in Table 4.

Table 5. Wilcoxon significance test of differences in mathematical communication skills

	Posttest – Pretest
Z	-5.328
Sig.	0.000

The analysis of the results indicated the differences in mathematical communication skills, namely Sig value $<0.05 = 0.000 <0.05$. This suggested that there was a difference in mathematical communication skills before using Webtoon digital comic and after learning. The negative sign (-) on the z-value only showed that the test performed was on the left side. This indicated that there was an increase after the intervention.

4. Discussion

Among the 36 students, a total of 31 (86.11%) achieved KKM, indicating the skills of digital comic to improve mathematical communication skills. In line with Jonassen [16], a follower of Slavin, there was a positive relationship between constructivist approaches and improved learning outcomes.

This was because Webtoon digital comic used constructivist learning theory as the basis for the development and were designed to be effective in conveying the materials. Reading Webtoon digital comic could make learning student-centered in accordance with the theory of constructivism and improve learning performance. Riska [17] also used student-centered learning theory as a solution to overcome low mathematical communication skills. This learning method had made the giver of mathematical concepts unlimited to the teacher alone, but could also be done by students and others [18]. Melinda [19] also reported that student-centered project-based learning could improve mathematical communication skills.

In line with the results, Webtoon digital comic was developed using students' daily stories that were closely related to their culture and the content attracted their attention and focus. The impact of this situation was that a high positive response was obtained from participants. Consequently, the average score obtained during post-test was higher compared to pre-test, ranging from 49.72 to 77.47. This was consistent with Hidi [20] that when students were focused on content that triggered attention and subsequently supported by other people who had similar abilities in a particular field and the same interests, this could have a positive impact and increase opportunities for the exchange of ideas and innovation. The results were further supported by Arthur [21] that learning could be easier for students to understand when it was linked to the experience or the knowledge already gained. Lin [22], Hsieh [23], and Tai [24] revealed that the information given to students was easier to understand when the material provided was in the form of things that were associated with daily lives.

Webtoon digital comic learning media was preferred by 95.85% of students based on data obtained from student response instruments on effectiveness quality standards. The colorful appearance of comic, attractive image design, and light story made students focus on reading and understanding the story presented on Webtoon. This had an impact on student learning outcomes as those who had a high interest in learning media and trying to focus on engaging with learning media intended to improve student learning outcomes. Although learning media itself cannot directly influence learning according to Clark [25], that, in the context of student interest it could help in detailing the role of interest in learning process through media. To ultimately affect learning outcomes, students who had a high interest in learning media could be more likely to follow and understand the material properly [26].

Students' interest in learning media could be an important factor in the engagement with learning materials [20].

The novelty of this research is to solve the two causes of low mathematical communication skills described in the introduction, namely, technology-based learning media and cultural links in learning. Thus, in this study, technology-based digital comic learning media were developed and integrated with culture, namely Karo culture. Webtoon learning media have a daily story context related to Karo culture. The images and names of the characters were adapted to the images of the traditional houses and clothes of the Karo people, and the names of the characters were accompanied by the clans of the Karo people, such as Sembiring, Tarigan, Sitepu, and Ginting. The context of the story in the digital comic also describes the daily life of the Karo community characters, such as school, farming, and participation in various Karo traditional ceremonies. These components are new and have not yet been developed. Then, the story in the webtoon digital comic implies the noble values contained in it, namely mutual cooperation and togetherness seen in how the characters in the webtoon help each other solve math problems; respect seen in the story of the character so respectful of his mother, courtesy, and ethics seen in the story of the character being polite and courteous when visiting his friend's house; harmony and balance seen in the characters' lives in living with family and friends; a sense of responsibility seen when the character helps his father in the garden; and a sense of gratitude and fairness seen in how the characters treat their friends. All these complex and specific components are a novelty in the world of education, especially in realizing Indonesia's goal of producing a "golden" generation in 2045 that has traits according to noble cultural values. The learning media technology related to the culture that has been developed has not been as complex and specific as the learning media developed in this research. For example, digital comics of Balinese local culture by Nurjanah [27], comic design based on West Java local culture by Hanifa [28], and digital comic media based on the local wisdom of Balinese traditional Jejaitan [29], from some of these examples, digital comics based on Karo culture have never been developed.

Another novelty of this research is the theory that by applying webtoon digital comic learning media, students experience changes in each indicator of their mathematical communication ability. The analysis of students' mathematical communication ability in this study was based on indicators of the mathematical communication ability test.

Other researchers have generally only examined how to optimize students' mathematical communication skills without clearly describing each element per indicator of mathematical communication skills that increased from a student or checked from the individual student level. Similar to Priatna's research [30], which uses web-based geometry to improve mathematical communication skills, and through data collected through interviews, observations of learning implementation resulted in web-based geometry learning that can help students explore ideas throughout the process of forming students' mathematical communication skills. Triana [31] used the brain-based learning (BBL) approach with an autograph to help students develop mathematical communication skills. Triana described the percentage of students who were able to solve problems well or who achieved each indicator, showing that BBL with an autograph contributed to improving mathematical communication skills. However, the achievement of these indicators is generally based on the percentage of students. Haji [32] conducted research on improving mathematical communication skills through realistic mathematics learning. Haji's research results showed that the achievement of students' mathematical communication skills through realistic mathematics was 63.96 and through conventional learning was 47.46. However, Haji did not describe changes in students' mathematical communication skills per indicator or individual. In addition, Saez [33], in his research on a teaching guide to see students' mathematical communication skills, described sample questions for indicators of mathematical communication skills. However, Saez did not describe the changes in students' mathematical communication skills for each indicator for each student.

Based on the discussion above, it can be stated that the development of culture-based Webtoon digital comic provided a high contribution to the success or achievement of mathematics learning outcomes.

5. Conclusion

In conclusion, the combination of two important components which had greatly influenced the achievement of maximum mathematical communication skills was novel in this study. Learning media components that attracted a lot of attention from generation z students were integrated with culture that was attached to students, making Webtoon digital comic a new solution to overcome problems in the educational sector.

Based on the results, this study showed that:

1. Webtoon digital comic development products had met the standards of validity, practicality, and effectiveness for improving students' mathematical communication skills.
2. Webtoon Learning Media received a score of 4.4 with one valid category.
3. Webtoon Digital Comics scored 4.2 in the practical category or had a high level of usability.
4. The effectiveness of webtoon digital comic learning media is influenced by two aspects: student learning outcomes obtained a score of 86.11% of students achieving KKM. Webtoons were in the effective category, and 97.7% of students' responses were positive towards webtoons. Webtoons are in the effective category.
5. Students' mathematical communication skills have increased through the implementation of Webtoon digital comic media. Based on the Wilcoxon non-parametric test, the sig. <0.05, or 0.000 <0.05, then if referring to the criteria for drawing conclusions, it means that there are differences in mathematical communication skills before and after learning with the implementation of webtoon digital comics, and the ability after the intervention is higher or increased.
6. There was a change in students' mathematical communication skills for all indicators of mathematical communication skills at each student's level.

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