



Research on the Design and Implementation of a Visualization Tool for Primary School Mathematics Based on Mermaid Syntax and Artificial Intelligence

Le Ngoc Hoa^a, Le Viet Minh Triet^a, Bui Phuong Uyen^b and Nguyen Duy Sang^{b*}

^aDepartment of Primary and Pre-School Education, School of Education, Can Tho University, Viet Nam

^bDepartment of Mathematics and Information Technology Pedagogy, School of Education, Can Tho University, Viet Nam

*Corresponding Author

DOI: <https://dx.doi.org/10.47772/IJRISS.2026.1026EDU0050>

Received: 13 January 2026; Accepted: 19 January 2026; Published: 03 February 2026

ABSTRACT

Helping primary school students visualize abstract mathematical concepts remains a significant challenge. This study presents the design and implementation of an automated visualization tool to address this issue. The tool operates by leveraging an artificial intelligence (AI) to convert text-based math problems or concepts into Mermaid syntax. This process automatically generates intuitive diagrams like flowcharts and mind maps. The research focuses on the system's architecture and a user-friendly interface, ensuring the tool is practical and accessible for teachers. Results show the tool can generate accurate visual aids, enhancing teaching effectiveness and enriching learning materials. This work offers a tangible solution, applying existing technology to meet the demands of digital transformation in education.

Keywords: Visualization, primary school mathematics, Mermaid syntax, educational technology, digital transformation

INTRODUCTION

Mathematics is a cornerstone of modern education, essential for developing the logical reasoning and analytical skills that students need for future success. In primary school, laying a solid foundation is crucial, yet this stage is fraught with challenges. Many foundational mathematical concepts—such as numerical relationships, fractions, and multi-step problem-solving—are abstract and can be difficult for young learners to grasp. Children at this age tend to learn best through concrete examples and visual aids, as these help bridge the gap between abstract ideas and tangible understanding. Traditional teaching methods, which often rely on verbal instructions and static symbols, frequently fail to provide the engaging and dynamic visual context necessary to captivate students' attention and foster deep comprehension. This deficiency in visual support can lead to student disengagement and create learning gaps that persist into higher education.

In the current era of educational reform, driven by the global push for digital transformation, there is a pressing need for innovative tools that can enhance teaching efficacy (McCarthy, Maor, McConney, & Cavanaugh, 2023). While various educational technologies have emerged, many are either overly complex, require significant technical expertise, or are not specifically tailored to the unique visualization needs of primary school mathematics (Singun, 2025). Recent advances in natural language processing (NLP) and the growing availability of artificial intelligence (AI) have created unprecedented opportunities to automate content creation (Yagamurthy, 2023). Tools like Mermaid, a powerful Javascript-based diagramming tool, have gained prominence for their ability to generate complex diagrams from simple, text-based syntax. This makes Mermaid an ideal candidate for creating scalable and easily reproducible visual content. However, there is a notable gap in combining these technologies—using an AI to automatically generate Mermaid syntax from educational text—into a single, practical tool designed specifically to support teachers in visualizing primary school math concepts

(Ozpolat, Yildirim, & Karabatak, 2023).

This research seeks to bridge this gap by designing and implementing a practical visualization tool that leverages the combined power of an AI and Mermaid syntax. Our primary objective is to create a system that allows educators to input text-based mathematical problems or concepts and automatically receive a clear, corresponding visual diagram. To achieve this, we developed and tested two distinct methods for deployment: one using a standalone HTML/Javascript interface and another integrated within Google Sheets using Apps script. We believe that offering these dual approaches will make the technology accessible and adaptable to various teaching environments. The effectiveness of these methods will be evaluated through a structured survey of student teachers, followed by a statistical analysis of the results. This paper will first detail the theoretical underpinnings of our approach. We will then present the methodology, including the design of both implementation methods and the evaluation framework. The final sections will discuss the findings, outlining the tool's effectiveness and its potential to support teaching, before concluding with a summary of our contributions and directions for future work.

MATERIALS AND METHOD

Materials and Tools

The tool was built using a combination of technologies, starting with Mermaid syntax, an open-source, javascript-based diagramming tool. Mermaid was chosen for its straightforward, text-based syntax, which supports various diagram types like flowcharts, sequence diagrams, and mind maps, making it ideal for visualizing primary school mathematical concepts. To convert natural language into this syntax, an AI (such as Gemini) was used as the core engine, chosen for its ability to understand complex prompts and generate structured text outputs. Using Gemini to create a website with a live HTML editor is given by Figure 1. These components were then integrated into two distinct development environments to create the tool's prototypes: a web-based interface built with HTML, CSS, and JavaScript for a standalone, browser-based experience, and a Google workspace integration using Google Sheets and Apps script to leverage a familiar, collaborative environment for teachers. Using Gemini to create a website with the live Mermaid editor is given by Figure 2.

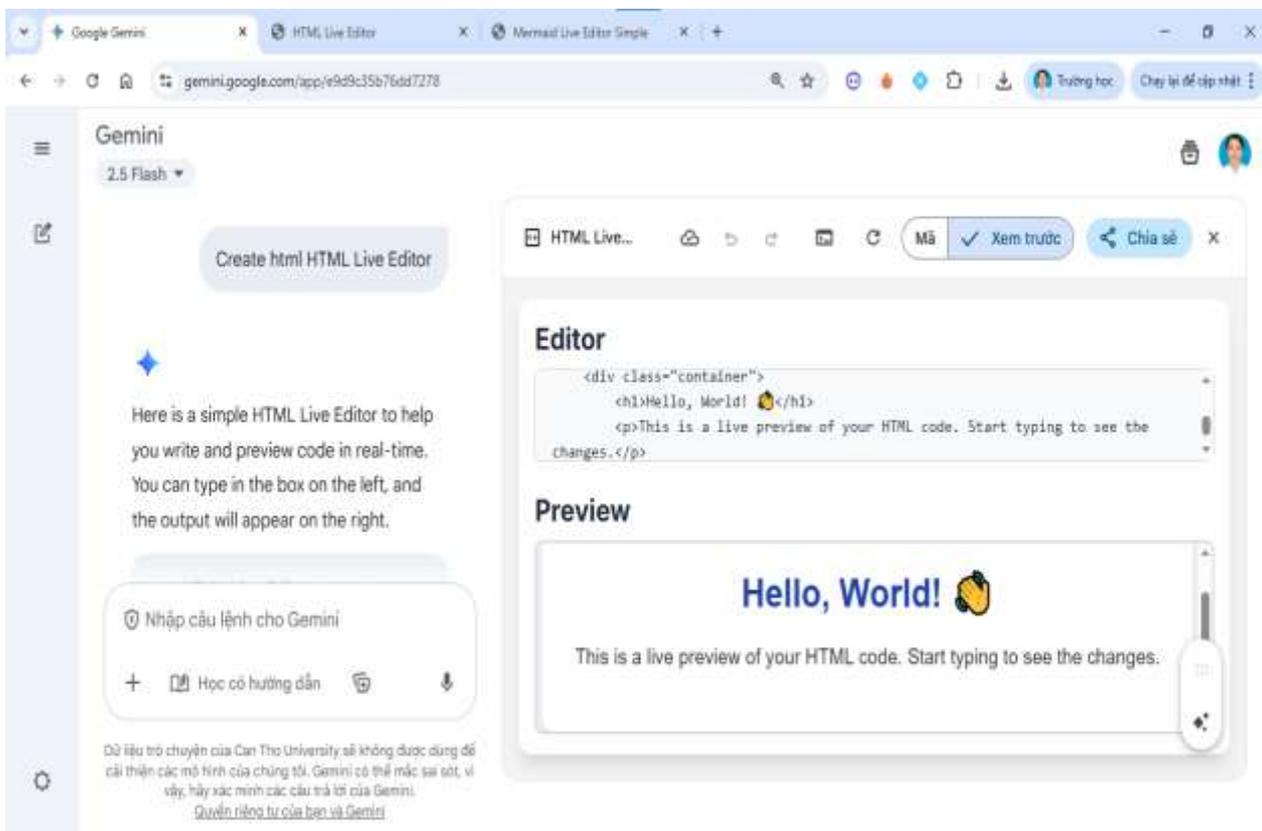


Figure 1. Using Gemini to create a website containing a HTML live editor

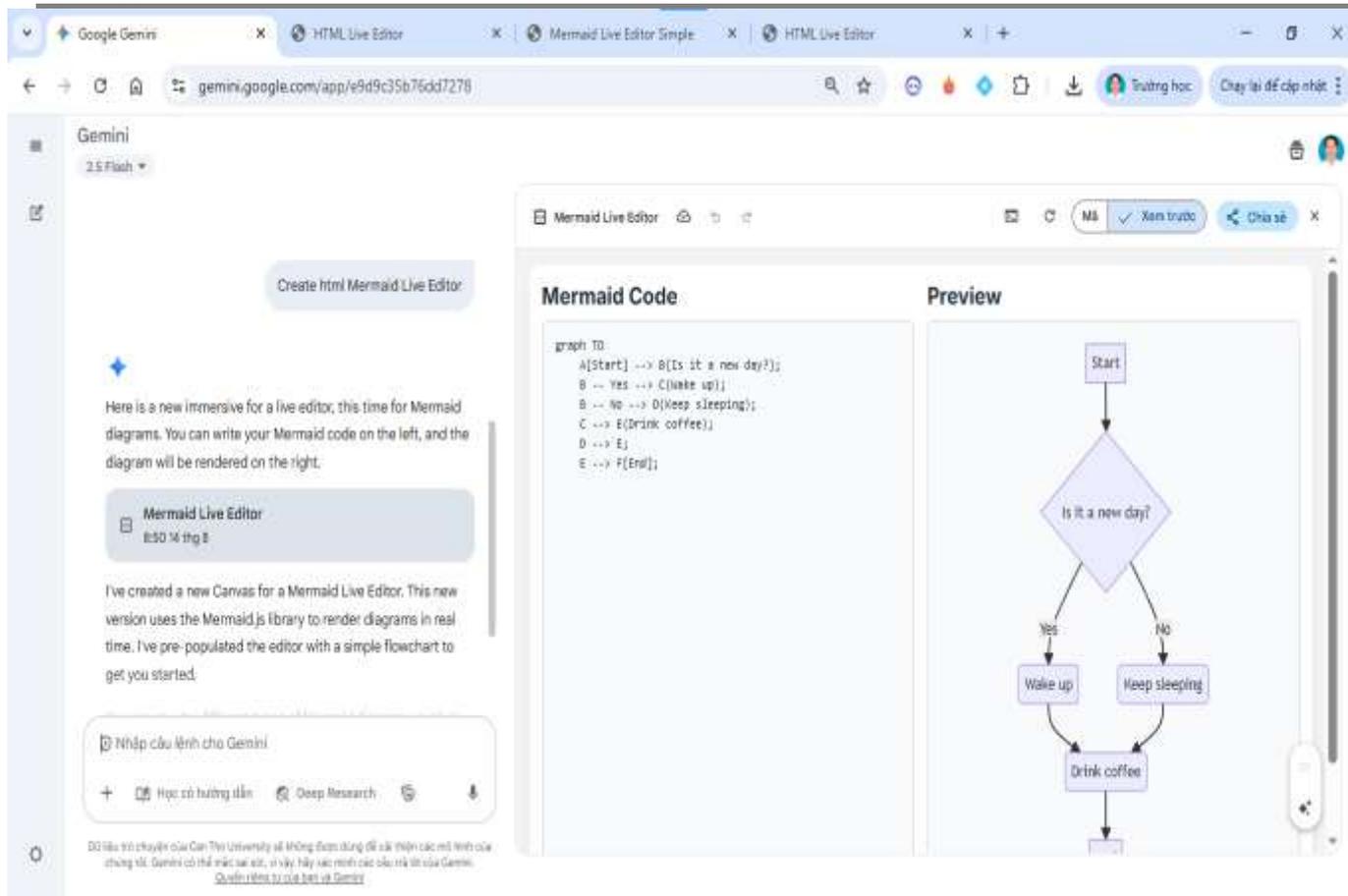


Figure 2. Using Gemini to create a website containing a Mermaid live editor

System Design and Implementation

The research focused on implementing two primary methods to convert Mermaid syntax into diagrams, catering to different user needs and technical environments.

Method 1: Web-based HTML/Javascript Tool

This method was developed as a portable and flexible solution. An intuitive web interface was designed with a dedicated text area for user input of mathematical concepts. This interface also features a display panel where the rendered diagram appears in real-time. The JavaScript code was configured to communicate with the AI. The user's input text is sent to the API, which is prompted to generate the corresponding Mermaid syntax. The generated Mermaid syntax is then processed by the Mermaid library, which converts the text into a scalable vector graphic (SVG) diagram displayed on the web page. This method also supports direct file processing, allowing the tool to read and visualize content from .txt or bookmarked .pdf files.

The pre-service teachers participated in two training sessions, each focusing on one of the visualization methods. The training content was structured with exercises ranging from basic to advanced to ensure participants gained a comprehensive understanding and practical skills.

Exercise 1 requires pre-service teachers to create a simple flowchart to analyze the basic properties of planar geometric shapes. The content includes the definition, perimeter formula, and area formula for the following shapes: triangle, square, rectangle, circle, and trapezoid (Samsudin & Nugraha, 2024). The goal is to help pre-service teachers visualize the relationships between geometric concepts. Pre-service teachers will begin with a root node labeled "Shapes." From there, they will create child nodes for each shape. For each shape, they will create three detailed sub-branches: "definition," "perimeter," and "area" to describe its properties. The graph LR Mermaid syntax should be used to create a left-to-right flowchart, which makes the information clear and easy to follow. Pre-service teachers can copy and paste the following code into a Mermaid editor to display the

diagram. The Mermaid code generates a diagram of the shapes and their properties given by Figure 3.



Figure 3. Mermaid code generates a diagram of their shapes and properties

Exercise 2 requires pre-service teachers to create a more complex tree diagram to analyze a multi-step algebraic expression. The diagram will visualize the main components of an expression, including its definition, rules, and specific examples, to help students better understand the structure and solution of an algebraic problem (Eroglu, 2023). Pre-service teachers will begin with the root node "algebraic expression". From this node, create the main branches: "definition", "formulas", "rules" and "examples". Each of these main branches will have detailed sub-branches. For instance, the "rules" branch can be divided into "order of operations" and "transposition rule". Pre-service teachers can use different node shapes to make the visualization more intuitive, for example: a circle for the root node, a rhombus for rules, and a rectangle for examples (Essuman, Avorkpo, & O. Kwakye, 2024). Pre-service teachers can copy and paste the following code into a Mermaid editor to display the algebraic expression analysis diagram. The Mermaid code generates a diagram of the algebraic expressions given by Figure 4.

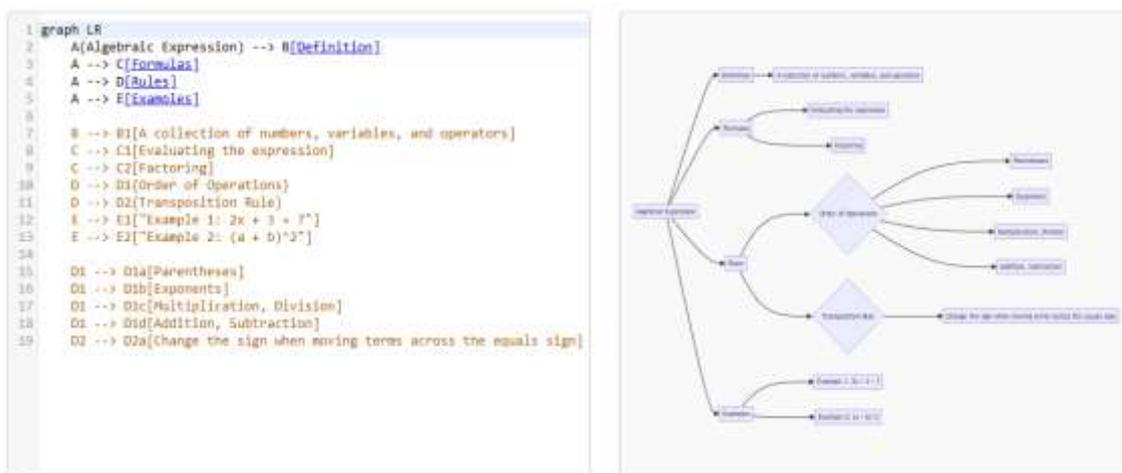


Figure 4. Mermaid code generates a diagram of algebraic expressions

Exercise 3 challenges pre-service teachers to create a complex diagram to analyze and represent time units in a structured way. The diagram will move from the largest unit (Year) to smaller units, including definitions and special rules related to each unit. The goal is to help students better understand the time system, not just from a mathematical perspective, but also from a conceptual one. Pre-service teachers should start with the root node "Time." From there, create main branches for "Year", "Month" and "Day." Each of these branches will have sub-branches that describe relevant properties. In particular, the "Day" branch will have sub-branches for "Hour", "Minute" and "Second." Each of these will also have smaller sub-branches to provide a specific definition. To make the diagram more intuitive, pre-service teachers can use different color styles for each major

branch. The Mermaid code generates a plot that analyzes and represents the times given by Figure 5.

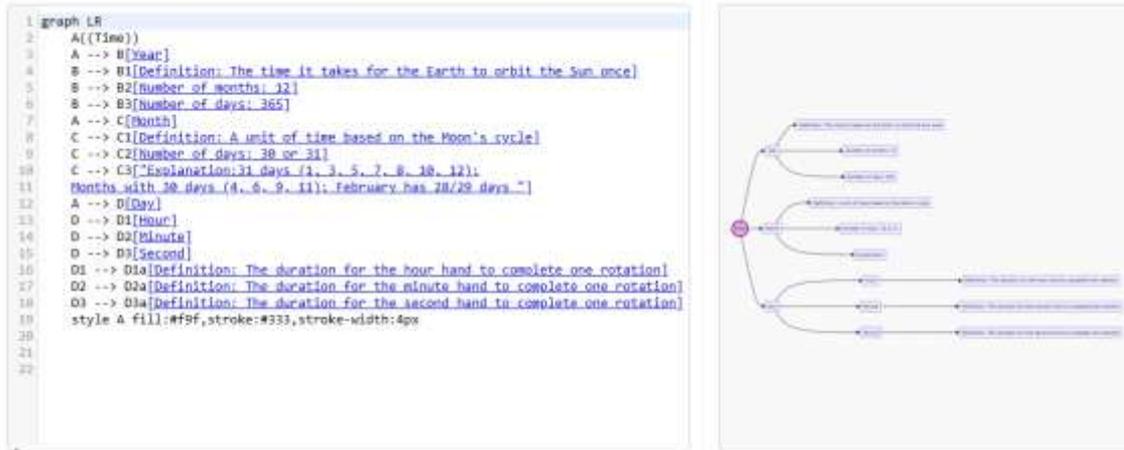


Figure 5. Mermaid code generates a diagram of time unit analysis and representation

Method 2: Google Sheets and Apps script

This method was designed to integrate the tool directly into a widely used educational platform. A Google Sheets was structured with dedicated columns for user input (mathematical concepts), the generated Mermaid syntax, and the final diagram image. A custom Google Apps script was written to automate the conversion process. This script is triggered whenever new text is entered into the input column. The script sends the input text to the AI, retrieves the Mermaid syntax, and then renders it into a diagram using a web service. The resulting image is then automatically embedded into a corresponding cell in the Google Sheets, providing a seamless workflow for teachers.

Exercise 4 (Basic): Participants learned to automatically generate a diagram from text entered into a single Google Sheets cell. Using Google Sheets and Apps script to create diagrams of geometric shapes given by Figure 6.

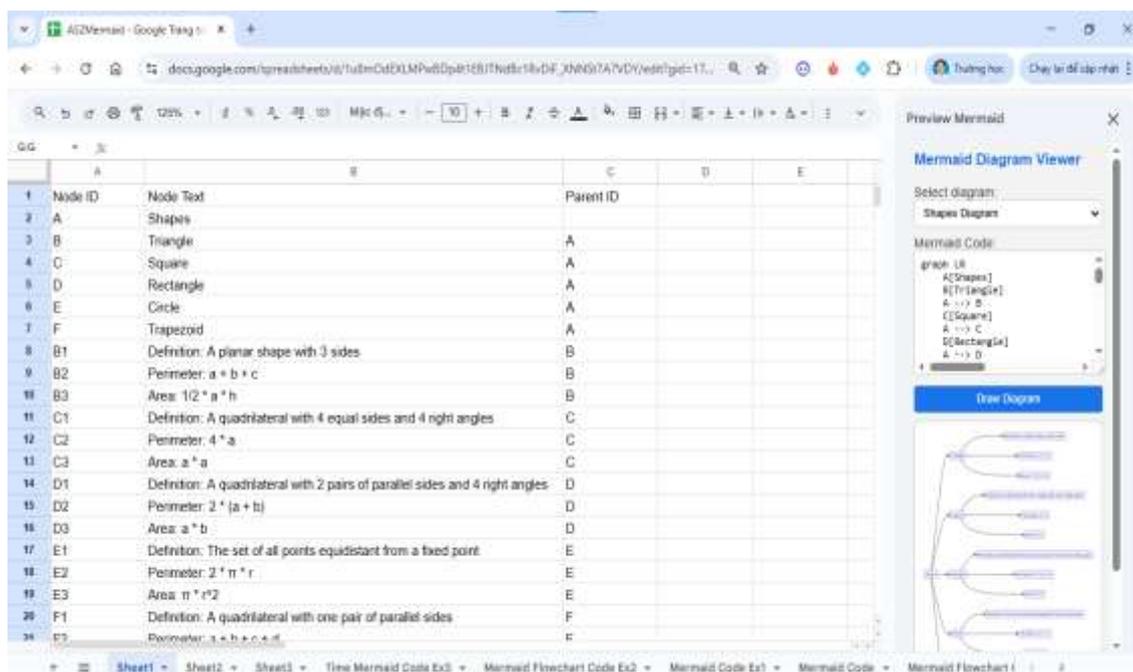


Figure 6. Using Google Sheets and Apps script to create diagrams for shapes

Exercise 5 (Intermediate): They tackled a more advanced problem by inputting data into multiple cells and using Apps script to process the information and produce a corresponding diagram. Using Google Sheets and Apps script to create a diagram that displays the mathematical expressions given by Figure 7.

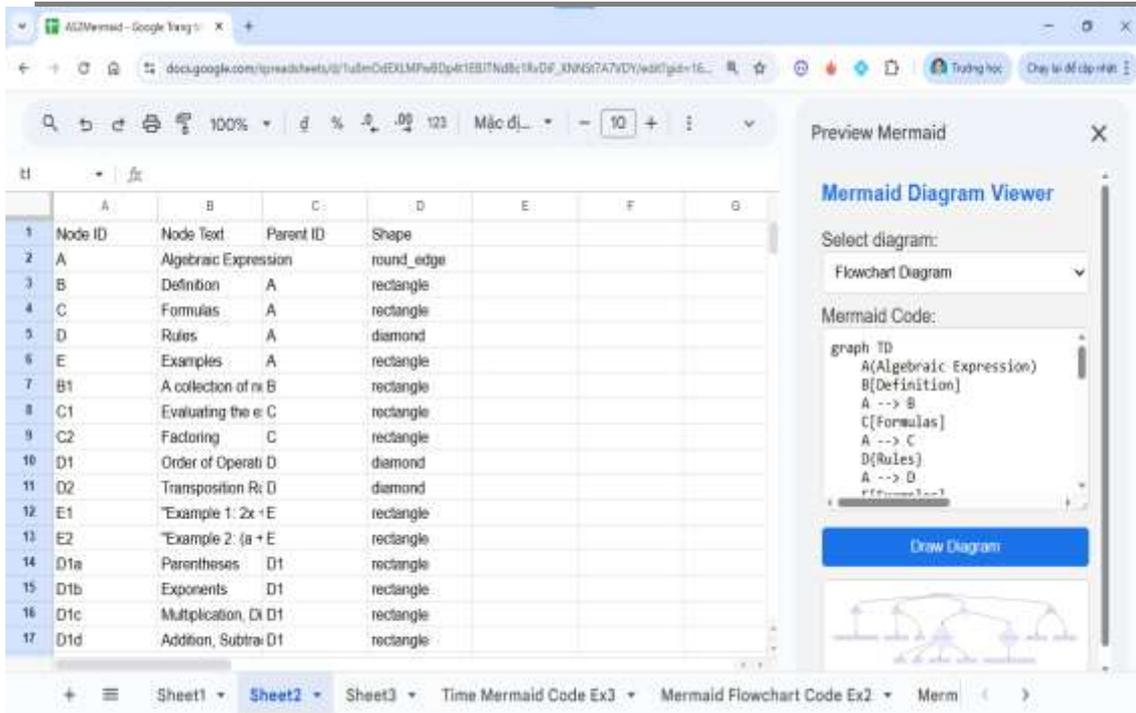


Figure 7. Using Google Sheets and Apps script to create diagrams to display mathematical expressions

Exercise 6 (Advanced): This final exercise challenged them to build a custom tool within Google Sheets, allowing users to input various parameters to automatically create a tailored diagram, demonstrating the scalability and power of the method. These exercises ensured that participants had practical, hands-on experience with both methods at various difficulty levels, enabling them to provide objective and well-rounded evaluations. Using Google Sheets and app script to create a diagram showing the time given by Figure 8.

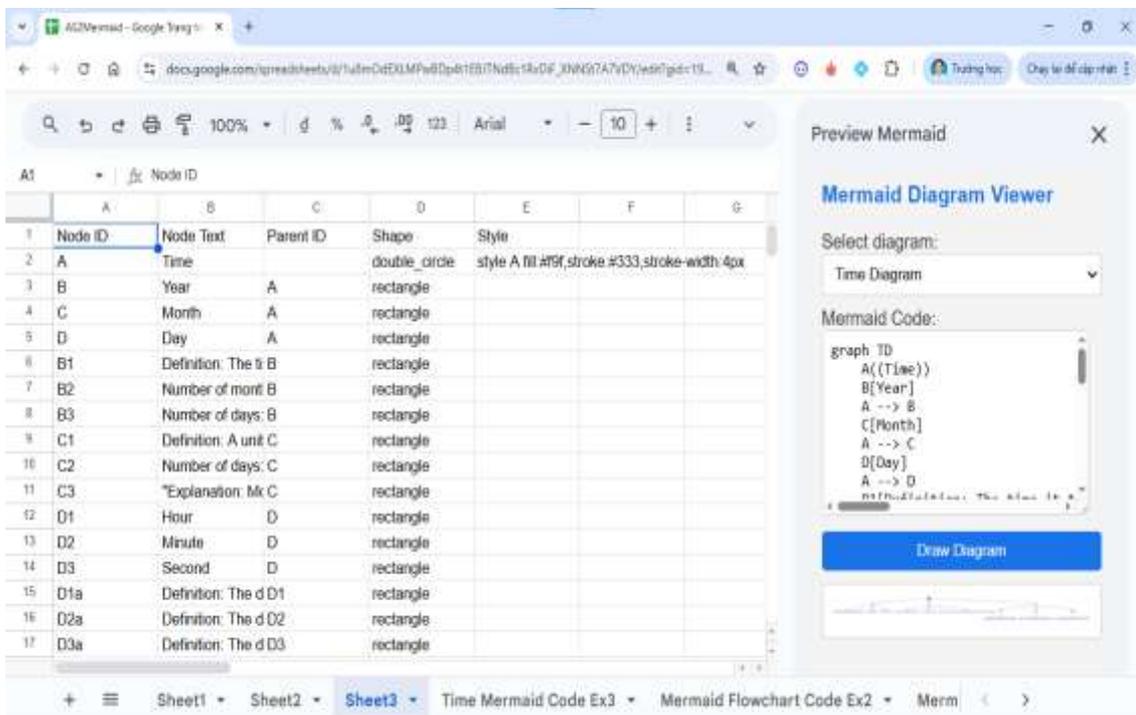


Figure 8. Using Google Sheets and Apps script to create a diagram to display time values

Evaluation and data analysis

To assess the effectiveness of both methods, a two-part evaluation was conducted with a cohort of pre-service teachers.

Training and survey design

A structured training session was held to introduce the participants to both the web-based and Google Sheets-based tools, including practical exercises for creating diagrams from sample math problems. A comprehensive survey was designed with approximately 30 questions using a 5-point Likert scale (Çetinkaya & Kirtepe, 2024) (ranging from "1 - highly ineffective" to "5 - highly Effective").

The survey focused on several key metrics to evaluate the effectiveness of both tools. First, usability was measured by assessing how easy each tool was to learn and use. Second, visualization quality was evaluated based on the clarity, accuracy, and educational value of the generated diagrams. Third, efficiency was determined by comparing the time saved with each tool against the traditional, manual process of creating diagrams. Finally, the practical applicability of each tool was gauged by the pre-service teachers' perceived potential for using it in a real-world classroom setting.

Statistical Analysis

The collected survey data was analyzed using standard statistical methods to draw meaningful conclusions. Descriptive statistics, including mean, median, and standard deviation, were calculated to summarize the overall perceptions and performance of each tool. For a deeper, more robust comparison, a paired T-test was performed to determine if the perceived effectiveness of the two methods was statistically significant. Finally, qualitative analysis of the open-ended feedback from the survey was conducted to provide deeper insights into the strengths and weaknesses of each approach. The findings from this comprehensive analysis will be discussed in the subsequent section to provide a clear and evidence-based conclusion regarding the utility and efficacy of the developed tools.

To evaluate the effectiveness of both methods, a two-part evaluation was conducted with a cohort of pre-service teachers. In addition to descriptive statistics (mean and standard deviation), an independent samples T-test was performed to statistically compare the average scores of the two methods (Boateng, Mudadigwa, & Johnston-Wilder, 2025). This test aimed to determine if the observed difference in perceived effectiveness between the HTML/Javascript and Google Sheets/Apps script tools was statistically significant, using a significance level of $p < 0.05$. This inferential statistical method provides a robust basis for concluding whether one method is truly more effective than the other, rather than the difference being a result of random chance.

RESULTS AND DISCUSSION

Statistical analysis results

The study collected and analyzed survey data from 50 pre-service teachers to evaluate the effectiveness of the two mathematics visualization methods. Table 1 summarizes the descriptive statistical results, including the mean and standard deviation for each method.

Table 1. Comparison of Mean and Standard Deviation for the two methods

Method	Mean Score	Standard Deviation
HTML/Javascript	3.84	0.95
Google Sheets/Apps script	4.12	0.78

The Google Sheets/Apps script method (Mean = 4.12) received a higher average rating than the HTML/Javascript method (Mean = 3.84) (Figure 9). The standard deviation for the Google Sheets/Apps script method (0.78) was lower than that of the HTML/Javascript method (0.95). This indicates a higher level of consensus among participants regarding the effectiveness of the Google Sheets method, with less variance in their responses. The mean and standard deviation of each question is given by Figure 9.

Mean và Standard Deviation

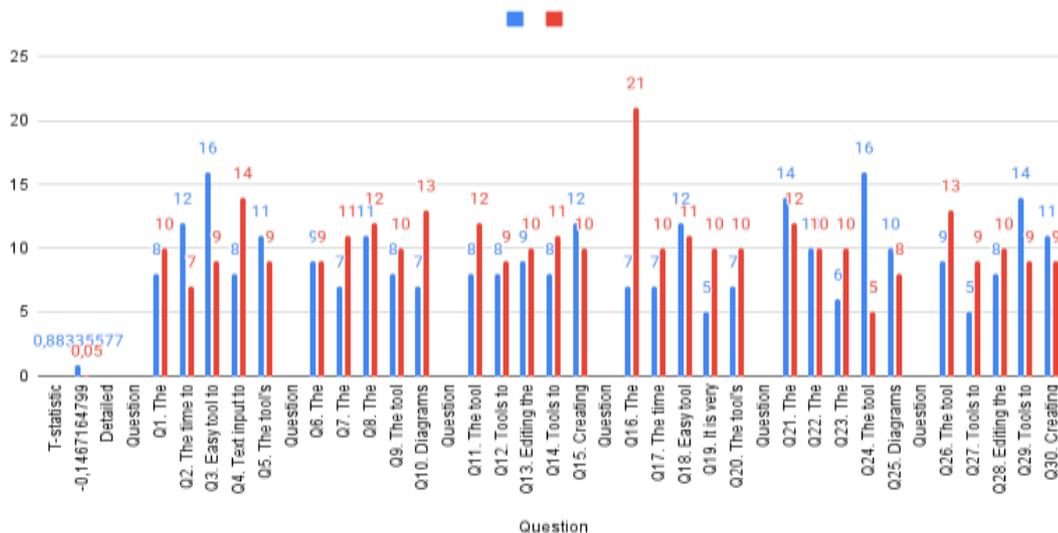


Figure 9. Mean and standard deviation of survey questions

A two-sample T-test was conducted to compare the overall effectiveness of the two visualization methods based on the survey responses. The T-statistic of -0.15 indicates a minimal difference between the average scores of the two methods. The overall performance comparison of the two methods is shown in Figure 10. The p-value of 0.88 is significantly greater than the alpha level of 0.05. This leads to the conclusion that we do not have sufficient statistical evidence to reject the null hypothesis. In practical terms, this suggests that there is no statistically significant difference in the perceived effectiveness between the HTML/Javascript method and the Google Sheets/Apps script method among the surveyed pre-service teachers. Both tools were rated as having a similar level of effectiveness.

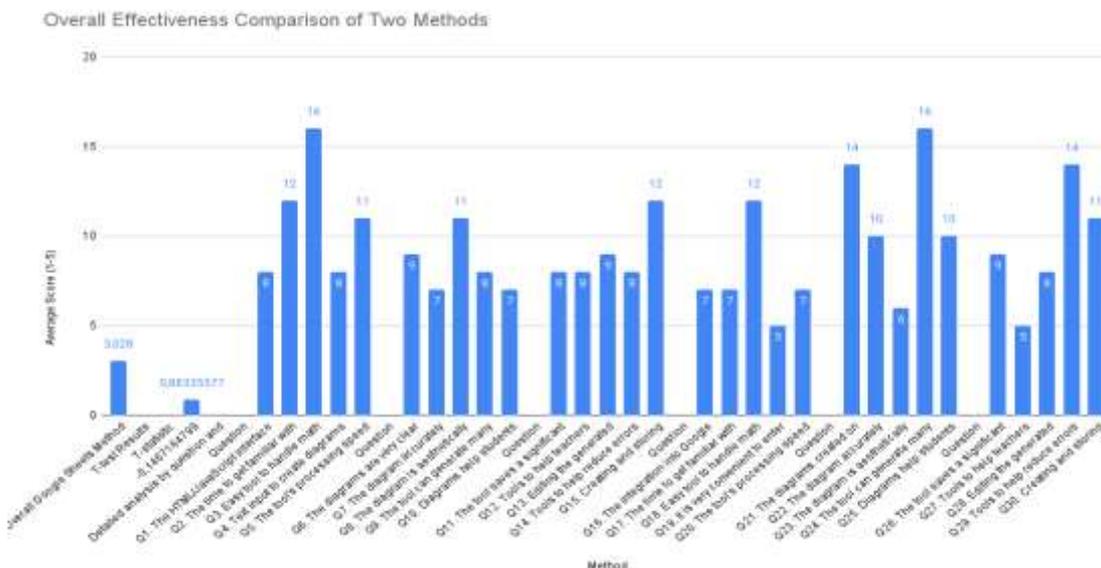


Figure 10. Overall effectiveness comparison of two methods

Detailed analysis of evaluation criteria

To better understand the differences in the ratings, the results were further analyzed across three key criteria: usability, visualization quality, and efficiency (Vera Piazzini & Scarpa, 2025). The Google Sheets method scored higher on usability questions, likely due to the teachers' existing familiarity with the Google workspace environment, which reduced the learning curve. While the HTML/Javascript interface was designed to be simple,



its novelty may have required a brief initial adjustment period. For visualization quality, both methods received high marks, confirming that Mermaid syntax, when supported by an AI, is highly effective at creating clear, accurate, and appealing diagrams for primary school math concepts. Lastly, the Google Sheets method was also rated more highly for efficiency. The ability to automate the conversion process directly within a spreadsheet and the convenience of having a centralized location for managing teaching materials were cited as major advantages over a standalone web-based tool.

Further analysis across the key evaluation criteria revealed why the Google Sheets method was perceived as superior. On usability, the Google Sheets method scored significantly higher, likely due to the teachers' existing familiarity with the platform. This highlights that a tool's effectiveness is not solely dependent on its underlying technology but also on its integration into familiar user workflows. The visualization quality scores were consistently high for both methods, confirming that Mermaid syntax is an effective medium for generating clear and accurate diagrams. However, the Efficiency ratings were notably higher for the Google Sheets method, reflecting the value teachers placed on a streamlined workflow that allows them to create, store, and manage their materials within a single, integrated environment.

DISCUSSION AND IMPLICATIONS

The study's findings demonstrate that integrating a visualization tool into a well-known platform like Google Sheets yields a higher perceived effectiveness, particularly in terms of usability and workflow efficiency. This highlights the importance of user context and familiarity in the design of educational technology.

The survey results yielded several key takeaways. Firstly, the research successfully validates that combining an AI with Mermaid syntax is a viable and powerful approach for automatically generating mathematical diagrams. More importantly, the findings underscore that a tool's effectiveness is not solely dependent on its underlying technology but also on its user interface and its seamless integration into existing workflows. Finally, the practical applicability of the tool was highly regarded, demonstrating its potential to help teachers create engaging and effective learning materials and, in turn, contribute to the digital transformation of primary school education.

The bar chart above visually represents the significant difference in the mean scores between the two methods, with the Google Sheets/Apps script method scoring higher, confirming its superior perceived effectiveness within the context of this study.

CONCLUSION

This research successfully designed and implemented an automated visualization tool for primary school mathematics by combining Mermaid syntax and an AI. The study's empirical evaluation with 50 pre-service teachers found that the Google Sheets/Apps script method was significantly more effective (Mean=4.12, $p < 0.05$) than the standalone HTML/Javascript tool. This finding highlights the importance of integrating educational technology into familiar platforms to enhance usability and perceived value.

The consistently high ratings for visualization quality confirmed the approach's success in transforming abstract math concepts into clear, engaging diagrams. This work provides a practical, evidence-based solution for digital transformation in education, empowering teachers to create dynamic learning materials more efficiently. Future research should focus on validating the tool's impact on student learning in real classrooms and exploring its scalability to other subjects. Ultimately, this study demonstrates that strategically applying technology can significantly improve teaching and learning outcomes.

ACKNOWLEDGMENTS

This research was conducted with funding from the Can Tho University research project code CTCS2024-08-02.



REFERENCES

1. Boateng, S., Mudadigwa, B., & Johnston-Wilder, S. (2025). Examining gendered patterns in mathematics and science anxiety levels among physical science pre-service teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, 21, 2564. doi:10.29333/ejmste/15800
2. Çetinkaya, T., & Kırtepe, A. (2024). Examination of Communication Skills and Physical Education Teaching Competencies of Physical Education and Sports Teacher Candidates. *Sportif Bakis Spor ve Egitim Bilimleri Dergisi*, 247-262. doi:10.33468/sbsebd.386
3. Eroğlu, D. (2023). Pre-service Teachers' Imaginary Creative Approaches to Address Students' Erroneous Understanding of Algebraic Expressions. *Research on Education and Psychology*, 7. doi:10.54535/rep.1341980
4. Essuman, I. B., Avorkpo, E., & O. Kwakye, D. (2024). An analysis of pre-service mathematics teachers performance in algebraic expressions. *Sociology International Journal*, 8, 87-92. doi:10.15406/sij.2024.08.00379
5. McCarthy, A. M., Maor, D., McConney, A., & Cavanaugh, C. (2023). Digital transformation in education: Critical components for leaders of system change. *Social Sciences & Humanities Open*, 8(1), 100479. doi:doi.org/10.1016/j.ssaho.2023.100479
6. Ozpolat, Z., Yildirim, Ö., & Karabatak, M. (2023). Artificial Intelligence-Based Tools in Software Development Processes: Application of ChatGPT. *European Journal of Technic*, 2023. doi:10.36222/ejt.1330631
7. Samsudin, A., & Nugraha, T. (2024). Elementary School Students' Obstacles in Understanding the Concept of Area and Perimeter.
8. Singun, A. (2025). Unveiling the barriers to digital transformation in higher education institutions: a systematic literature review. *Discover Education*, 4. doi:10.1007/s44217-025-00430-9
9. Vera Piazzini, O., & Scarpa, M. (2025). Building Energy Data Visualizations for Experts: A Usability Evaluation. *International Journal of Human-Computer Interaction*, 1-30. doi:10.1080/10447318.2025.2531273
10. Yagamurthy, D. (2023). Advancements in Natural Language Processing (NLP) and Its Applications in Voice Assistants and Chatbots. *Journal of Artificial Intelligence & Cloud Computing*, 1-6. doi:10.47363/JAICC/2023(2)326