

VISUALIZING SPACE: UTILIZING “BANIG” AS A CONTEXTUAL TOOL TO ENHANCE STUDENTS’ CRITICAL THINKING AND PROBLEM-SOLVING SKILLS IN AREA AND PERIMETER OF RESIDENTIAL SPACES IN GENERAL MATHEMATICS

Mary Joy C. Gomez

Student, Bukidnon State University, Fortich Street, Malaybalay City, Bukidnon 8700 Philippines

ABSTRACT

This study investigated the use of Banig as a contextualized instructional tool to enhance the critical thinking and problem-solving skills of Grade 11 students in learning area and perimeter of residential spaces in General Mathematics. The study employed a quasi-experimental pre-test and post-test design using quantitative and qualitative approaches. Sixty Grade 11 students from Bukidnon National High School of Home Industries in Maramag, Bukidnon participated in the study, with 30 students in controlled group and 30 in the experimental group. The study utilized achievement tests, the Cornell Critical Thinking Test, a problem-solving assessment, an observation checklist, and an interview questionnaire. The experimental group engaged on activities using Banig to model residential floor layouts, measure and scale spaces, compute area and perimeter, and design floor plans. Findings revealed that both groups improved, but the experimental group demonstrated greater gains. Critical thinking increased from a mean of 2.63 to 6.13, while problem-solving improved from 2.43 to 70.1. Observations showed excellent engagement and use of contextualized material. Students also found the activities enjoyable and meaningful. The study concludes that Banig can enhance critical thinking and problem-solving while making mathematics more meaningful, engaging, and culturally relevant.

Keyword: Banig, Contextualized, Critical Thinking, Residential Spaces, Visualize

1. INTRODUCTION

Mathematics involves all the numbers and symbols, it is also composed of fundamental operations, formulas, properties and rules. Commonly we master these things through rote learning and forgetting the true essence of those lessons that they are all preparation for the most important part of mathematics and that is applications, the problem-solving which requires deep understanding using a lot of mathematical skills such as critical thinking and problem-solving skills.

Students often find it challenging to apply area and perimeter in real-life situations such as designing residential spaces. And that difficulty affects their critical thinking and problem-solving skills, which are very essential in mathematics and in our everyday life.

Students struggle to visualize concepts like area and perimeter. So, we need to integrate familiar cultural objects to make our learning more

concrete and meaningful. In this study I will use the ‘Banig’, a traditional Filipino woven mat, a culturally rich and geometric object that can be used to visualize space and measurement. Each pattern, weave, and rectangular section of a ‘Banig’ can represent units of measurement, making it a creative and contextual tool for teaching area and perimeter in residential spaces or garden.

This study explores the effectiveness of using Banig as a contextual learning tool in enhancing students’ critical thinking and problem-solving skills when learning about the area and perimeter of residential spaces in General Mathematics.

2. STATEMENT OF THE PROBLEM

This study aims to enhance students’ critical thinking and problem-solving skills in solving problems involving area and perimeter through Banig as a contextual tool. Specifically, it seeks to answer the following questions:

1. Does Banig improves students' critical thinking skills in area and perimeter?
2. Does it enhance students' problem-solving skills in residential spaces?
3. What are the students' perceptions and experiences in using Banig in learning mathematics?

2.1. Research Objectives

This study aims to enhance students' critical thinking and problem-solving skills in solving problems involving area and perimeter through Banig as a contextual tool. Specifically, it aimed to:

1. Assess the level of students critical thinking and problem-solving skills before and after the implementation of contextualization;
2. Determine the students' perception and experiences in using Banig in learning mathematics.

3. SIGNIFICANCE OF THE STUDY

This research is significant to the following:

Students- It promotes learning through familiar and culturally meaningful materials, improving engagement and conceptual understanding.

Teachers- It provides a creative and contextual teaching approach that enhances students' critical thinking and problem-solving skills.

Curriculum Developers- It supports the integration of contextualization and localization in mathematics teaching as encouraged by the K-12 curriculum.

Future Researchers- It serves as a reference for further studies on cultural and contextual tools in mathematics education.

4. SCOPE AND LIMITATIONS

The study focuses on Grade 11 students learning about the subject General Mathematics in area and perimeter in the context of residential spaces. The use of "Banig" is limited to classroom-based activities and problem-solving sessions over one week. The study does not cover other measurement topics such as volume or surface area.

5. REVIEW OF RELATED LITERATURE

Contextualized and culturally responsive teaching approaches have become increasingly recognized for their role in making mathematics meaningful and relevant to learners. According to Fabrigas and Taban (2021), contextualization and localization in mathematics instruction bridge abstract ideas with students' real-world experiences, improving comprehension and retention. Similarly, Czarnocha and Baker (2013) emphasize that hands-on, contextual activities promote mathematical creativity and critical thinking skills.

In a study conducted by Denaga and Mendoza (2025), students taught through contextualized learning strategies outperformed those under traditional instruction, showing higher levels of engagement and understanding. These findings support the idea that real-life contexts and concrete materials help learners grasp measurement concepts such as area and perimeter.

Cultural and contextual Tools in Mathematics Learning

The use of cultural artefacts in education aligns with the concept of ethnomathematics, which recognizes the mathematical ideas embedded in cultural practices. Iskandar, Karjanto, Kusumah, and Ihsan (2022) reviewed ethnomathematics research in geometry and found traditional crafts, such as weaving and architectural patterns, effectively support geometry instruction. The Banig, a traditional woven mat, fits this framework, its geometric patterns and grid-like structure make it an ideal visual.

Similarly, Supiarmo, Harmonika, Utama, and Tarmuzi (2023/2024) designed a cultural-based contextual learning material using a local tool called "ancak" to teach area and circumference. Their study demonstrated that integrating cultural tools enhances both conceptual understanding and appreciation for local culture.

Vygotsky (1978) emphasized that meaningful learning occurs within social and cultural contexts, while Bruner (1966) introduced enactive learning, where students manipulate tangible materials to internalize abstract ideas. The Banig serves as both a cultural and cognitive bridge, linking mathematical ideas with hands-on, culturally relevant experience.

Spatial Reasoning and Visualization in Mathematics

Recent studies have underscored the importance of spatial reasoning as a key component of mathematical learning. Gilligan-Lee, Hawes, and Mix (2022) identified spatial thinking as a “missing piece” in many mathematics curricula, highlighting its strong connection to students’ success in geometry and measurement. They assert that visual-spatial experiences are essential to understanding concepts like area and perimeter. Lowrie et al. (2018) found that intervention programs that emphasize spatial reasoning and visual learning significantly enhance students’ engagement and performance in mathematics. Their study supports the use of tools and activities that allow students to manipulate, visualize, and model mathematical ideas, such as using Banig to represent real-world floor spaces.

Harris (2023) also noted that embedding spatial reasoning tasks within meaningful cultural or real-life contexts strengthens mathematical understanding, as students connect cognitive reasoning with contextual applications. The Banig, as a physical visualization of space, provides such a context for students to engage in spatial problem-solving.

Medina Herrera, Juárez Ordóñez, and Ruiz-Loza (2024) concluded that spatial visualization tools whether digital or physical that enhance conceptual clarity and mathematical performance. Their research aligns with this study’s use of the Banig as a concrete spatial visualization aid.

Xu, Sun, and Kong (2025) further demonstrated that spatial reasoning skills, including mental rotation and visualization, strongly predict students’ achievement in geometry and measurement. These findings confirm the significance of teaching approaches that cultivate spatial reasoning that is precisely what this study seeks to achieve through contextual learning using the Banig.

Student-Cantered and Active Learning Approaches

Student engagement and active participation are vital to developing critical thinking in mathematics. Alfian Zainuddin, and Muzaki (2020) showed that using interactive and student-centered strategies, such as the Think-Pair-Share

model, improved student outcomes in area and perimeter lessons. This suggests that learning models encouraging collaboration and exploration, like manipulating the Banig, enhance understanding and analytical skills.

Moreover, Denaga and Mendoza (2025) found that contextual and collaborative problem-solving activities lead to deeper conceptual grasp and retention. These findings collectively reinforce that contextualized; hands-on instruction strengthen both cognitive and effective learning dimensions.

6. METHODOLOGY

6.1. Research Design

This study used a quasi-experimental design employing a pre-test and post-test to determine the effectiveness of using “Banig” as a contextual learning tool. Both quantitative and qualitative data were gathered to measure improvement in critical thinking and problem-solving skills.

6.2. Participants of the Study

The participants were 30 students in Grade 11 DEWEY for the controlled group and 30 students in Grade 11 PIAGET for the experimental group and they are enrolled in General Mathematics at Bukidnon National School of Home Industries in Maramag, Bukidnon. They were selected through purposive sampling based on their willingness to participate

6.3. Research Instruments

1. Achievement Test – A set of questions on area and perimeter to assess conceptual understanding. The critical thinking skills test was adapted by the standard test developed at Cornell University the Cornell Critical Thinking Test (CCTT) and the Problem-solving test was adapted also from Fitriana and Supahar (2021) Development of Mathematical Problem-Solving skills Assessment Instrument for Senior High School Students.
2. Observation Checklist- a teachers’ checklist to record students’ engagement, cooperation, and problem-solving behaviours during activities.
3. Interview questionnaire- a teacher made questionnaire for the students described their experiences and insights after the activity.

6.4. Procedure

1. Pre-test- Students took a test measuring their initial understanding of area and perimeter.
2. Intervention- Students participated in activities using “Banig” as a model for the residential floor layout of their dream house. They measured sections, scaling, mapping, computed area and perimeter and designed floor plans based on the Banig grid. They will present their output in front.
3. Post-Test- The same test was administered to measure progress.
4. Reflection- Students shared observations and realizations about the use of Banig in Learning.

7. DATA ANALYSIS

Table 1. This table is the descriptive interpretation of Students’ Critical thinking skills both groups of students before and after integrating the contextualized tool, Banig.

Score Distribution	Descriptive Equivalent
9-10	EXCELLENT CRITICAL THINKING
7-8	PROFICIENT
5-6	DEVELOPING
Below 5	NEEDS IMPROVEMENT

Table 2. This table is the descriptive interpretation of Students’ Problem-solving skills both groups of students before and after integrating the contextualized tool, Banig.

Percentage Distribution	Descriptive Equivalent
86-100%	VERY HIGH
71-85%	HIGH
56-70%	MEDIUM
41-55%	LOW
0-40%	VERY LOW

Table 3. This table is the descriptive interoretaion if my observation checklist.

There are 4 categories (ENGAGEMENT, PROBLEM-SOLVING SKILLS, CRITICAL THINKING SKILLS, USE OF CONTEXTUALIZED MATERIAL). For the three responses (Yes-2, Partially- 1, No-0)

Percentage Distribution	Descriptive Equivalent
90%-100%	EXCELLENT
75%-89%	VERY GOOD
60%-74%	GOOD
45%-59%	FAIR
0%-45%	NEEDS IMPROVEMENT

Pre-test and post-test scores were analysed using the independent t-test in Jamovi that is for Quantitative. As for qualitative data the observation checklist and interview were analysed thematically to identify common insights about critical thinking and problem-solving development. The instruments used in the study was the pre-test and post-test both teachers made questions. In Critical thinking skills, it is adapted from Cornell Critical Thinking Test and Fitriana and Supahar (2012) for problem-solving skills.

8. RESULTS AND DISCUSSION

This section presents the analysis and interpretation of data gathered in the students’ critical thinking and problem-solving skills in area and perimeter of residential spaces in General Mathematics using the Banig as the contextual tool.

INTERPRETATION	Score	Controlled Group				Experimental Group			
		Pretest		Posttest		Pretest		Posttest	
		F	%	F	%	f	%	f	%
EXCELLENT	9-10	0	0	0	0	0	0	5	16.67
CRITICAL THINKING									
PROFICIENT	7-8	0	0	1	3.33	0	0	7	23.33
DEVELOPING	5-6	4	13	20	66.67	3	10	12	40
NEEDS IMPROVEMENT	Below 5	26	.87	9	30	27	90	6	20
Mean		3.37		4.80		2.63		6.13	
Level		NEEDS IMPROVEMENT		NEEDS IMPROVEMENT		NEEDS IMPROVEMENT		DEVELOPING	
Standard Deviation		1.40		1.16		1.50		1.91	

Group Descriptive for Critical Thinking Skills

Group	N	Mean	Median	SD	SE
CONTROLLED PRETEST	30	3.37	3.00	1.40	0.256
POST TEST	30	4.80	5.00	1.16	0.211
EXPERIMENTAL PRETEST	30	2.63	2.00	1.50	0.273
POST TEST	30	6.13	5.50	1.91	0.348

The descriptive statistics of the students' critical thinking skills show noticeable differences between the controlled and experimental groups before and after the intervention. In the pre-test, the controlled group obtained a higher mean score (M=3.37) compared to the experimental group (M=2.63), indicating that the controlled group started with slightly better critical thinking skills. However, after the intervention, both groups demonstrated improvement, but the gains of the experimental group were substantially greater. The controlled group increased to a post-test mean of 4.80, while the experimental group achieved a much higher mean of 6.13. This remarkable improvement from pre-test to post-test suggests that the use of the Banig as a contextual tool was highly effective in enhancing students' critical thinking skills in lessons on area

and perimeter. The higher post-test median of the experimental group and its larger mean gain further support the positive impact of the intervention. Overall, the data indicate that the experimental strategy produced stronger and more meaningful improvements compared to traditional instruction.

INTERPRETATION	PERCENT AGE	Controlled Group				Experimental Group			
		Pretest		Posttest		Pretest		Posttest	
		f	%	F	%	f	%	f	%
VERY HIGH	86-100%	0	0	0	0	0	0	0	0
HIGH	71-85%	0	0	2	67	0	0	2	67
MEDIUM	56-70%	0	0	9	30	0	0	9	30
LOW	41-55%	0	0	14	47	0	0	13	47
VERY LOW	0-40%	30	100	5	17	30	100	5	17
Mean		5.27		61.13		2.5		70.1	
Level		VERY LOW		LOW		VERY LOW		MEDIUM	
Standard Deviation		4.98		13.14		3.09		16.6	

Table 2. Level of students' problem-solving skills of both groups of students before and after integrating the contextualized tool, Banig.

Group Descriptive for PROBLEM-SOLVING SKILLS

Group	N	Mean	Median	SD	SE
CONTROLLED PRETEST	3	5.2	5.0	4.98	0.910
POST TEST	3	61.	60.	13.4	2.45
EXPERIMENTAL PRETEST	30	2.4	2.0	3.09	0.56
POST TEST	30	70.	67.	16.6	3.03

The pre-test results shows that both the control and experimental groups started with relatively low problem-solving skills in area and perimeter of residential spaces, with the control group having a slightly higher baseline performance (mean=5.27) than the experimental group (mean=2.43). The wide standard deviations in both

groups indicate large differences among students' initial abilities. After the intervention, however, both groups improved dramatically, but the experimental group, who learned through the contextualized "Banig" approach, showed a notably higher level of performance. The control group achieved a post-test mean of 61.1, while the experimental group reached a higher mean of 70.1, suggesting that the Banig-based lessons were more effective in enhancing students' problem-solving skills in area and perimeter. The increase in median scores from pre-test to post-test in both groups further supports substantial learning gains, but the larger improvement of the experimental group highlights the positive impact of using the Banig as a contextual tool in instruction.

The findings showed that the students demonstrated a significant improvement in understanding and applying formulas for area and perimeter after using Banig in classroom activities. Students reported that visualizing measurements on the Banig helped them see the relationship between shapes and space, which led to better comprehension. They also engaged more in collaborative discussions, showing improved reasoning and decision-making when solving real-life problems like designing rooms or computing floor areas.

Qualitative analysis revealed that students appreciated the activity's cultural connection. They expressed pride and curiosity in using a local material, which made the learning process enjoyable and relevant.

These findings are consistent with Denaga and Mendoza (2025) and Czarnocha and Baker (2013), confirming that contextual and hands-on learning enhances mathematical understanding and higher-order thinking.

For the observation. In the Students Engagement they got 90%- Excellent, I have observed that they like the activity given in which they participated actively sharing their ideas voluntarily, for the problem-solving skills they got 80%- Very good, there are some of them who are still confused which part is the length and width, Critical Thinking skills is 90%- Very Good, students can answer and explain their work and they are able to crack some differences. Use of contextualized Material (Banig) 100%- Excellent, they have shown an excellent performance in which they can

justify why does given the big area can fit in a Banig and that is scaling. They are excited for their future when they build their dream house. For the interview most of them mentioned that they have enjoyed the activity especially they did the floor planning lay-out, they were very excited in organizing the spaces where they can put their bedrooms and so on with other parts. The part where they do the scaling made them realize the smart way of estimation how can feet or meters fit in the Banig which is just small mat. It catches their interest because they can decide whatever lay-out they want and it made them imagine the future.

9. CONCLUSION

The findings of the demonstrate that using the Banig as a contextualized instructional tool significantly improved students' problem-solving and critical thinking skills in lessons on area and perimeter. Although both the control and experimental groups began with low baseline performance, the experimental group consistently showed greater gains in both domains. In problem solving, the experimental group achieved a higher post-test mean (70.1) compared with the control group (61.1), indicating that contextualized, hands-on learning using the Banig was more effective than traditional teaching methods. Similarly, in critical thinking skills, the experimental groups post-test mean (6.13) surpassed that of the control group (4.80), reflecting deeper conceptual understanding and enhanced reasoning abilities.

Qualitative findings reinforced these results by revealing that the Banig helped students visualize measurements, understand spatial relationships, and actively participate in collaborative discussions. Students also expressed a strong appreciation for the cultural relevance of the activity, which increased motivation and engagement. Overall, the integration of the Banig into mathematics instruction not only improved their performance but also made learning more meaningful and culturally connected.

The result of the study revealed the statistically significant difference in the pre-test and post-test; the results demonstrate an improvement in students' critical thinking and problem-solving skills in area and perimeter of residential spaces in general mathematics following the utilization of Banig as a contextualized instructional tool.

According to Fabrigas and Taban (2021), contextualization in mathematics instruction bridges abstract ideas with students' real-world experience, improving comprehension and retention. The result shows how the Banig as a tool really helped the students' engagement in the activity and it was supporting also to real-world situation. According to the results, the perception of the students and experiences in using Banig in Learning Mathematics is a big help for them to visualize real-world scenario, they even think of what their future houses looks like. The students also found the learning activity interesting and engaging, suggesting that the integration of the familiar and culturally relevant material such as Banig can make mathematics more concrete, relatable, and enjoyable for learners.

9. RECOMMENDATION

Teachers may use the Banig intervention as an alternative strategy to enhance students' understanding of area and perimeter. Use more contextual materials and hands-on activities in teaching mathematics to improve students' critical thinking, problem-solving skills and engagement.

For the schools. I would like to suggest them to provide trainings about contextualization using a lot of tools, especially traditional tools which are culturally familiar to them. A training for a certain lesson in mathematics and what contextualize tool to use that.

For the future researchers. They may replicate this study to use in their class focusing rectangular area and perimeter, they may use it other activities not just floor plan layout.

For curriculum developers. They may consider integrating cultural and contextual materials to culturally responsive education.

REFERENCES

- [1] Alfian, M., Zainuddin, H., & Muzaki, F. (2020). Increase the results of learning mathematics material area and circumference of square and rectangle through the Think-Pair Share model.
<https://doi.org/10.2991/assehr.k.201112.021>
- [2] Denaga, R. M., & Mendoza, R. V. (n.d.). A comparative study of contextual and traditional teaching on general mathematics performance among Grade 11 EIM students at Angelo L. Loyola Senior High School. *International Journal of Multidisciplinary Research and Growth Evaluation*.
<https://doi.org/10.54660/ijmrge.2025.6.3.547-551>
- [3] Fabrigas, J. P. G., & Taban, J. G. (2023). Contextualization and localization of teaching mathematics in the new normal. *The Asian Journal of Education and Human Development*.
<https://doi.org/10.69566/ajehd.v4i1.74>
- [4] Gilligan-Lee, K. A., Hawes, Z. C. K., & Mix, K. S. (2022). Spatial thinking as a missing piece in mathematics curricula. *npj Science of Learning*, 7, Article 10.
<https://doi.org/10.1038/s41539-022-00128-9>
<https://www.jamovi.org>
- [5] Jaramillo, J. A. (1996). Vygotsky's sociocultural theory and contributions to the development of constructivist curricula. **Education 3-13**
- [6] Lowrie, T., Logan, T., Harris, D., & Hegarty, M. (2018). The impact of an intervention program on students' spatial reasoning: Student engagement through mathematics-enhanced learning activities. *Cognitive Research: Principles and Implications*, 3, Article 50.
<https://doi.org/10.1186/s41235-018-0147-y>
- [7] Medina Herrera, L. M., Juárez Ordóñez, S., & Ruiz-Loza, S. (2024) Enhancing mathematical education with spatial visualization tools. *Frontiers in Education*, 9, 1229126
<https://doi.org/10.3389/educ.2024.1229126>
- [8] Ratu Sarah, R., Iskandar, F., Karjanto, N., Kusumah, Y., & Rainal, I. (2022). A systematic literature review: Ethnomathematics in geometry.
- [9] Xu, T., Sun, S., & Kong, Q. (2025). Spatial reasoning and its contribution to mathematical performance across different content domains: Evidence from Chinese students. *Journal of Intelligence*, 13(4), 41.
<https://doi.org/10.3390/jintelligence13040041>