

Use of culturally-inspired materials as models: Effects on learning solids in geometry

 Jehad A. Abo^{1*}, Faiza M. Abdul Latip²,  Tamano S. Mantawil³

^{1,2,3}Mindanao State University – Maguindanao Datu Odin Sinsuat, Maguindanao del Norte, Philippines;

jaabo@msumaguindanao.edu.ph (J.A.) fmabdullatip@msumaguindanao.edu.ph (F.M.A.L.)

tsmantawil@msumaguindanao.edu.ph (T.S.M.).

Abstract: The research examined the impact of culturally-inspired materials on Grade 8 students' performance in Geometry at Mindanao State University, Maguindanao Integrated Laboratory Science High School. It sought to compare pre-test and post-test performances of students taught with culturally-inspired materials with those taught using the Lecture and Discussion Approach. The experimental group (49 students in Section C) employed culturally-inspired materials, whereas the control group (47 students in Section D) utilized conventional approaches. An experimental design was employed, utilizing researcher-developed questionnaires, surveys, and a rubric for collaborative problem solving. Statistical analysis employed frequency counts, percentages, means, standard deviations, paired t-tests, and independent t-tests. Results indicated that 65.31% of experimental group students exhibited low performance in the pre-test. Yet, post-test results indicated that the use of culturally-inspired materials significantly enhanced student performance and learning capabilities compared to conventional methods. The majority of students reacted positively to this, and their products were of higher scores, with a mean of 17 out of 20. Training for mathematics teachers on the use of culturally-inspired materials in lessons, particularly in teaching solids in Geometry, was recommended in the study. It also proposed incorporating this strategy into the secondary school mathematics curriculum to make learning more meaningful, relevant, and interesting.

Keywords: *Culturally-inspired materials, Geometry, Students' performance.*

1. Introduction

Mathematics is everywhere in the world, which makes it very relevant. This is because everyone needs mathematics in their day-to-day life. Additionally, it has been a compulsory subject at all grade levels, such as geometry. However, geometry remains one of the poorly taught, widely disliked, and poorly understood branches of mathematics in education [1]. This can be seen from students' poor performances in mathematics.

Many studies attempt to find solutions to the very poor performance of students in mathematics, considering various factors. One of these factors, which is closely examined in this study, is the inappropriate method of teaching. According to Andaya [2], instructional factors significantly affect students' achievement in mathematics, such as geometry, a key component of the secondary mathematics curriculum in the country. Geometry provides knowledge on dealing with measurements, relationships of lines, angles, surfaces, and solids.

Experts in education argue that methods of teaching mathematics, particularly geometry, in the Philippines are out of phase with the backgrounds and local environment of learners. Furthermore, these methods are Eurocentric, which leaves learners thinking in abstractions that are alien to their environment or in their real world, and they have no bearing on Philippine culture. One consequence of Eurocentric teaching in mathematics is the lack of basic mathematical principles, resulting in rote

learning and poor achievement. Attempts to address this problem necessitate that learning be adaptive, integrating new knowledge with existing knowledge and allowing for the generation of innovative ideas or work [3]. Thus, educators usually want to understand the learning process students are undergoing and aim to enrich it. This calls for the option of giving ethnomathematics a trial as a teaching approach.

D'Costa [4] stated that cognition is largely influenced by one's culture. Thus, ethnomathematics brings valuable concepts to the forefront, which help frame research on the interplay of culture and mathematics education. One of the prevailing methods of teaching used is the ethnomathematics teaching approach (ETA), such as using culturally-inspired materials as models. This approach to teaching and learning mathematics builds on students' previous knowledge, background, and past and present experiences in their immediate environment. Therefore, this approach could be practical [5].

Educators have widely used this teaching approach to improve performance in mathematics, especially in geometry concepts. Geometry is used daily by almost everyone, exploring spatial sense and geometric reasoning. This study investigates the effects of using culturally-inspired materials as models on students' performance and their experiences in learning solid geometry.

The research particularly aims to assess the impact of culturally-inspired materials on students' performance and learning experiences in solid geometry. It seeks to determine: (1) the experimental group's pre-test performance, (2) the post-test performance of both experimental and control groups, (3) areas of student experiences and outputs, and (4) whether significant differences exist between pre-test and post-test results, as well as between the post-test performances of the two groups.

Through answering these research questions, the research hopes to enhance teaching approaches, rendering geometry more relevant, practical, and meaningful to students.

2. Literature Review

The review of related literature (RRL) addresses important factors affecting students' performance in geometry, focusing on teaching approaches, cultural factors, and the influence of ethnomathematics.

2.1. Students' Performance in Geometry

Filipino learners excel in acquiring knowledge but are poor in higher-order thinking skills in mathematics, especially in geometry [6]. Low performance is attributed to various factors, with ineffective teaching methods being a major issue [2]. Geometry, an essential component of the secondary mathematics curriculum, develops logical thinking and spatial skills [7]. Poor instructional strategies, however, are responsible for students' negative attitude and inability to grasp the subject [1, 8].

2.2. Culture and Learning

Culture has a large impact on learning since it defines perceptions, interpretation, and communication [9, 10]. Schools also have their own cultures that can be harmonious or not with students' home culture, impacting learning experiences [11]. Multicultural education helps counteract incongruence between school and home settings and enables equal opportunities in learning [12]. Filipino students, for example, are challenged by a lack of support in noticing their physical surroundings at home [13]. Culturally relevant teaching, therefore, promotes significant links between students' lives and learning experiences [14, 15].

2.3. Ethnomathematics Teaching Approach

Ethnomathematics emphasizes the incorporation of cultural knowledge in mathematical learning [16]. It links mathematical ideas to students' cultures, enhancing understanding and engagement [17, 18]. Culturally motivated materials heighten cognitive activity by rendering learning more meaningful [4]. It recognizes varying mathematical practices among cultures, presenting a wider vision of mathematical use [19, 20]. When students perceive mathematics as applicable to their culture, they gain a more profound understanding and appreciation of the subject [21].

3. Materials and Methods

The research used an experimental design to compare students' performance in geometry prior to and following the implementation of culturally-inspired materials. The impact of these materials was determined by comparing pre-test and post-test scores and examining students' experiences with their application. The study was conducted at Mindanao State University-Maguindanao Integrated Laboratory Science High School (ILSHS), Datu Odin Sinsuat, Maguindanao. The said school, initially MSU Maguindanao High School Department, was transformed in 2004 into a laboratory school under the College of Education. The school mostly comprises Maguindanaon students.

Participants were Grade 8 students during the 2017–2018 school year. Among the four sections (A, B, C, and D), Section A was excluded due to its homogeneity. Using Post-Hoc ANOVA, Section C, which had the lowest mean grade of 78.67, was selected as the experimental group, while Section D, with a mean grade of 79.15, served as the control group. A total of 49 students from Section C and 47 from Section D participated in the study.

There are two questionnaires used to collect data. The first one was a test constructed by the researcher using 22 items, which included 20 multiple-choice questions and two word problems, intended to assess students' performance in solid geometry. It was validated by experts and had a reliability coefficient of 0.753 using Cronbach's Alpha. The second was the survey questionnaire modeled from Kolb's Learning Style Inventory with 20 items allocated into four stages of experiential learning: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. Students' responses were measured using a four-point Likert scale. A rubric was also used to measure students' problem-solving ability under the Ethnomathematics Teaching Approach.

Prior clearance from the university administration was sought before conducting the study. The student grades from the first grading period were gathered to establish the sample sections. The research took three weeks, starting with a pre-test for the experimental group. Both groups received instruction on the surface area and volume of solids, with the experimental group using culturally-inspired materials and the control group using the traditional lecture and discussion method. The research concluded with the post-test and questionnaire survey given to the experimental group.

For analysis of data, descriptive statistics, including frequency, percentage, mean, and standard deviation, were employed in explaining pre-test and post-test performances of students. The difference in performance within the experimental group before and after intervention was determined by conducting a paired t-test. An independent t-test was used to compare post-test outcomes between the experimental and control groups, with 0.05 used for significance in all statistical tests.

4. Results and Discussion

The research tested students' performance before and after teaching solids using culturally-inspired materials in Geometry. The pre-test scores (Table 1) indicated that the majority of students in the experimental group performed poorly, with 65.31% having scores ranging from 1 to 6, and only 34.69% scoring from 7 to 12. None of the students scored more than 12, reflecting insufficient knowledge of solid figures. The mean score was 5.88 with a standard deviation of 2.19.

Overall, the table shows that the mean score of the experimental group in solid figures was 5.88 with a standard deviation of 2.19. This implies that most students have poor knowledge and difficulties in solving the surface area and volume of solid figures. As Ubana [1] mentioned, geometry remains one of the poorly taught, widely disliked, and poorly understood branches of mathematics in mathematics education.

Table 1.
Pre-Test Performance of Experimental Group.

Score Range	Frequency (f)	Percentage (%)
25 – 30	0	0.00
19 – 24	0	0.00
13 – 18	0	0.00
7 – 12	17	34.69
1 – 6	32	65.31
Total	49	100
Mean	5.88	
SD	2.19	

As shown in Table 2 on the next page, the students' performance of the control group using the lecture discussion approach and the experimental group using culturally-inspired materials as models in teaching-learning solids in Geometry.

Only one (1) top student or 2.04% from the experimental group scored in the range 19 to 24, and none from the control group.

One (1) or 2.13% of control group students and fifteen (15) or 30.61% of experimental group students had scores ranging from 13 to 18. Those with scores from 13 to 18 in the control group were 31 or 65.96%, and in the experimental group, 33 or 67.35%. This indicates that more than half of the students in both groups scored within the 13 to 18 range.

The lowest score was from 1 to 6, which was 15 or 31.91% of control group students, and there were 0 or 0% of experimental group students.

As revealed in the table, the lowest scores were found only in the control group, showing that the students in the control group have a very poor understanding of solid figures, especially in solving surface area and volume. This was supported by Leongson [6], who stated that Filipino students excel in knowledge acquisition but perform considerably lower in lessons requiring higher-order thinking skills. Most students did not solve questions that involved problem-solving. This implies that most students in the control group are low in questions requiring higher-order thinking skills.

Table 2.
Post-Test Comparison of Groups.

Range of Scores	Control Group		Experimental Group	
	f	%	f	%
25 – 30	0	0	0	0
19 – 24	0	0	1	2.04
13 – 18	1	2.13	15	30.61
12-Jul	31	65.96	33	67.35
1- 6	15	31.91	0	0
Total	47	100	49	100
Mean	7.51		12.06	
SD	1.99		2.41	

Finally, the mean score of the control group was 7.51 with a standard deviation of 1.99, and the experimental group mean score was 12.06 with a standard deviation of 2.41. This indicates that the experimental group has a higher mean compared to the control group. Moreover, instructional factors most affect students' performance in mathematics, such as geometry [2].

Students' experience of culturally-inspired resources (Table 3) portrayed a favorable influence on learning with a total mean of 3.35 (SD = 0.06). Most of the top scores were recorded with "I pay close attention and observe activities involving geometry" (M = 3.57) and "I learn how to see issues from all perspectives through the use of artifacts" (M = 3.51), demonstrating high involvement.

The use of culturally-inspired materials was effective for students' learning and experience in Geometry. Dewey strongly agreed, suggesting that people learn through authentic experience and

reflection. It integrates new knowledge with existing knowledge and can lead to innovative ideas or work. Furthermore, experience accounts for much of what students learn, but for optimal results, experience must be accompanied by systematic analysis and reflection, as Arends [22] mentioned. In this way, learners' experiences significantly influence their performance.

Table 3.
Students' Learning Experience with Culturally-Inspired Materials.

Experience statement	Mean	Sd	Interpretation
I listen carefully and watch the activities in geometry.	3.57	0.50	Strongly agree
I learn how to look at all sides of an issue using artifacts.	3.51	0.62	Strongly agree
I learn by watching every activity.	3.43	0.50	Agree
Ethnomathematics helps me evaluate things.	3.43	0.58	Agree
It guides me to work hard to get things done.	3.43	0.61	Agree
Overall	3.35	0.06	Agree

Students' output scores (Table 4) were also positive, with all groups having scores greater than 15 out of 20. The mean score was 16.25 (SD = 0.96), indicating excellent problem-solving and conceptual understanding.

The average output score was 16.25 with a standard deviation of 0.96. This implies that all groups have high output scores. This was supported by Manning et al. [23], who stated that Mathematics integrates culture into the curriculum because it is more effective. This insight involved using culturally-inspired materials in teaching solid Geometry, where Mathematics integrates learners' culture and promotes learning through reflection and doing.

As pointed out by Fenwick [24], learning through reflection on experience considers individuals to gain and construct knowledge by interpreting their environment through a set of perceived experiences. Consequently, all students' outputs had high scores, which were achieved through their cooperation, exploring, understanding, representing, formulating, planning, executing, monitoring, and reflecting.

Table 4.
Students' output scores in experimental group

Criteria	Group 1	Group 2	Group 3	Group 4
Exploring and understanding	4	5	4	3
Representing and formulating	5	4	4	5
Planning and executing.	3	4	5	3
Monitoring and reflecting	4	4	4	4
Total score	16	17	17	15
Mean	16.25	Sd	0.96	

Comparison of pre-test and post-test scores of the experimental group (Table 5) validated improvement, with a mean difference of 6.18, a t-value of -13.932, and a p-value of 0.000, resulting in the rejection of the null hypothesis.

This result agrees with what D'Costa [4] theorized, that cognition is largely influenced by one's culture, and Banks [12], who said that learning is due to students' understandings, awareness, and ability to connect students' backgrounds to improve performance. Thus, to provide more appropriate and effective learning for all students, the connections between students' everyday experiences and their own knowledge need to be established.

Table 5.
Pre-Test vs. Post-Test Performance of Experimental Group.

Pair	Mean	SD	Mean Difference	t-value	Df	p-value	Interpretation	Decision
Pre-test	5.88	2.19	6.18	-13.932	48	0.000	Significant	Reject Ho1
Post-test	12.06	2.41						

The last comparison (Table 6) of the control and experimental groups' post-test scores also reaffirmed the effectiveness of culturally-influenced materials. The experimental group scored much higher with a mean score (12.06 vs. 7.51), t-value of -10.069, and p-value of 0.000, and thus the second null hypothesis was rejected.

Based on Kolb [25], he described "Learning is a process whereby knowledge is created through the transformation of experience. This process is based on experiential learning theory. Accordingly, the core of this model of experiential learning is a simple description of a learning cycle, how experience is translated into concepts, which in turn are used as guides in the choice of new experiences. Thereby, enhancing their ability and skills to make meaningful connections and deepening their understanding of mathematics through the use of culturally-inspired materials as models in teaching geometry.

Arends [26] also supported that you learn best when you are personally involved in the learning experience. Alessi [27] added that learners are active creators of knowledge, able to learn by observing, manipulating, and interpreting the world around them as they make sense of their learning experiences. Therefore, when learners have the desire to absorb knowledge, it has positive effects by guiding them in the right direction.

Table 6.
Post-Test Performance Comparison (Control vs. Experimental Group).

Group	N	Mean	SD	t-value	Df	p-value	Interpretation	Decision
Control	47	7.51	1.99	-10.069	94	0.000	Significant	Reject Ho2
Experimental	49	12.06	2.41					

These findings align with education theories emphasizing experiential learning and cultural inclusion in mathematics education. As Kolb [25] and Banks [12] attest, linking students' cultural backgrounds to their learning process increases participation and understanding. Culturally-inspired materials significantly enhanced students' performance in geometry, solidifying their understanding and application of mathematical principles.

5. Conclusions

The research found that students' performance in learning solid figures in Geometry was greatly improved through culturally-inspired materials. This method not only increased understanding but also encouraged cooperative learning and the development of skills through hands-on experiments. The research reaffirmed that the use of culturally relevant materials is more productive than the conventional lecture method and that it is an important teaching practice for mathematics instructors. In accordance with this, it is suggested to give training to mathematics teachers on how to incorporate culturally inspired materials into their teaching, particularly in teaching solids in Geometry, include the use of culturally inspired materials in the secondary school mathematics curriculum to enhance learning by making it more relevant and interesting, and carry out more research on using this method in other areas of Mathematics to further improve student learning.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Copyright:

© 2026 by the authors. This article is an open-access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

References

- [1] A. Ubana, "Ethnomathematics concepts in Yakurr culture: Applicability of ethnomathematics concepts in conjunction with conventional methods of teaching geometry," in *The IAFOR International Conference on Education – Dubai 2017 Official Conference Proceedings*, 2017.
- [2] O. J. F. Andaya, "Factors that affect mathematics achievements of students of Philippine Normal University–Isabela Campus," *Researchers World – International Refereed Research Journal*, vol. 5, no. 4, pp. 83–91, 2014.
- [3] T. Kalpana, "A constructivist perspective on teaching and learning: A conceptual framework," *International Research Journal of Social Sciences*, vol. 3, no. 1, pp. 27–29, 2014.
- [4] A. D'Costa, "Rethinking the pedagogic possibility- mathematics teaching can be enriching," 2016. <https://www.thenewleam.com/>. [Accessed September 12, 2017]
- [5] S. D. Wurdinger, *Engaging students through experiential learning: Activities for the college classroom*. Lanham, MD: Rowman & Littlefield Publishers, 2010.
- [6] J. B. Leongson, "Assessing the mathematics achievement of college Freshman using Piaget's Logical operation," presented at the Hawaii International Conference on Education, Waikiki, Hawaii, USA, 2003.
- [7] F. Kurina, *Primary school geometry*. Seoul: The Korea Society of Mathematical Education, 2010.
- [8] A. Telima, "Problems of teaching and learning of geometry in secondary schools in Rivers State, Nigeria," *International Journal of Emerging Sciences*, vol. 1, no. 2, pp. 143–152, 2011.
- [9] S. Nieto, *Affirming diversity: The sociopolitical context of multicultural education*. New York: Longman, 2000.
- [10] S. Kitayama and D. Cohen, *Culture and psychology: People around the world*. New York: Routledge, 2007.
- [11] L. Darling-Hammond, *The classroom mosaic: Culture and learning*. Stanford, CA: Stanford University Press, 2012.
- [12] J. Banks, "The canon debate, knowledge construction, and multicultural education," 1993. <https://citeseerx.ist.psu.edu/>
- [13] B. Ogena, "Science education in the Philippines: Challenges for development," Science Education Institute, National Academy of Science and Technology, Center for Integrative Development Studies, University of the Philippines. Quezon City, 2005.
- [14] D. M. Gollnick, P. C. Chinn, and J. S. Moon, *Multicultural education in a pluralistic society*, 8th ed. Upper Saddle River, NJ: Pearson, 2009.
- [15] V. O. Pang, *Multicultural education in the 21st century: A global perspective*. New York: McGraw-Hill, 2005.
- [16] U. D'Ambrosio, "Reflections on ethnomathematics," *International Study Group on Ethnomathematics Newsletter*, vol. 3, no. 1, pp. 3–5, 1987.
- [17] G. F. Gilmer and M. T. Milwaukee, "Ethnomathematics: An African American perspective on developing women in mathematics," 2001. <https://www.nottingham.ac.uk/>. [Accessed August 25, 2017]
- [18] T. Seimon, R. Brown, and D. C. Orey, *Ethnomathematics: Linking mathematics and culture*. In D. C. Orey (Ed.), *Emerging perspectives on learning, teaching, and technology*. Charlotte, NC: Information Age Publishing, 2011.
- [19] U. d'Ambrosio, "In my opinion: What is ethnomathematics, and how can it help children in schools?," *Teaching Children Mathematics*, vol. 7, no. 6, pp. 308–310, 2001. <https://doi.org/10.5951/TCM.7.6.0308>
- [20] D. Orey, "The ethnomathematics of the Sioux tipi and cone," 2000. https://link.springer.com/chapter/10.1007/978-94-011-4301-1_13
- [21] M. Rosa and D. C. Orey, "Cultural assertions and challenges towards pedagogical action of an ethnomathematics program," 2007. <http://flm-journal.org/Articles/7E5E9FA4B24CB97110973C060200F3.pdf>
- [22] R. I. Arends, *Learning to teach*, 4th ed. New York: McGraw-Hill Companies, Inc, 1998.
- [23] K. Manning, J. Denner, and Y. Hwang, *Integrating culture into mathematics instruction: Engaging diverse learners*. New York: Routledge, 2009.
- [24] T. J. Fenwick, *Experiential learning: A theoretical critique from five perspectives*. Columbus, OH: Ohio State University, ERIC Clearinghouse on Adult, Career, and Vocational Education, 2001.
- [25] D. Kolb, *Experiential learning : Experience as the source of learning and development*. New Jersey: Prentice-Hall, 1984.
- [26] R. Arends, *Learning to teach*, 5th ed. New York: McGraw – Hill Companies, Inc, 2001.
- [27] S. Alessi, *Multimedia for learning, methods and development*, 5th ed. Boston: Allyn and Bacon, 2001.