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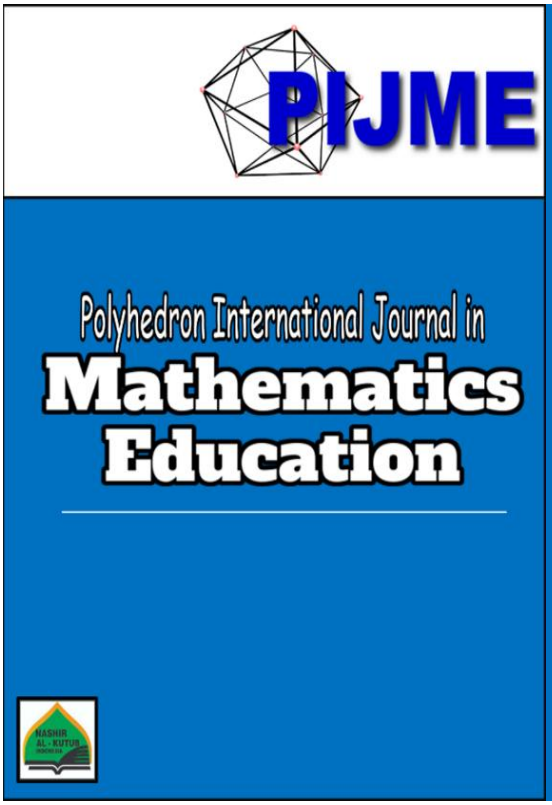

Integrating cultural contexts into mathematics: effects of culture-based worksheets on students' mastery of geometric transformations

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Abstract
The integration of cultural elements into the learning process, particularly in mathematics, served as a strategic approach to create a contextual and engaging classroom environment. The use of Student Worksheet played a significant role in enhancing students' comprehension of the subject matter and improving their academic performance. This research aimed to examine the effect of implementing culture based worksheet featuring the Mandau Talawang Dance of the Dayak Tribe in Central Kalimantan on students' learning outcomes in the topic of geometric transformations. The research employed a quasi-experimental design, specifically using the one group pre-test and post-test design. Quantitative methods were used to analyze the data, applying statistical tests such as the shapiro-wilk test, the paired sample t-test, and the N-Gain Score. The participants consisted of 15 ninth grade students. The findings indicated that the data followed a not normally distributed, with significance levels of 0.013 for the pre-test and 0.002 for the post-test. The average N-Gain score showed a notable improvement in learning outcomes, reaching a high category score of 0.7829. Furthermore, the hypothesis testing using the Wilcoxon Signed Rank Test confirmed the acceptance of H_1 ($\overline{x_{NG}} > 0.3$), with a significance value of 0.000 ($p < 0.05$), demonstrating that the culture based worksheet had a statistically significant positive effect on students' learning outcomes. Integrating culture-based worksheets into classroom mathematics instruction fostered students' awareness of local cultural heritage, enhanced their mathematical abilities, and improved their learning outcomes.

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1. Introduction

Human life was inseparable from culture, which represented an evolving legacy of norms, values, and traditions within society (Bantaika et al., 2025; Rodríguez-Nieto et al., 2025; Sudirman et al., 2024). Education played a crucial role in preserving culture, one of which was through the integration of cultural elements into the learning process (Pakabu et al., 2024; Zhu & Yuan, 2023). This integration made learning more meaningful and contextual by connecting mathematics with students' experiences, including the cultural aspects present in their local environments, since meaningful learning occurred when individuals possessed prior knowledge relevant to daily life (Olivero-Acuña et al., 2025; Rodríguez-Nieto et al., 2025; Sudirman et al., 2022).

The learning process in the classroom was carried out through various activities. However, its success largely depended on the appropriateness of the treatment and its alignment with students'

needs. The effectiveness of classroom learning could be examined from several perspectives, one of which was through learning outcomes (Firman et al., 2018; Mejía-Rodríguez & Kyriakides, 2022). Fundamentally, learning outcomes reflected changes in an individual's behavior encompassing cognitive, affective, and psychomotor abilities following a particular educational process (Yandi et al., 2023). These outcomes were frequently used as benchmarks to assess the extent of one's mastery of the taught material (Rahim et al., 2023). They could be understood as the competencies acquired by students after undergoing a series of educational and instructional experiences (Asidiqi, 2022). Learning outcomes were the achievements obtained by students after participating in instructional processes over a certain period (Yandi et al., 2023), and they played a role in influencing behavioral changes among learners (Asidiqi, 2022).

One approach that bridged culture and mathematics education was ethnomathematics (Rosa & Orey, 2011). According to Mairing et al. (2024), the product of acculturation between culture and mathematics was referred to as ethnomathematics. Thus, ethnomathematics could also be interpreted as mathematics embedded within culture. Teachers enriched the application of mathematical concepts around students by incorporating ethnomathematical objects into the learning process. This approach proved more accessible and facilitated students' understanding of abstract mathematical concepts by offering direct experiences through tangible cultural objects (Mairing et al., 2024; Nurafifah et al., 2024). Moreover, integrating ethnomathematics into didactic situations rooted in students' cultural backgrounds enhanced their comprehension of mathematical concepts (Sudirman et al., 2024). Ethnomathematics served to present mathematics not only as an abstract discipline but also as a contextual field, grounded in culturally inherited practices (Lubis et al., 2024).

One effective learning medium that teachers developed to support mathematics instruction was the LKPD (Destareiza et al., 2024; Setiyaningsih et al., 2022). Selecting LKPD as a teaching tool enabled educators to tailor learning materials to students' conditions and needs, while also encouraging their active engagement in the learning process, thereby achieving instructional goals more effectively (Firdausi, 2024). By utilizing LKPD, students engaged in five mathematically productive instructional routines: understanding reasoning, working with mathematical concepts, and participating in mathematical discussions (Bina et al., 2024). With the presence of LKPD, students were trained to solve mathematical problems and enhance their academic performance (Rokma, 2024).

Numerous studies examined the influence of culture based worksheet on students' learning outcomes. The research by Ulantina et al. (2023) revealed that locally grounded LKPD effectively improved the academic performance of seventh grade students at SMPN-9 Mataram. Similarly, Destareiza et al. (2024) discovered that ethnomathematics based worksheet enhanced students' problem-solving skills, learning outcomes, and motivation at SMPN-1 Sedayu. Furthermore, the interactive ethnomathematics-based E-LKPD developed by Prayoga et al. (2022) demonstrated its effectiveness in improving first-grade elementary students' academic performance. The research by Astuti et al. (2021) concluded that the ethnomathematics based worksheet they designed significantly improved learning outcomes among eighth-grade students at SMPN-11 Tapung. Warni et al. (2022) also found an increase in students' performance after implementing a culture based worksheet that featured Batak Toba traditional cloth motifs using the PMR approach. Similarly, Rokma (2024) identified improvements in student achievement following the use of LKPD rooted in local wisdom at SDN-187 Pekanbaru. Another research by Agustina (2024) indicated enhanced student learning outcomes through mathematical problem-solving skills after the application of ethnomathematics-based worksheets among tenth-grade students at SMKN-4 Padangsidimpuan. Furthermore, Pakabu et al (2024) concluded that the use of E-LKPD based on Papuan Culture can help students understand mathematics material, especially the material on two-variable linear equation systems.

Despite the growing body of research on ethnomathematics based worksheet, studies investigating the influence of culturally-based Student Worksheet related to the Mandau Talawang Dance of the Central Kalimantan Dayak Tribe, on students' learning outcomes remained scarce. The Mandau Talawang Dance represented a cultural heritage that symbolized the tribe's defense system and heroic values. This dance not only possessed aesthetic value but also incorporated mathematical concepts, particularly within its choreography and attributes, such as the Mandau and Talawang.

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Consequently, this research aimed to examine the impact of implementing culture based worksheet on students' academic performance in classroom learning.

The research problem addressed in this research involved analyzing the impact of culturally based worksheet on the academic performance of ninth grade students. The question in this research aimed to examine the impact of implementing culture based Student Worksheet on the improvement of ninth grade students' learning outcomes in geometric transformation material. To resolve this problem, the research employed a quasi-experimental design with a one group pre-test and post-test framework. Data were analyzed using the Shapiro-Wilk test to assess normality, a paired sample t-test to test the hypothesis, and N-Gain scores to determine improvement in learning outcomes. The anticipated result of this research was a statistically significant impact on student achievement following the implementation of the culture based worksheet.

2. Method

2.1 Type and Design of the Research

This research employed a quasi experimental approach using a One Group Pre-test and Post-test Design. This design was utilized to measure the effectiveness of culture based worksheet in enhancing students' learning outcomes. In this design, the experimental group was administered a pretest prior to the implementation of the instructional material, followed by a posttest after the intervention to observe any changes in learning outcomes (Santosa & Siregar, 2022). The table below presented the research design of the one-group pre-test-post-test model used in this research (See Table 1).

Table 1
One-Group Pretest-Posttest Research Design

Class	Pre-test	Treatment	Post-test
Group Experiment	O_1	X	O_2

Description:
O_1 : Score before the treatment was given
X : Treatment (Intervention)
O_2 : Posttest score after the treatment

2.2 Subject

The research was conducted at Junior High School 2 of Central Katingan during the second semester of the 2024/2025 academic year, specifically from January 22 to February 8, 2025. It involved 15 ninth-grade students from class IX B, selected through purposive sampling based on recommendations from the mathematics teacher. The selection criteria included students' willingness to participate, consistent attendance, and varied levels of mathematical ability to ensure a representative range of learning experiences. Prior to data collection, informed consent was obtained from both the students and their parents or guardians. All necessary permissions were also secured from the school administration, and the research was carried out in accordance with ethical guidelines for educational research. Throughout the study, confidentiality and anonymity of the participants were maintained.

2.3 Data Collection

The data in this research were obtained through written descriptive tests in the form of a pre-test and a post-test, which were used to examine the effectiveness of implementing the Student Worksheet in the learning process by measuring students' learning outcomes before and after the use of the Student Worksheet. The following parameters and criteria were applied to determine the effectiveness of the developed Student Worksheet

$$N - Gain = \frac{(Post\ test\ Score - Pre\ test\ Score)}{(Maximum\ Score - Pre\ test\ Score)}$$

Table 2
N-Gain Level Parameters

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N-Gain	Criteria
$g > 0{,}7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

To interpret the effectiveness of the intervention, the normalized gain (N-Gain) score was used as a measure of students' improvement. The N-Gain categorizes learning gains into three levels: high, medium, and low. A score greater than 0.7 ($g > 0.7$) is classified as high, indicating a substantial increase in student performance. Scores between 0.3 and 0.7 ($0.3 \leq g \leq 0.7$) fall under the medium category, reflecting a moderate level of improvement. Meanwhile, scores below 0.3 ($g < 0.3$) are considered low, suggesting minimal learning gains. This classification helps in evaluating the degree of conceptual understanding achieved by the students as a result of the instructional intervention.

Table 3
Criteria for Determining the Level of Effectiveness

Percentage %	Criteria
> 76	Effective
$56 - 75$	Moderately Effective
$40 - 55$	Less Effective
< 40	Ineffective

To assess the overall impact of the learning intervention, the level of effectiveness was determined based on percentage scores, which are categorized into four distinct criteria. A percentage score above 76% (>76%) indicates that the intervention is effective**,** demonstrating a strong positive influence on student learning outcomes. Scores ranging from 56% to 75% fall under the moderately effective category, reflecting a satisfactory but not optimal result. When the percentage falls between 40% and 55%, the intervention is considered less effective**,** signaling limited success in achieving the intended learning objectives. Finally, a score below 40% (<40%) is categorized as ineffective**,** suggesting that the instructional strategy had minimal or no measurable impact on student performance. This classification framework provides a clear benchmark for evaluating the success of the applied educational approach.

2.4 Data Analysis

Data analysis was conducted using the Shapiro-Wilk normality test to determine the distribution normality, with the testing criterion that H0 was rejected if Sig < α = 0.05. The N-Gain calculation was used to measure the level of improvement in learning outcomes before and after the treatment. Additionally, a paired sample t-test was performed to test the significance of the improvement in learning outcomes after the implementation of the Student Worksheet, with the criterion that H_0 was rejected if Sig (2-tailed) < 0.05, and the Student Worksheet was considered effective if the improvement indicated by the N-Gain score was at least in the moderate category, such that $\overline{x_{NG}} > 0.3$. All analyses were carried out with consideration of the relevance of the findings to the research objectives, ensuring that the conclusions drawn were based on strong empirical foundations.

3. Results and Discussion

3.1 Result

The following instruments (Pre-test and Post-test) were used to measure the effectiveness of the developed Student Worksheet.

Figure 1

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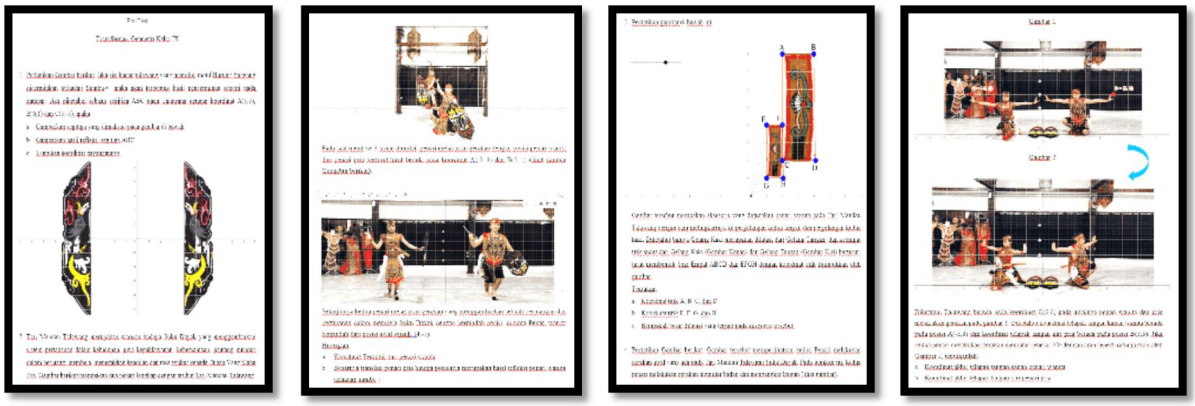
Example Student Worksheet



The culture-based worksheet featuring the Mandau Talawang Dance of the Dayak Tribe in Central Kalimantan was designed to integrate local cultural heritage into the learning process, fostering both cognitive and cultural development among students. This traditional dance, which symbolizes bravery and the spirit of defense among the Dayak people, serves not only as an artistic expression but also as a meaningful context for learning. By embedding elements of the dance—such as its movements, symbolic meanings, and historical background—into the worksheet activities, students are encouraged to connect mathematical concepts with real-life cultural practices. This approach not only enhances engagement and relevance in learning but also helps preserve and appreciate local wisdom, promoting a culturally responsive pedagogy that respects and reflects the identities of indigenous communities.

Table 4
Learning Outcomes

No	Name	Pre-test	Post-test
1	A. I	0	79.5
2	A. R.	0	79
3	C. A. P.	59.5	100
4	E.	34	72
5	F. G. M.	39.5	100
6	G. A. N.	0	14.5
7	M. A.	0	71
8	M. F.	0.5	98
9	M. M.	16	95
10	N.	0	88
11	N. A.	41.5	85.5
12	R. W.	34	99
13	R.	23	57
14	S. M. J.	40	89
15	Y. S.	4	93.5

The data from the pre-test and post-test results (See Table 4) of 15 students demonstrate a significant improvement in students' understanding after the instructional intervention. Prior to the intervention, a majority of the students scored very low on the pre-test, with several students (e.g., A. I, A. R., G. A. N., M. A., and N.) starting with a score of 0, indicating minimal prior knowledge of the tested material. However, the post-test scores reveal substantial gains, with most students achieving scores above 70, and some reaching near-perfect scores (e.g., C. A. P., F. G. M., and R. W. with scores of 100, 100, and 99 respectively). Even students with initially low scores, such as M. F. (from 0.5 to 98) and N. (from 0 to 88), showed marked progress. This overall trend suggests that the learning intervention was highly effective in enhancing students' mathematical understanding, as evidenced by the dramatic increase in post-test performance across nearly all participants.

The results of the normality test were analyzed using SPSS and are presented below.

Table 5

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Normality Test Results

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pre-test	.242	15	.018	.841	15	.013
Post-test	.203	15	.098	.775	15	.002

In the Test of Normality Table 5, the Shapiro-Wilk test results for the Pre-test and Post-test showed significance levels of Pre-test = 0.013 and Post-test = 0.002. The significance levels of both tests exceeded the threshold value of 0.05 and can be written as follows.

Sig. Pre-test $= 0.013 < \alpha = 0.05$

Sig. Post-test $= 0.106 < \alpha = 0.05$

Based on the hypothesis and the proposed hypothesis testing criteria, it was concluded that "H_0 was rejected," indicating that the data followed a not normally distributed. The results of the N-Gain test conducted using SPSS are presented Table 6.

Table 6

N-Gain Test Results

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
NGain_Score	15	.15	1.00	.78	.062	.239
NGain_persen	15	14.50	100.00	78.29	6.189	23.969
Valid N (listwise)	15					

From the test results table above, the following findings were obtained:

- The mean Normal Gain (N-Gain) was 0.78 > 0.7, indicating that the N-Gain Score fell into the "High" category.
- The mean Normal Gain Percentage (N-Gain%) was 78.29% > 76%, indicating that the N
- Gain Percentage fell into the "Effective" category.

Based on the average results obtained from N-Gain and N-Gain Percentage, it was concluded that the Culture Based Worksheet on the Mandau Talawang Dance of the Dayak Tribe in Central Kalimantan was "Effective".

The results of the paired sample t-test, conducted using SPSS, are presented Table 7.

Table 7

Wilcoxon Signed Rank Test

		N	Mean Rank	Sum of Ranks
Pre-test-Post-test	Negative Ranks	0[a]	.00	.00
	Positive Ranks	15[b]	8.00	120.00
	Ties	0[c]		
	Total	15		

The normality assessment revealed that the dataset did not conform to a normal distribution. Consequently, the Wilcoxon signed-rank test was utilized to evaluate the research hypothesis. This non-parametric analysis was conducted using IBM SPSS Statistics software. Based on the results of the Wilcoxon signed-rank test, the Asymp. Sig. (2-tailed) value for the Pre-test and Post-test was found to be 0.001. This significance level was lower than the threshold value of α = 0.05, and can be expressed as: Asymp. Sig. (2-tailed) Pre-Test–Post-Test = 0.001 < α = 0.05.

In accordance with the stated hypothesis and testing criteria, it was concluded that H_1 ($\overline{x_{NG}} > 0{,}3$) was accepted, indicating a statistically significant improvement in the N-Gain score, which reached at least a moderate category. This result implied that the developed Student Worksheet had a positive impact on the learning outcomes of ninth grade students.

3.2. Discussion

The results of this research revealed that the Culture-Based Worksheet integrating the Mandau Talawang Dance of the Dayak Tribe in Central Kalimantan, which was implemented in the classroom setting, proved effective in significantly improving the learning outcomes of ninth-grade students. The use of this worksheet, which contextualized mathematical concepts within the local cultural heritage, allowed students to engage with the subject matter in a more meaningful and relatable way. By incorporating elements of the Mandau Talawang Dance—such as the symmetrical movements, geometric patterns found in the dance costumes and shields (talawang), and the symbolic meanings rooted in Dayak cultural narratives—students were able to experience mathematics not as an abstract and distant subject, but as something embedded within their own cultural environment. This cultural contextualization fostered deeper conceptual understanding and greater enthusiasm for learning.

This finding is in line with a growing body of research that supports the integration of ethnomathematics into mathematics education as a powerful pedagogical approach. Ulantina et al. (2023), for example, found that a culture-based local worksheet significantly enhanced the learning outcomes of seventh-grade students. Their study highlighted how cultural context can serve as a bridge between students' prior knowledge and abstract mathematical concepts, thereby facilitating improved comprehension and retention (Hlas & Hlas, 2012). In their research, students exhibited not only better test scores but also increased participation and curiosity during the learning process.

Similarly, Destareiza et al. (2024) demonstrated that ethnomathematics-based worksheets contributed meaningfully to the development of problem-solving skills, learning outcomes, and intrinsic motivation among junior high school students. Their findings emphasize that when students see their cultural practices and traditions reflected in academic content (Aronson & Laughter, 2016), they are more likely to value the learning experience, leading to enhanced cognitive engagement and academic success.

In another related study, Prayoga et al. (2022) developed an interactive ethnomathematics-based E-LKPD (electronic student worksheet) and concluded that culturally contextualized materials were effective in promoting better learning outcomes. This study is particularly relevant in today's digital age, showing that technological integration does not have to come at the expense of cultural relevance. Instead, digital tools can serve as effective mediums to deliver culturally rich content that speaks directly to students' identities and experiences (Isnawan et al., 2024, 2024; Kuswara et al., 2024).

Astuti et al. (2021) also provided strong evidence for the effectiveness of ethnomathematics-based worksheets. In their research involving eighth-grade students, the worksheets developed around local cultural themes were shown to improve not only students' scores but also their critical thinking and collaborative skills. The researchers noted that culture-based learning fosters a sense of belonging and identity, which in turn strengthens student engagement and performance.

Furthermore, Warni et al. (2022) explored the use of a worksheet based on Batak Toba culture and found substantial improvement in students' learning outcomes. Their study emphasized how students' familiarity with cultural symbols and practices allowed them to approach mathematical problems with greater confidence and contextual understanding. They argued that such approaches reduce the cultural disconnect often felt in traditional mathematics instruction, particularly in multicultural and multiethnic classroom settings.

This research is also supported by Rokma (2024), who found a positive shift in student learning outcomes after implementing a local wisdom-based worksheet. Rokma's findings highlight how the inclusion of cultural themes in learning materials can serve as a motivational tool and enhance students' ability to apply mathematical reasoning in real-life contexts. The use of culturally meaningful contexts appeared to reduce math anxiety and foster a more positive attitude toward the subject.

Agustina (2024) further substantiated these conclusions by showing how ethnomathematics-based student worksheets improved not only learning outcomes but also students' abilities in mathematical problem-solving. The research concluded that integrating culture into learning materials encourages students to think more critically and creatively, especially when faced with non-routine problems that require logical reasoning and pattern recognition.

The consistent findings across these studies reinforce the idea that culture-based mathematics education is more than an innovation—it is a necessary transformation in pedagogy that addresses the

cultural diversity of learners. In the specific case of this research, the Mandau Talawang Dance served as a rich cultural anchor that connected mathematical learning with students' lived experiences. The worksheet allowed students to explore mathematical concepts such as angles, symmetry, measurement, and geometric shapes through the lens of their own heritage. As a result, students developed not only stronger academic skills but also a deeper appreciation for their cultural identity.

Moreover, the success of the worksheet indicates that cultural integration in learning materials should not be limited to early grades or specific subjects like social studies or language. Mathematics, often perceived as culturally neutral or universal, can and should be taught in ways that reflect the diverse cultural backgrounds of students. Doing so not only promotes equity and inclusion but also enhances the effectiveness of instruction by making abstract concepts more tangible and relatable.

In conclusion, the findings of this study support the growing consensus that ethnomathematics-based instructional materials—such as the culture-based worksheet featuring the Mandau Talawang Dance—can play a crucial role in enhancing learning outcomes. These materials bridge the gap between abstract academic content and students' everyday cultural experiences, making learning more engaging, meaningful, and effective. The consistent evidence from various researchers further validates this approach as a best practice in culturally responsive mathematics education. As such, educators, curriculum developers, and policymakers are encouraged to consider integrating local cultural contexts into teaching materials to improve both academic performance and cultural literacy among students.

4. Conclusion

Based on the findings of the research outlined, the researchers concluded that the Culture Based Worksheet of the Mandau Dance of the Dayak Tribe in Central Kalimantan on the topic of Geometric Transformation was proven effective in improving the learning outcomes of students. The limitations of this research were that it only implemented a culture based worksheet on one cultural form of the Dayak Tribe in Central Kalimantan, namely the Mandau Talawang Dance. The researchers hope that, in the future, educators will implement culture based worksheet in other cultural forms of the Dayak Tribe in Central Kalimantan, such as traditional ceremonies, traditional foods, other dances such as Manasai dance, Tambun and Bungai dances, Kayau dance, Giring-giring dance, Balean Dadas dance, Hugo and Huda dances, Putri Malawen dance, Tuntung Tulus dance, Manganjan dance, traditional games, cultural festivals, traditional songs, the farming system, and the historical relics of the Dayak Tribe in the Balanga Museum of Palangka Raya City, Central Kalimantan, into the mathematics learning process in the classroom.

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