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The Impact of Ethnomathematics Activities Using Zapin and Kuda Dances on Students' Academic Achievement and Appreciation of Isometric Transformations

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Abstract

Cultural integration in education has emerged as a powerful tool for enhancing student engagement and learning outcomes. However, the specific impact of cultural integration on mathematics education, particularly in relation to students' academic achievement and their appreciation of mathematical beauty, has not been thoroughly examined. This study explores the effects of a teaching module that integrates Zapin and Kuda Kepang dances with isometric transformations on these outcomes. Using a quasi-experimental design, the research involved 60 Form Two students from Johor Bahru, divided into treatment and control groups. The module was implemented over five weeks, with data collected through academic performance tests, questionnaires, and semi-structured interviews. Independent t-tests and Mann-Whitney U tests (conducted using SPSS version 21) revealed significant improvements in academic achievement and appreciation of mathematical beauty among students in the treatment group. Thematic analysis of interview data further revealed increased motivation, interest, and emotional connection to mathematics. These findings highlight the potential of integrating cultural elements into mathematics education to foster deeper engagement and academic success, emphasizing the need for innovative teaching approaches in secondary education.

Keywords: Appreciations of Mathematical Beauty, Effectiveness, Ethnomathematics, Mathematics Achievement, Zapin and Kuda Kepang Dances

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INTRODUCTION

The Mathematics Curriculum 4.0, aligned with the goals of 21st-century education, has transformed the teaching of mathematics. Notably, it focuses on mastering mathematical concepts and skills and applying them to real-world situations, thereby enhancing students' problem-solving and critical-thinking abilities (Kusno & Setyaningsih, 2021). To achieve these outcomes, educators are increasingly encouraged to adopt innovative teaching strategies beyond traditional methods, aiming to improve academic performance and student engagement in mathematics. Accordingly, the Mathematics Curriculum 4.0, aligned with the objectives of 21st-century education, has transformed the teaching of mathematics. This curriculum emphasizes the mastery of mathematical concepts and skills and their real-world applications, fostering students' problem-solving abilities and critical thinking skills (Kusno & Setyaningsih, 2021). To achieve these goals, educators are increasingly encouraged to adopt innovative teaching strategies that move beyond traditional methods, aiming to enhance both students' academic performance and engagement in the subject. In particular, one promising strategy in

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mathematics education is the integration of ethnomathematics, which involves embedding cultural practices and artifacts into the teaching process. Ethnomathematics connects abstract mathematical concepts to students' cultural and social contexts, making learning more relevant and engaging. In Malaysia, with its rich cultural heritage, integrating traditional elements such as Zapin and Kuda Kepang dances into mathematics instruction offers a unique opportunity to bridge cultural heritage with mathematical education (Barghi et al., 2017). This approach fosters students' appreciation of mathematics and helps preserve cultural practices.

The Standard Curriculum for Secondary Schools (SCSS) in Malaysia provides a structured framework for mathematics education, covering areas such as numbers and operations, measurement and geometry, and discrete mathematics. Among these, isometric transformations, including translation, reflection, rotation, and enlargement, are fundamental for developing spatial reasoning and geometric proof skills (Breuils et al., 2021). A dynamic, interactive approach to teaching these concepts has the potential to inspire greater student engagement and foster a deeper appreciation of mathematics (Kovacheva et al., 2022). Culturally relevant pedagogical methods, when combined with effective teaching modules, offer an opportunity to enrich students' learning experiences.

In the assessment of the Trends in International Mathematics and Science Study (TIMSS) 2023, announced at the end of 2024, Malaysian students who value mathematics more tend to have higher average scores in mathematics compared to those who do not value it. This is evident from the results of TIMSS 2023; 35% of students who highly value mathematics have an average score of 431. Meanwhile, 50% who "sometimes value mathematics" have an average score of 409, and 15% who do not value mathematics have an average score of 374. These results generally suggest that the greater the students' appreciation for mathematics, the better their performance in the subject. This finding also highlights one of the objectives outlined in the Mathematics Curriculum and Assessment Standard Document (CASD) within the SCSS. That is, to appreciate and recognize that the beauty of mathematics has yet to reach a satisfactory level. Previous studies have consistently proven that one effective way to cultivate students' appreciation for mathematics is to relate it to real-life contexts. This includes incorporating cultural elements into mathematics, a practice known as ethnomathematics.

Zapin and Kuda Kepang are two well-known traditional dances in Malaysia, specifically in Johor. Therefore, their traditions should be preserved for the knowledge and appreciation of current and future generations. Incorporating Zapin and Kuda Kepang dances into teaching isometric transformations represents an innovative ethnomathematical approach. These traditional dances, characterized by symmetrical movements and mathematical patterns, provide a culturally resonant medium for teaching abstract mathematical concepts. Thus, this strategy bridges the gap between theory and practical application, making learning more tangible and engaging for students (Zuhri et al., 2023). Additionally, the integration of technology into such teaching methodologies aligns with the goals of the Mathematics Curriculum 4.0, facilitating interactive and visually enriched learning experiences (Bakar et al., 2021; Husain & Wahab, 2020).

This study focuses on developing an ethnomathematics-based teaching module that incorporates Zapin and Kuda Kepang dances to teach isometric transformations to Form Two students. Specifically, the research investigates the effectiveness of this culturally integrated approach in improving students' academic achievement and conceptual understanding. Notably, by comparing this innovative method with conventional teaching approaches, the study aims to evaluate the viability of ethnomathematics as a solution to ongoing challenges in mathematics education. Ultimately, the research contributes to the discourse on integrating culture and technology in education to create inclusive and impactful learning experiences. The objectives of this study are as follows:

1. To determine the effectiveness of teaching isometric transformations integrated with elements of Kuda Kepang and Zapin on the academic achievement of Form Two students,
2. To assess the effect of teaching isometric transformations integrated with elements of Kuda Kepang and Zapin on the appreciation of mathematical beauty among Form Two students,
3. To understand the perspectives of Form Two students regarding the appreciation of mathematical beauty, particularly in terms of their attitudes and feelings of affinity for the subject, after participating in the teaching of isometric transformations integrated with Zapin and Kuda Kepang elements.

Kuda Kepang Dance in Mathematics Education

Kuda Kepang is a traditional Javanese performance art that involves dancing with horses-like constumes and often features in village processions and ritual celevrations (Budiawan et al., 2025). Ahmad et al. (2023) demonstrated that mathematical connections in Kuda Kepang can be explored by using its elements to foster students' understanding of mathematics creatively and engagingly, particularly through activities that integrate numerical representation and problem-solving skills. Furthermore, the process of creating a Kuda Kepang involves several geometric concepts, such as the formation of symmetrical patterns, measuring the length and width of the bamboo weave, and applying geometric principles to shape the horse figure. In addition, Kuda Kepang can be linked to mathematical concepts through rhythm and dance patterns. These include number sequences, geometric patterns, and repetition, providing a rich context for integrating mathematics into teaching. The beauty of the dance movements offers a powerful analogy for abstract mathematical concepts, particularly in the topic of isometric transformations.

First, translation can be observed when the dancer moves from one point to another along a specific path (Rawani et al., 2023). In Kuda Kepang, translations visually demonstrate how an object or pattern can be displaced horizontally or vertically without altering its shape. By associating the dancer's movement with the translation of a point in an isometric transformation, students can grasp this concept in a creative and contextually meaningful way. Next, reflection is illustrated when a dancer mirrors their movement along a line (Buttingsrud, 2021). The symmetrical movements created by the

dancer's reflection reinforce students' understanding of the concept of reflection in geometry (Ahmad et al., 2023). Finally, rotation is exemplified when the dancer turns around a point, resulting in a change in orientation and position (Susanti et al., 2021). This motion serves as a visual representation of the concept of rotation in isometric transformations.

By integrating the concepts of translation, reflection, and rotation through the Kuda Kepang dance, it becomes evident that both mathematical concepts and the preservation of cultural heritage hold significant value in mathematics education (Amalia et al., 2024). In particular, students gain an understanding of isometric transformations in theory and experience and appreciate these concepts through an engaging artistic experience. Amalia et al. (2024) conducted an ethnographic study exploring the mathematical concepts embedded in Gamelan musical instruments and Kuda Kepang dance movements in Indonesia. The study highlighted that the ethnomathematical approach contributes significantly to the integration of cultural elements into mathematics education. In a similar vein, Ahmad et al. (2023) developed e-Kuda Kepang (e-KuPang), an interactive mathematics education courseware, to integrate the performance art of Kuda Kepang into mathematics learning. The study's findings demonstrated that e-KuPang successfully met its objectives, achieving a high level of usability. Additionally, Novikasari et al. (2024) explored the integration of cultural elements in teaching geometry, emphasizing how cultural contexts can enrich the learning experience. The findings indicated that embedding culture into lessons positively enhances students' understanding of mathematical concepts, particularly in geometry.

Zapin Dance in Mathematics Education

The Zapin dance is a traditional art form originating from the Malay community and has become an integral part of both Malaysian and Indonesian culture. In Johor, Zapin is traditionally performed at weddings, but today, it also serves as a way for the local community to gather and celebrate. Even the dancers' clothing reveals a mathematical dimension, with geometric patterns woven into the fabric, connecting the art form to mathematical concepts. The garments worn during Zapin performances often feature these geometric designs, which can be explored through mathematical ideas. Additionally, the dance itself requires precision and measurement in the movements, which can be linked to mathematical concepts such as calculating angles, distances, and the time required for dancers to change positions in sync with the music. Translation in Zapin can be observed when dancers shift positions according to a specific formation. For example, dancers may form shapes like flowers, with their movements adhering to specific geometric patterns. This type of translation provides a visual representation of how an object or pattern can move horizontally or vertically without any distortion or change in shape.

The second concept, reflection, occurs when a dancer creates symmetrical movements relative to a line, mirroring the motion on either side. This symmetry reinforces students' understanding of

reflection in geometry (Wan Muhammad Fauzan et al., 2018). Through this visual symmetry, students gain a concrete grasp of how reflection works, both in dance and in mathematical contexts. Rotation is evident when dancers move around a fixed point, performing a rotating movement. This serves as a visual representation of rotation, a key concept in isometric transformations, helping students understand how objects rotate in mathematical space.

Wan Muhammad Fauzan and Said Husain's study (2018) focused on integrating Malay traditional dance and ethnomathematics, analyzing the mathematical concepts embedded in Malay cultural practices. In their research, they explained how the leg movements in Zapin dance can create various geometric shapes and patterns. The study also explored the relationship between these geometric patterns and the different styles of Zapin dance in detail. In a subsequent study, Wan Muhammad Fauzan and Said Husain (2018) further investigated the connection between Malay traditional dance and mathematics. The findings demonstrated that the ethnomathematical approach can make a significant contribution to the development of a more inclusive and culturally relevant mathematics education. Furthermore, Albakri et al. (2019) proposed a method for extracting three-dimensional keyframe motion data of Zapin traditional dance directly from video footage, instead of relying on expensive motion capture technology. Their approach involves extracting 3D body joint coordinates from each keyframe and reconstructing the motion onto a character model to verify the accuracy and efficiency of the captured dance movements compared to the original video.

METHODS

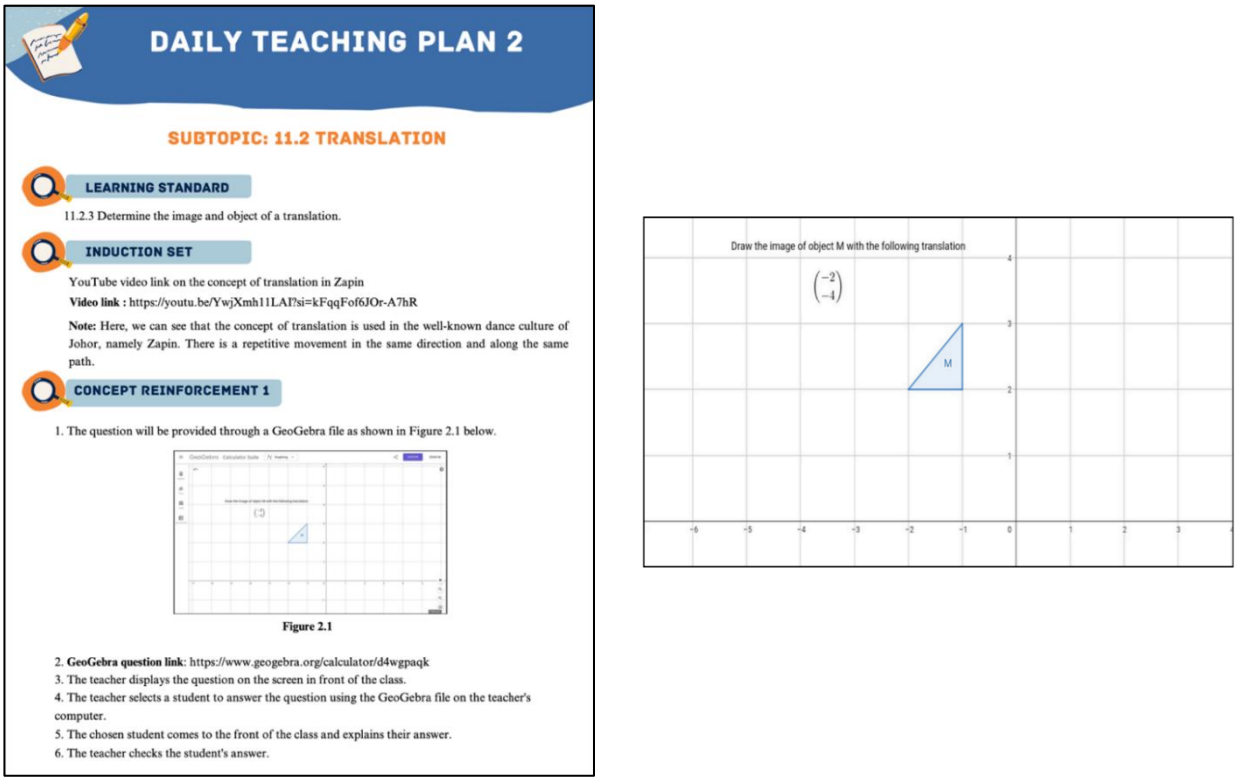
The methodology section outlines the research design, sample and sampling technique, research instruments, research procedure, and data analysis methods used to investigate the impact of a teaching module on isometric transformations integrated with Kuda Kepang and Zapin dance. Specifically, the study examines its effects on both academic achievement and the appreciation of mathematical beauty among Form Two students.

Developing Teaching Module

The ethnomathematics-based activity, titled "*Terokai Rahsia Matematik Di Sebalik Tarian Zapin dan Kuda Kepang*," is specifically designed for mathematics teachers, focusing on Form Two students. This activity centers on the topic of isometric transformation and provides a framework for teachers to integrate traditional cultural elements into their classroom teaching. Additionally, the activity is developed in alignment with the lesson plan from the Universiti Teknologi Malaysia (UTM). The activity consists of three main components: the induction set, concept reinforcement, and formative assessment. The integration of this traditional dance into GeoGebra does not involve animation. Instead, it focuses on using activities to explore mathematical concepts. For example, students can examine the

movement of a dancer's steps using GeoGebra tools such as transformations, symmetry, or angles. This approach allows students to connect mathematical concepts with the cultural context of dance. In this paper, the authors present an example of a teaching and learning activity from Week 1, which uses GeoGebra to assess students' understanding of translation. The first activity emphasizes the concept of translation, which is the initial topic in the broader subject of isometric transformations. It corresponds to the second subtopic in the Curriculum and Assessment Standard (CAS), specifically 11.2.3: Determining objects and images for translation. The GeoGebra activities are designed for students' concept reinforcement activities.

As illustrated in Figure 1, the activity begins with an induction set, where the concept of translation is demonstrated through various Zapin dance movements in a nearly two-minute video. The video features repeated movements in the same direction and over the same distance, effectively illustrating the concept of translation. Following this, the concept reinforcement phase utilizes GeoGebra software, where students engage with basic translation questions to solidify their understanding.



DAILY TEACHING PLAN 2

SUBTOPIC: 11.2 TRANSLATION

LEARNING STANDARD

11.2.3 Determine the image and object of a translation.

INDUCTION SET

YouTube video link on the concept of translation in Zapin

Video link : https://youtu.be/YwjXmh11LAI?si=kFqqFof6JOr-A7hR

Note: Here, we can see that the concept of translation is used in the well-known dance culture of Johor, namely Zapin. There is a repetitive movement in the same direction and along the same path.

CONCEPT REINFORCEMENT 1

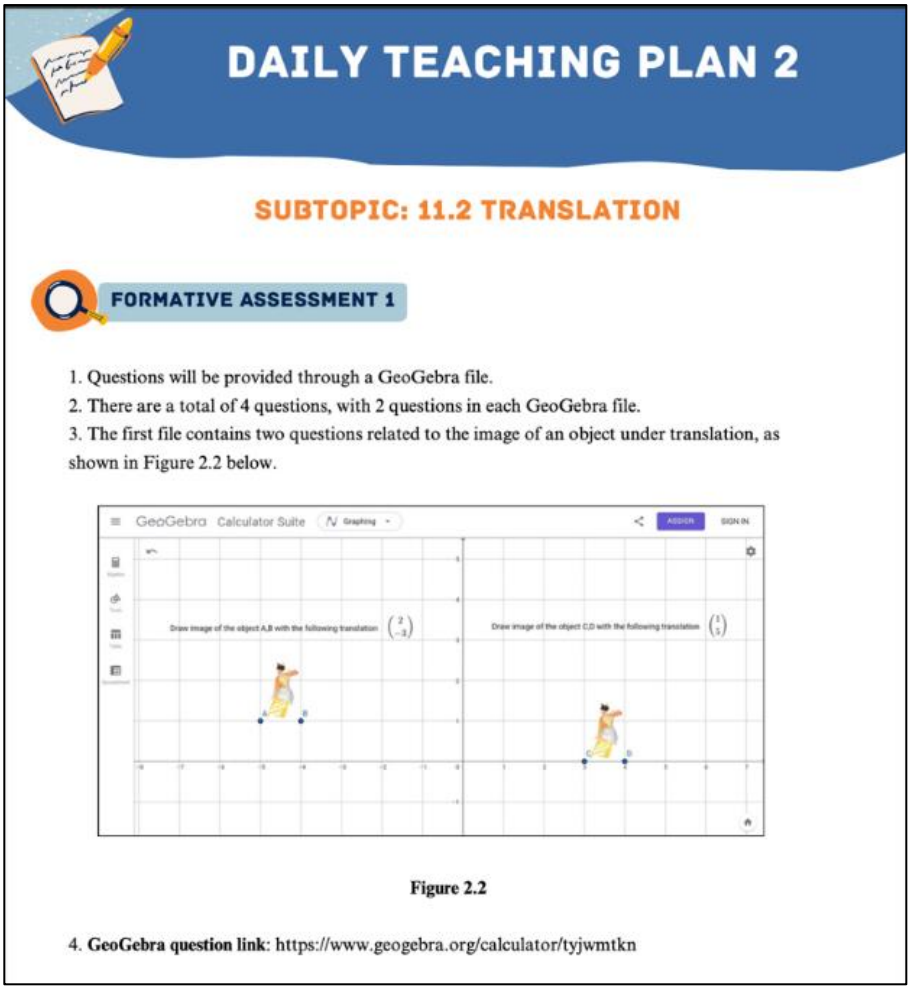
1. The question will be provided through a GeoGebra file as shown in Figure 2.1 below.

Figure 2.1

2. **GeoGebra question link**: https://www.geogebra.org/calculator/d4wgpaqk
3. The teacher displays the question on the screen in front of the class.
4. The teacher selects a student to answer the question using the GeoGebra file on the teacher's computer.
5. The chosen student comes to the front of the class and explains their answer.
6. The teacher checks the student's answer.

Figure 1. The first page of the first activity

The activities in the first formative assessment (Figures 2 and 3) utilized GeoGebra software to assess students' understanding of translation based on the vector values provided. An example of the task involves determining the position of objects and images using vector values, represented through a dancer diagram rather than the typical polygon diagram. This activity is conducted in pairs, encouraging collaborative learning.



DAILY TEACHING PLAN 2

SUBTOPIC: 11.2 TRANSLATION

FORMATIVE ASSESSMENT 1

1. Questions will be provided through a GeoGebra file.
2. There are a total of 4 questions, with 2 questions in each GeoGebra file.
3. The first file contains two questions related to the image of an object under translation, as shown in Figure 2.2 below.

Figure 2.2

4. **GeoGebra question link**: https://www.geogebra.org/calculator/tyjwmtkn

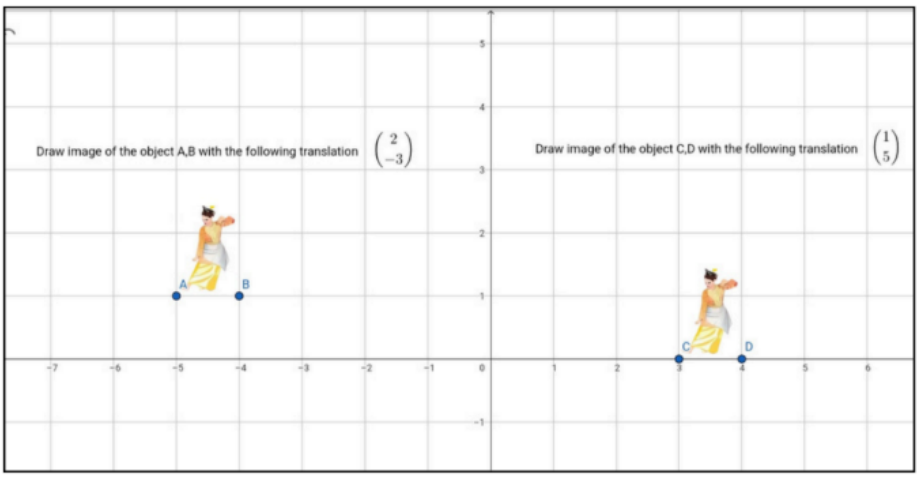
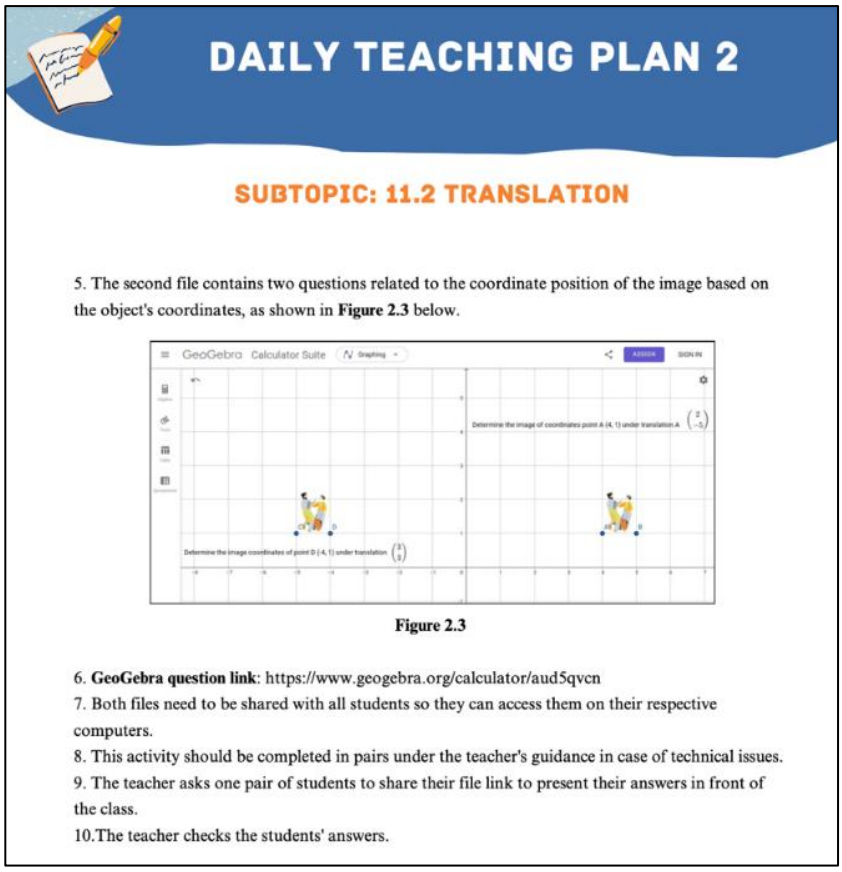


Figure 2. The second page of the first activity



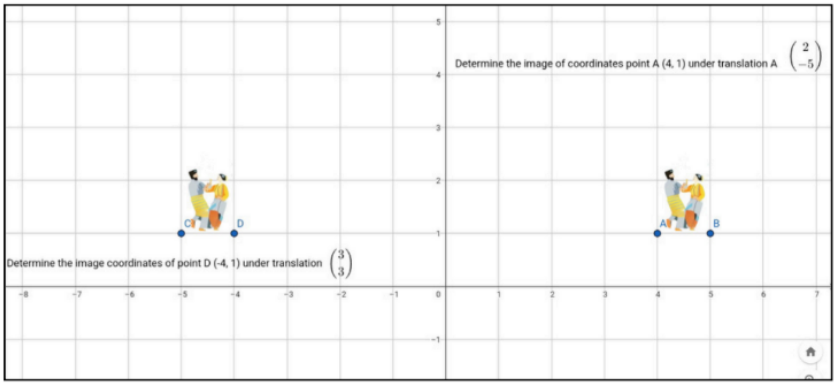
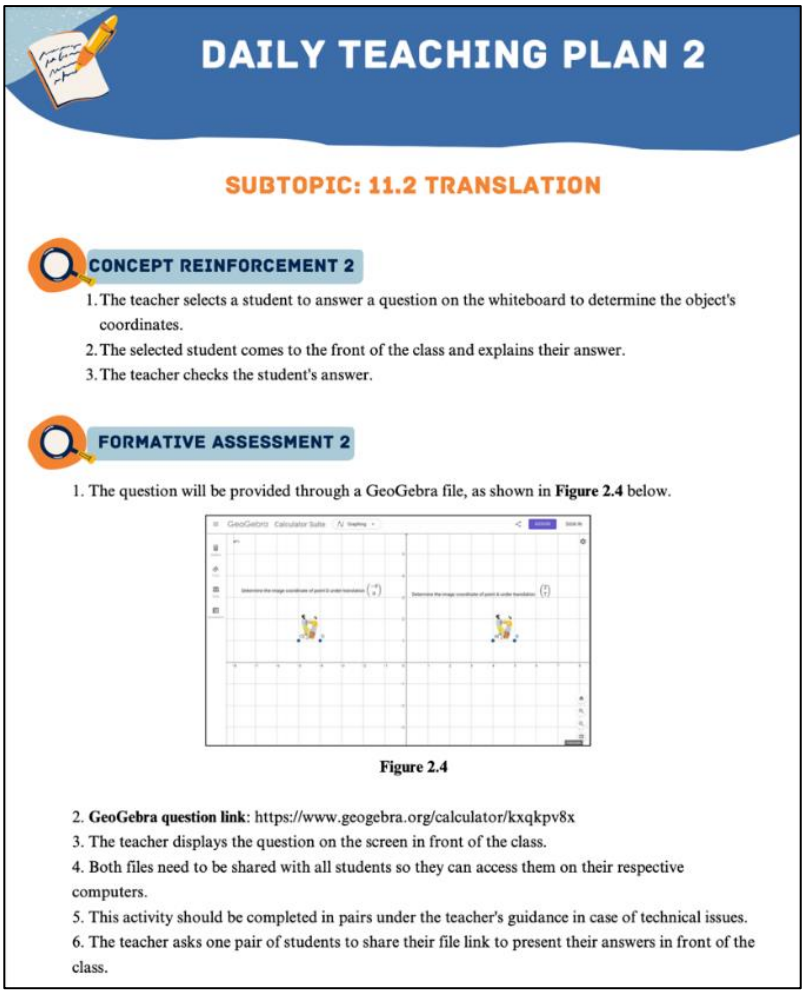


Figure 3. The third page of the first activity

The second formative assessment (Figure 4) also utilized GeoGebra software to assess students' understanding of translation based on the vector values provided. This second formative assessment builds on the activities from the first, following the objective sequence outlined in the daily lesson plan.



DAILY TEACHING PLAN 2

SUBTOPIC: 11.2 TRANSLATION

CONCEPT REINFORCEMENT 2

1. The teacher selects a student to answer a question on the whiteboard to determine the object's coordinates.
2. The selected student comes to the front of the class and explains their answer.
3. The teacher checks the student's answer.

FORMATIVE ASSESSMENT 2

1. The question will be provided through a GeoGebra file, as shown in **Figure 2.4** below.

Figure 2.4

2. **GeoGebra question link**: https://www.geogebra.org/calculator/kxqkpv8x
3. The teacher displays the question on the screen in front of the class.
4. Both files need to be shared with all students so they can access them on their respective computers.
5. This activity should be completed in pairs under the teacher's guidance in case of technical issues.
6. The teacher asks one pair of students to share their file link to present their answers in front of the class.

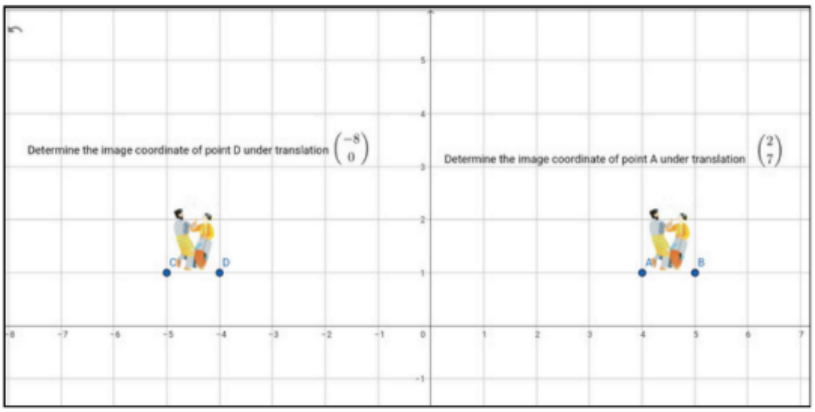


Figure 4. The fourth page of the first activity

Research Design

This study adopted a mixed-methods approach, combining quantitative and qualitative research methods. Quantitative methods involve systematically collecting and analyzing numerical data to evaluate, explain, or predict phenomena (Henson et al., 2020). A quasi-experimental design with pre-

and post-tests for non-equivalent groups was employed to assess the impact on student's academic achievement and appreciation of mathematical beauty. This design was selected since the sample groups were not randomly assigned (Allan & Skinner, 2020). The treatment group received instruction using a teaching module that integrates Kuda Kepang and Zapin dance, while the control group was taught using GeoGebra, without the dance elements. Additionally, qualitative data were collected through semi-structured interviews to explore students' appreciation of mathematical beauty in greater depth. To guide the study, the following hypothesis was formulated:

H_0**:** There is no significant difference in the mean academic achievement scores on the topic of isometric transformations between the group of students taught using the teaching module and the group taught using the conventional method.

Sample and Sampling Technique

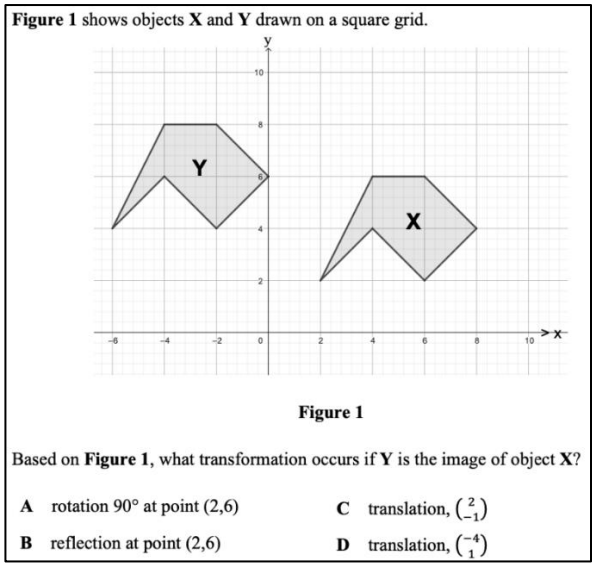
This study focused on Form Two students from secondary schools in the Johor Bahru district enrolled in the SCSS Mathematics curriculum. A purposive sampling method was employed to select participants, ensuring the sample accurately represented the population under study (Gopalan et al., 2020). Two intact classes were selected: 2 Etika, assigned as the treatment group, and 2 Tekun, assigned as the control group. Each group consisted of 30 students placed without prior streaming or academic stratification to ensure balance and fairness between the groups (Okougbo et al., 2021). For the quantitative analysis, all 60 students participated in pre-test and post-test assessments to evaluate changes in their academic achievement and appreciation of mathematical beauty. In addition, two students from each group were randomly selected for semi-structured interviews as part of the qualitative component, providing deeper insights into their experiences and perspectives. Accordingly, this combined sampling strategy enhanced the reliability and depth of the data collected.

Research Instruments

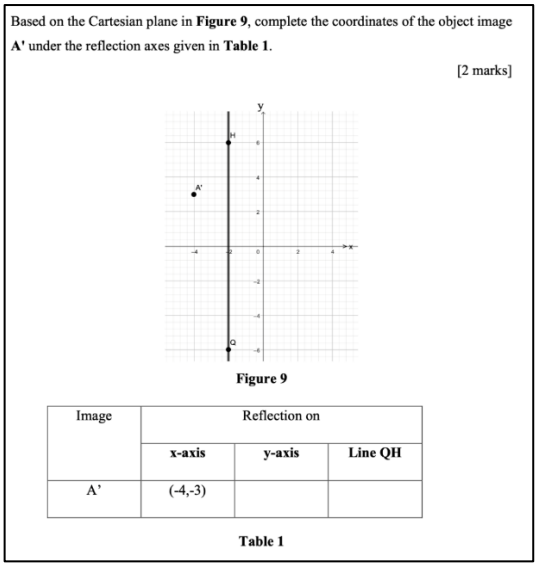
Two research instruments were used to collect data for the study: an academic performance test focusing on isometric transformations and a questionnaire designed to assess students' appreciation of the beauty of mathematics. These instruments were specifically developed to align with the study's objectives, addressing both academic achievement and affective outcomes.

Academic Performance Test

The academic performance test assessed students' understanding and application of isometric transformations, including concepts such as reflection, rotation, and translation. The test consisted of 20 items, equally divided between objective and subjective questions, and was developed in alignment with the SCSS Mathematics curriculum. These items (Figure 5) evaluated students' ability to analyze and apply transformation concepts in various mathematical contexts.



Example of an objective question



Example of a subjective question

Figure 5. Example of academic performance test

Questionnaire on Mathematical Beauty

The questionnaire was designed to gather information from Form Two students in secondary schools regarding their attitudes and feelings toward the beauty of mathematics. The questionnaire was divided into three parts: (i) Part A: Student demographics, (ii) Part B: Attitudes toward the appreciation of the beauty of mathematics, consisting of ten items, and (iii) Part C: Feelings of love toward the appreciation of the beauty of mathematics, also consisting of ten items. Notably, the items in Parts B and C were adapted from a study on the use of the Second Form Malay Poetry Teaching Module, which explored the beauty of flora, fauna, and the sky in relation to the meaning of the Qur'an (Mohd et al., 2018). In addition, modifications were made to the sentence structure and content to ensure relevance to the context of mathematical beauty. Responses were recorded on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Examples of the items include **(i)** Part B (Attitudes): "I find patterns and symmetry in mathematics interesting and inspiring." and **(ii)** Part C (Feelings of Love): "Learning mathematics through artistic activities increases my appreciation for its beauty."

Qualitative Component

For the qualitative analysis, a semi-structured interview protocol was employed. This protocol was developed based on the questionnaire results to gain a deeper understanding of the quantitative findings. The interview questions were organized thematically to explore students' experiences and perceptions of integrating artistic elements into the teaching module (see Table 1).

Table 1. Sample questions for semi-structured interview

Theme	Sample Questions
Attitudes	How do the dance activities help you understand isometric transformations?
Feelings of Love	What is your favorite part of combining dance with mathematics, and how does it affect your appreciation of its beauty?

Research Procedure

The study was conducted from March 1 to May 5, 2024. It began with a pre-test for both the treatment and control groups to assess students' initial knowledge of isometric transformations and their appreciation of mathematical beauty. The assessment instruments included an academic performance test and a questionnaire, complemented by a semi-structured interview protocol for qualitative insights. Following the pre-test, the treatment group was taught using a teaching module that integrated Kuda Kepang and Zapin dance with hands-on activities and GeoGebra software. In contrast, the control group received traditional instruction using the Mathematics textbook, which included conventional activities integrated with GeoGebra but without cultural elements. Both methods were implemented over five weeks (Alemu, 2020). Furthermore, to ensure effective implementation, the researchers developed a weekly plan (see Table 2) outlining activities for both groups that were aligned with the study objectives. Teachers independently conducted the lessons, while researchers actively observed each session to ensure consistency. At the end of the study, a post-test and a questionnaire were administered to evaluate changes in students' academic achievement and their appreciation of mathematical beauty. Moreover, semi-structured interviews were also conducted with selected students to complement the quantitative findings.

Table 2. Weekly schedule for the treatment and control groups

Week	Treatment Group	Control Group
1	Students engage in hands-on activities inspired by Kuda Kepang dance movements to explore the concept of translation. Teachers guide students in connecting these movements to mathematical translations. Using GeoGebra, students construct polygons and apply translation vectors to visualize and verify their understanding.	Students complete traditional textbook-based exercises to learn about translation. Teachers guide them in discussing and solving problems on graph paper. GeoGebra is used solely as a tool to illustrate examples without further exploration or practical application.
2	Students perform Zapin dance movements to identify reflective symmetry. Teachers explain how these dance steps relate to mathematical reflections. Students then use	Students use static diagrams in their textbooks to understand reflections. Teachers led discussions on the properties of reflections, and GeoGebra is limited to solving textbook

Week	Treatment Group	Control Group
	GeoGebra to confirm and visualize their findings from the dance-based exploration.	exercises without meaningful engagement or hands-on activities.
3	Students investigate the concept of rotation through specific Kuda Kepang dance patterns. Teachers guide students in relating the rotational movements to mathematical transformations. GeoGebra helps students validate their understanding by simulating these movements.	Students follow traditional textbook lessons to learn about rotations. Teachers use tracing paper for demonstrations, and GeoGebra is used to simulate rotations. However, there is no integration of cultural or practical activities.
4	Students integrate their knowledge of translation, reflection, and rotation through artistic activities that combine Kuda Kepang and Zapin's movements. In addition, students build Kuda Kepang models using cardboard to demonstrate transformation concepts. GeoGebra is used to confirm and explore these transformations creatively.	Students review the concepts of translation, reflection, and rotation through textbook exercises. GeoGebra is used to solve problems mechanically, focusing primarily on diagrams. Practical or integrative approaches are not included, leading to minimal engagement.
5	Students revisit transformations (translation, reflection, rotation) to explore isometry concepts such as congruency and distance preservation. Through the Kuda Kepang dance, students demonstrate these properties in groups. GeoGebra is used to verify and visualize the isometric transformations.	Students learn about isometries through traditional lectures and textbook-guided activities. They perform basic ruler-and-compass exercises to illustrate isometry concepts, but there are no cultural or hands-on elements to facilitate deeper learning.

Data Analysis

This study employed both quantitative and qualitative methods to assess the effectiveness of integrating cultural and hands-on teaching approaches in enhancing students' understanding of mathematical transformations.

Achievement Test Analysis

To evaluate the effectiveness of the teaching intervention, an independent t-test was conducted to compare the pre-test and post-test scores between the treatment and control groups. The Shapiro-Wilk test was employed to assess the normality of data distribution, which is particularly suitable for small sample sizes (Pallant, 2020). The results indicated no significant deviations from normality ($p > 0.05$). At the same time, Levene's test was used to confirm the homogeneity of variances across groups ($p > 0.05$), validating the use of the independent t-test (Gastwirth et al., 2009). The results demonstrated a statistically significant improvement in post-test scores for the treatment group compared to the

control group ($p < 0.05$). The treatment group's enhanced performance suggests that integrating cultural elements, such as Kuda Kepang and Zapin dances, into teaching mathematical transformations effectively improved student learning outcomes. Additionally, effect sizes, calculated using Cohen's *d*, indicated a substantial impact of the intervention.

Questionnaire Analysis

Data collected through questionnaires were analyzed using descriptive statistics to summarize students' perceptions of the teaching intervention. Responses were recorded on a 5-point Likert scale. The findings revealed that the treatment group reported higher satisfaction levels, particularly in terms of engagement, motivation, and understanding of mathematical concepts. These results highlight the positive influence of integrating cultural and practical activities on students' learning experiences, compared to the traditional methods used in the control group.

Interview Analysis

Qualitative data from semi-structured interviews were analyzed using content analysis to identify recurring themes and insights. Firstly, interview transcripts were systematically organized, with line numbers assigned to facilitate the identification of key information. Secondly, patterns and recurring ideas from participant responses were grouped into themes to provide a comprehensive understanding of the data. Finally, a deductive coding approach was used, guided by predefined categories aligned with the study objectives (Bonner et al., 2021). This process involved coding the data into meaningful categories and labeling themes based on their relevance to the research questions. The thematic analysis revealed that students in the treatment group viewed integrating cultural activities as highly engaging and beneficial for understanding mathematical transformations. Teachers also reported increased student participation and motivation during lessons, further supporting the effectiveness of the intervention.

RESULTS AND DISCUSSION

The Difference in Mean Academic Achievement Scores on Isometric Transformations

The normality test using the Shapiro-Wilk test confirmed that the data for academic achievement were normally distributed ($p > 0.05$). Levene's test also confirmed the homogeneity of variances ($p > 0.05$), satisfying all assumptions for conducting an independent t-test. Based on the analysis, Table 3 illustrates a significant difference in mean scores between the treatment group, which utilized the integrated teaching module (mean = 85.77, SD = 3.421). Meanwhile, the control group followed the conventional method (mean = 59.47, SD = 5.981); $t(30) = 20.906$, $p < 0.001$). These results indicate that the integrated module was significantly more effective in improving students' academic

achievement in isometric transformations.

Table 3. Mean academic achievement score of students on the topic of isometric transformations between groups

	Group	N	Mean	Standard deviation	t-value	Sig.
Achievement	Control	30	59.47	5.981	20.906	<0.001
	Treatment	30	85.77	3.421		

Results in Table 3 indicate that the significant value is (P = < 0.001; < 0.05). Therefore, the null hypothesis was rejected. The study's findings reveal a significant difference in the mean academic achievement scores on the topic of isometric transformations between the students who used the teaching module and the group that followed the conventional method. This suggests that the use of the teaching module can effectively support teachers in reinforcing students' understanding of mathematical concepts (Othman et al., 2021) Notably, the module's design helps teachers explain mathematical concepts more clearly, resulting in an enhanced comprehension level among students. Furthermore, the module provides a systematic teaching structure that aids students in better understanding the processes and applications of the topic (Bidiyah et al., 2024). This is consistent with previous studies, which suggest that well-structured teaching modules help teachers deliver content more effectively, reducing confusion and improving students' grasp of mathematical concepts.

Additionally, research by Ambayon (2020) indicated that well-designed modules can enrich students' learning experiences. The interactive activities within the module engage students actively in the learning process, while exploratory tasks allow them to delve deeper into mathematical concepts through self-discovery. This aligns with Bibi and Aziz (2024), who found that the development of instructional modules significantly enhanced students' academic achievement. The structured module content, combined with creative elements such as visual and artistic components, contributed to improving students' understanding and engagement, particularly in connecting concepts across disciplines like mathematics and art. Begović (2023) supported this finding, demonstrating that students can connect mathematical knowledge, particularly in geometry, with artistic elements such as geometric abstraction. Her study found that this cross-curricular connection enhances students' ability to recognize, analyze, and understand abstract compositions, leading to improved comprehension in both mathematics and art.

The use of concrete materials in teaching mathematics has also been noted to positively impact student's academic achievement. Fauzi et al. (2021) highlighted that concrete materials, such as the Polygon Kit used in Form One basic polygon topics, can enhance students' understanding by making lessons more effective. Quigley (2021) highlighted that the use of concrete materials is crucial for

assisting students in understanding abstract mathematical concepts, ensuring information is presented in a clear and structured manner to facilitate students' comprehension. Furthermore, she emphasized that incorporating concrete materials has a significant positive impact on students' academic achievement, as the absence of such materials may result in less effective teaching and learning processes.

Furthermore, the use of technology in teaching mathematics has been demonstrated to positively impact students' academic performance. Khansila et al. (2022) reported that the use of technology, such as the GeoGebra software, enhances students' achievement and mastery of geometry. However, this finding is not fully supported by Abdullah et al. (2020), who noted that some Form One students still face challenges in identifying various types and properties of quadrilaterals. Students tend to make errors in recognizing shapes and detecting orientation changes. Simultaneously, Halim et al. (2021) suggested that GeoGebra, with its animation features, can help visualize different shapes and orientations. This, thereby, makes mathematical concepts more realistic and improves students' understanding of geometry.

Inference Analysis of the Level of Appreciation of the Beauty of Mathematics

The data analysis of the main questionnaire is the Mann-Whitney U test using Statistical Package for Social Sciences (SPSS), and the significance level used is 0.05 (5%). P-value (Asymp. Sig.) is used to determine the significant difference between the variables of this study.

Table 4. Results of the inference statistic

Appreciation Toward the Beauty of Mathematics	
Mann-Whitney U	0.000
Wilcoxon W	465.000
Z	-6.666
Asymp. Sig. (2-tailed)	<0.001

Based on Table 4 above, the p-value for students' appreciation of the beauty of mathematics, as presented through SPSS analysis, is less than 0.001. Since this p-value is less than the significance level of 0.05, the null hypothesis is rejected. Therefore, we can conclude that there is a significant difference in students' appreciation of the beauty of mathematics.

The teaching module integrates elements of Kuda Kepang and Zapin to provide an engaging multisensory learning experience. This approach helps make the abstract concept of isometric transformation clearer and easier to understand through the visualization of dance movements. Studies asserted that dance can be a fun and effective teaching aid in mathematics (Viñas et al., 2022). The

application of this art needs to be adapted to learning time to ensure meaningful learning. As a result, students can understand and appreciate the beauty of mathematics more deeply. However, Matthews' study (2020) posited that not all students can appreciate the beauty of mathematics through dance elements, especially those used to traditional and analytical approaches. For these students, dance may be viewed as something complex and interfere with the learning process of mathematics. Moreover, this study emphasized that appreciation of the beauty of mathematics is more related to the logical and structural nature of mathematics than external elements such as dance.

Teaching modules that use existing materials can increase students' appreciation of the beauty of mathematics through experience-based learning. This approach combines conventional content with hands-on activities, making teaching isometric transformations more dynamic and memorable. Physical movement in activities with tangible materials helps students understand concepts better and makes learning more enjoyable. Osman's study (2023) supported the idea that tangible teaching aids can stimulate students' interest and help them remember concepts. Kaminski and Sloutsky (2020) also stated that existing materials attract students to apply learning in the real world and increase the seriousness of learning. However, Beswick (2021) argued that existing materials alone are insufficient to connect mathematical concepts with real-world applications effectively since appreciation of the beauty of mathematics requires deeper cognitive and emotional involvement. This study emphasized the need for creative problem-solving and discovery in the real world rather than relying solely on existing materials. In addition, Beswick's study only focused on the material without considering other elements, such as dance.

The use of technology such as GeoGebra in teaching modules can increase students' appreciation of the beauty of mathematics through interactive and visual learning. GeoGebra's dynamic capabilities allow students to manipulate abstract mathematical concepts, making transformations easier to understand. This active engagement bridges the gap between abstract concepts and concrete applications, enriching the learning experience. The study by Zhang et al. (2023) supported the idea that GeoGebra is very effective in small classes, helping students better master mathematical concepts through dynamic visualization. Conversely, the study of Zulnaidi et al. (2020) revealed that the use of this technology also has constraints, such as time management problems, since not all students are proficient in technology. There are also challenges in controlling the use of computers by students to ensure that they remain focused on their studies. Therefore, teachers need to plan and guide carefully to ensure technology is used effectively without affecting educational efficiency.

A teaching module that integrates elements of Kuda Kepang and Zapin dances, together with existing materials and technology such as GeoGebra, offers a transformative approach to mathematics education that increases students' appreciation of the beauty of mathematics. Accordingly, this approach is attractive to various learning styles and deepens the understanding and application of mathematical concepts.

Students View on Beauty Appreciation Mathematics

Attitude

The findings of the interviews suggest that the implementation of the module-integrated study of Kuda Kepang and Zapin has an impact in terms of attitude; among them are perseverance and interest.

"...help me understand transformation movements because there are movements related to isometric transformations..."

"...give me a better understanding of learning this isometric transformation title..."

"...can attract students' interest in learning to apply movements such as kuda kepang and zapin..."

"...this dance can attract me to learn. For example, I usually study with the teacher alone in front and I just sit and listen to what the teacher is saying. So training, I do. With the existence of this activity dance, we have a kind of movement zapin and braid horse. We're not bored..."

Feelings of Love

The findings of the interview indicate that the implementation of the module-integrated study of Kuda Kepang and Zapin has an impact in terms of attitude; among them are love and pleasure.

"...the dance I liked the most when I learned the concept of transformation isometry is the zapin. Zapin is the best because he uses the concept of rotation. For example, earlier, I make a Zapin by rotating in a movement with the direction of self-rotation and clockwise. Another reason I choose Zapin is that Zapin is the best; if you make it, a lot of people like that day we made a lot of people; it's the best..."

"...the dance I like the most is the Kuda Kepang because of this Kuda Kepang; one reason is that we fought in a group, then we had to make a horse decoration braid and do the same. I like it because his movement is like an example my friend is like that..."

"...my feelings during this dance movement activity are performed in this isometric transformation is fun, happy but at the same time nervous because other classes saw us dancing..."

"...I'm excited because many of my friends also do the dance, learn together, and there are also stretches…"

"... I remember my teacher was fierce, but apparently, my teacher also taught dance in mathematics. In chapter 11, I like him because he teaches a dance that refreshes our brains. Just like before, there were a lot of Zapin dances and braided horses, and they were the best and cohesive. So, that teacher is actually the one who pushed me to develop a love for mathematics..."

"...this dance can attract my interest to learn more about what is in this math subject..."

"...This also allows me to explore the application of mathematics more. I can also apply what my dance does. For example, when I do homework, I remember that dance has a back turn and a forward turn, and I can learn a lot with these kinds of activities..."

The study discovered that students who use teaching modules with elements of Kuda Kepang and Zapin exhibit positive attitudes and feelings toward the beauty of mathematics. In particular, the experience of dancing in class increased their interest and love for mathematics, reflecting their appreciation of its beauty. Teaching modules integrating artistic elements such as dance make teaching more interactive and fun, increasing students' interest in mathematics. Through kinesthetic learning,

students can understand mathematical concepts more deeply and retain knowledge better. The study of Twinner et al. (2022) supported the idea that students respond positively to dance activities, effectively relating dance to mathematical concepts. However, the study of Tan et al. (2022) indicated that not all students enjoy the integration of dance, as it becomes a pedagogical and artistic challenge that requires the teacher's expertise in the field of dance for effective implementation.

Additionally, teaching modules that involve existing materials help increase students' appreciation of the beauty of mathematics by providing real experience of abstract concepts. This allows students to better visualize and manipulate mathematical ideas, strengthening their memory and understanding. In addition, the use of existing materials also promotes active learning and fosters curiosity and a deeper emotional connection to mathematics. Alkayem et al. (2023) reinforced the idea that tangibles provide stronger memories through tactile experiences. In contrast, the study by Xiao et al. (2021) mentioned that existing materials are not always effective since some students consider them as toys due to the lack of clear procedures from the teacher in their use.

Teaching modules integrated with technology, such as GeoGebra, help improve student understanding, not just memorizing concepts. Teachers use data and simulations to demonstrate practical applications of mathematics, making learning more fun and interactive. When students enjoy learning, their understanding of mathematical concepts becomes stronger. The study of Hidayat et al. (2024) underlined that visualization in GeoGebra improves student understanding and interaction in a cooperative learning environment. Meanwhile, the study of Jiew and Chin (2022) suggested that technology can have an adverse effect if students lack exposure, causing them to be stressed and find it difficult to understand mathematics. This occurs due to the teachers' lack of initial preparation for the use of technology. Overall, the integration of dance in mathematics education can increase students' appreciation of the beauty of mathematics by making learning more interactive and enjoyable. Nonetheless, factors such as cultural relevance, teacher readiness, assessment difficulty, and different student interests need to be considered to ensure more effective learning.

CONCLUSION

In summary, this study effectively demonstrates the impact of integrating ethnomathematics activities based on the Zapin and Kuda Kepang dances into teaching isometric transformations. By incorporating these cultural elements, the approach enhanced students' understanding and engagement with mathematical concepts. It also improved their learning experiences by connecting abstract ideas to culturally meaningful contexts. This method illustrates how mathematics can be made more relatable and accessible through culturally relevant teaching strategies. Thus, the integration of these traditional dances into a teaching module provides a practical framework for culturally responsive pedagogy, aligning with the goals of modern education to foster inclusivity and diversity in learning. Therefore,

by bridging cultural heritage and mathematical education, this approach not only preserves traditional practices but also supports the development of students' spatial reasoning and critical thinking skills.

Additionally, the use of technology within the module amplifies its impact, offering students interactive and visually engaging ways to explore mathematical concepts. This combination of cultural and technological elements aligns with contemporary curricular goals, ensuring that learning is both innovative and effective. While the study highlights significant benefits, it is essential to note that the sample size was limited to Form Two students in Johor Bahru, and the findings may not be generalizable to other regions or age groups. Thus, future research could explore the broader application of ethnomathematics activities across different mathematical topics and educational levels and investigate the long-term effects on students' academic achievement and cultural appreciation.

In conclusion, developing ethnomathematics activities based on Zapin and Kuda Kepang dances represents a transformative approach to mathematics education. Accordingly, this study lays the groundwork for future research into integrating cultural elements in teaching, promising to create dynamic, inclusive, and culturally resonant educational practices that connect mathematics to students' identities and lived experiences.

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Author Contribution : AHA: Conceptualization, Writing – Original Draft, Editing, and Visualization.
MIZ: Writing – Review & Editing, Formal Analysis, and Methodology.
MM: Validation and Supervition.
NKK: Resources and Software.
NIAMR: Resources and Software.
NHH: Investigating and Data Curation.
NRAS: Investigating and Data Curation;
IS: Funding Acquisition.
A: Visualization.
A: Project Administration.
RS: Project Administration.

Y: Validation.

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Additional Information : -

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