Culturally Driven Game-Based Strategies: A Tool for Developing Students' 4C's in Mathematics Education

Rhelene Kaye D. Bercades[1*], Allan Jay S. Cajandig[2]

[1]New Pangasinan National High School, Sultan Kudarat, Philippines

[2] Sultan Kudarat State University, Tacurong City, Philippines

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ABSTRACT

This study investigated the effectiveness of culturally driven game-based instruction in enhancing the 21st-century skills—creativity, critical thinking, collaboration, and communication (4C's)—of Grade 10 students in mathematics. In response to persistent challenges such as math anxiety, disengagement, and low performance in standardized assessments, culturally relevant pedagogical approaches are becoming increasingly vital in Filipino classrooms. This research aimed to bridge traditional culture and modern instruction by integrating indigenous Filipino games into mathematics lessons to promote deeper engagement and skill development. The study employed a quasi-experimental design involving 64 students from New Pangasinan National High School during the 2024–2025 academic year. Participants were randomly divided into control and experimental groups. The experimental group received a culturally driven game-based instructional intervention using validated modules infused with traditional games such as *Tumbang Preso* and *Luksong Tinik*, while the control group was taught using conventional teaching strategies. Pretest and posttest instruments measuring the 4C's skills were administered to both groups. Statistical analyses including mean, standard deviation, and paired t-tests revealed that students in the experimental group exhibited significantly higher gains across all four domains compared to those in the control group. The integration of traditional games created an interactive and culturally familiar learning environment that boosted student motivation, improved problem-solving abilities, and encouraged collaborative learning. These findings underscore the potential of game-based instruction rooted in local culture to not only enrich mathematics learning but also foster essential 21st-century competencies. The study recommends the broader implementation of culturally contextualized strategies in other subject areas to enhance both academic performance and cultural identity.

Keywords: collaboration, communication, creativity, critical thinking, game-based instruction

INTRODUCTION

Teachers are faced with the challenge of equipping students with essential 21st-century skills such as creativity, critical thinking, collaboration, and communication—collectively known as the 4C's. These competencies are vital not only for academic success but also for students' ability to thrive in complex, real-world environments. However, many learners experience anxiety and disengagement, particularly in mathematics, which hinders the development of these skills and affects overall learning outcomes.

Cultivating these skills is crucial for students to succeed in both their academic and professional lives (Stephens, 2024). However, barriers such as mathematics anxiety can hinder students from fully developing these skills. Camariata (2015) found that math anxiety negatively impacts self-efficacy and problem-solving performance, stifling students' ability to think critically and creatively. This anxiety not only affects individual problem-solving but also diminishes students' willingness to engage in collaborative and communicative aspects of learning mathematics, further inhibiting the development of these essential 4C's. Thus, addressing math anxiety is crucial to creating an environment where students can thrive in acquiring 21st-century skills (Acevedo et al., 2020).

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In the 2022 PISA, the Philippines ranked among the lowest in mathematics, scoring 355 compared to the global average of 472. Although there was a slight improvement from 2018, around 84% of Filipino students still struggled with basic math skills. This performance reflects widespread issues like math anxiety, as highlighted by Dela Cruz and Lapinid (2014), which hinders problem-solving and overall engagement. These findings emphasize the need for targeted, skill-enhancing interventions to improve students' creativity, critical thinking, collaboration, and communication in mathematics.

Emenet and Kezer (2021) concluded that student-centered teaching methods are more effective in improving math achievement and reducing anxiety toward mathematics compared to traditional methods. By placing students at the center of learning, these approaches foster greater engagement, understanding, and confidence. Game-based instruction, as a form of student-centered teaching, actively involves students in the learning process by promoting interaction, collaboration, and hands-on problem-solving. This method not only helps reduce math anxiety but also supports the development of 21st-century skills such as creativity, critical thinking, collaboration, and communication, making it an effective strategy for enhancing both academic performance and engagement in mathematics (Qian & Clark, 2016).

Forrest (2006) emphasized that gameplay enhances skill development, especially when learners actively engage and collaborate with teachers. Arciosa (2021) and Mathrani et al. (2016) support Game-Based Learning (GBL) as an effective method to promote creativity and critical thinking in math education. Likewise, traditional Filipino games have long supported physical, mental, and social growth, fostering collaboration and academic success beyond recreation (Dizer, 2022).

New Pangasinan National High School, located in a rural area and deeply rooted in local culture and traditions, faces the challenge of helping students fully engage with mathematics. While the school achieved a Mean Percentage Score (MPS) of 82 in S.Y. 2023-2024, interpreted as 'Satisfactory,' this indicates that students have met the minimum required competencies but still show noticeable gaps in understanding. To bridge these gaps and enhance the development of key 21st-century skills, including creativity, critical thinking, collaboration, and communication, this study incorporates traditional Filipino games like 'Tumbang Preso' and 'Luksong Tinik' into math lessons. By linking cultural familiarity with academic skill development, the approach fosters both improving comprehension and a stronger connection to cultural identity, creating a more holistic learning experience.

Given students' struggles in engaging with mathematics, this study explores how culturally driven game-based instruction impacts their creativity, critical thinking, collaboration, and communication (4C's) skills. It also compares this approach with traditional teaching to determine which more effectively supports academic growth and skill development.

METHODOLOGY

Research Design

This study employed a quasi-experimental research design. The design aimed to manipulate one variable while controlling other factors, enabling the researchers to understand causal processes. Key elements of this design involved the deliberate control and manipulation of conditions by the investigator, introduced an intervention, and measured the resulting difference.

This study examined the impact of culturally driven game-based instruction on students' creativity, critical thinking, collaboration, and communication skills in Mathematics. Meanwhile, the control group engaged in traditional teaching methods and strategies outlined in the K-12 curriculum. Conversely, the experimental group underwent an investigation program using culturally driven game-based instruction.

Assessment tools were adapted from Bayron (2020) and Thornhill-Miller et al. (2023), while instructional materials were compiled from DepEd's Self-Learning Modules and validated by experts. Activities were refined to meet identified learning needs, and both groups completed a final assessment to measure outcomes.

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This study acknowledges several limitations, including the small sample size, the confinement to a single educational setting, and the absence of a long-term follow-up to assess retention. These factors may affect the generalizability and sustainability of the intervention outcomes.

Research Locale

This study was conducted at New Pangasinan National High School (NPNHS) in New Pangasinan, Isulan, Sultan Kudarat, a public secondary school that catered to junior and senior high school students, with a total population of 459 students and 27 teaching staff, along with three non-teaching staff. NPNHS had been recognized as a Regional SBM Level 3 practitioner, reflecting its commitment to community service and its ability to attract more students, thus showcasing its operations.

The selection of NPNHS as the research site was based on several factors. First, its direct relevance to the research topic allowed for a more focused assessment of the impact of culturally driven game-based instruction on students' creativity, critical thinking, collaboration, and communication skills in Mathematics education. Second, the willingness of NPNHS to participate and collaborate helped facilitate a smooth research process. Moreover, the diverse demographic composition of its student population provided an opportunity to investigate how the instruction influenced students with varying backgrounds and abilities. Lastly, practical considerations such as proximity and accessibility made NPNHS a suitable choice, ensuring efficient data collection and participant interaction.

Notably, the control and experimental groups' classrooms at NPNHS were intentionally situated far apart to prevent any potential interference between them, ensuring that the intervention did not affect the control group, as shown in Figure 2. The decision to focus on a rural school like NPNHS was informed by the specific challenges faced by rural educational institutions, including limited resources, teacher recruitment and retention issues, poor internet connectivity, and economic disadvantages (Volmer, 2023; Challenges Facing Rural Education | Tutor Doctor, 2017).

Rural students often had lower expectations of pursuing higher education than their urban counterparts, highlighting the importance of addressing aspirations and opportunities in rural education (Organization for Economic Co-operation and Development [OECD], 2019). By selecting NPNHS as the study site, the research aimed to understand and address these challenges within a rural context, enhancing educational outcomes for students in similar settings.

Research Participants

Critical thinking and boosting creativity skills began in early adolescence. An early adolescent was a young person between 10 and 15 years old who underwent rapid physical, cognitive, and emotional changes, explored identity, independence, and social relationships. The Grade 10 students were chosen as respondents due to this traditional period between middle and high school, where many skills like creativity, critical thinking, collaboration, and communication typically advanced. This stage was optimal for pinpointing areas of improvement in secondary education and assessing the effectiveness of teaching methods and curriculum in fostering 21st-century skills (Lai, 2011).

For this study, Grade 10 students from New Pangasinan National High School for the academic year 2024-2025 were selected as respondents, totaling 64 students, all of whom participated. The school employed a heterogeneous sectioning approach, randomly assigned 32 students to the control group and 32 to the experimental group, per Department Order 21, series of 2006 guidelines. Selection for both groups was based on random sampling using pretest results.

Research Instrument

The study used four research instruments: a culturally driven game-based module focused on circles, incorporating Filipino games to enhance learning; a validation tool adapted from Herrera (2011) using a five-point Likert scale (Likert, 1932; cited by Bayron, 2020) to assess the module’s acceptability; a problem-solving pretest-posttest on circles, with follow-up questions targeting the improvement of creativity, critical thinking,

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collaboration, and communication (4C's) skills; and an evaluation tool adapted from Thornhill-Miller et al. (2023) with an interpretation table from Brown and Soren (2010) to assess pretest and posttest responses.

A culturally driven game-based instruction module was created to strengthen students' math skills through interactive activities. Games like *Tumbang Preso Geometry*, *Luksong Garter*, *Equality Piko Race*, and *Luksong Baka* taught circle theorems, while *Patintero Coordinates*, *Doctor Quack Quack*, *Habulan ng Quadrants*, and *Ubusan Lahi* reinforced concepts like the distance formula and circle equations. These culturally relevant activities promoted creativity, critical thinking, collaboration, and communication in mathematics.

Five (5) panel experts answered a validating instrument to evaluate the module's acceptability. They evaluated the module's content, relevance, instructional quality, and presentation. A survey instrument was adapted from Herrera (2011), and a five-point Likert Scale type measurement of Likert (1932), as cited by Bayron (2020), was employed in this study.

The responses from each expert were gathered, tallied, and tabulated. The intra-class correlation coefficient was computed to assess the level of agreement among the experts regarding the content, relevance, instructional quality, and presentation acceptability. The experts rated each item's structure and appropriateness on a scale of 1 to 5, evaluated clarity, and offered suggestions for improvement.

The problem-solving questions were meticulously crafted based on the self-learning modules developed by the Department of Education (DepEd), ensuring alignment with the Philippine educational standards and curriculum. These questions were thoughtfully modified to specifically target and assess the four key competencies: creativity, critical thinking, collaboration, and communication. Such competencies, often referred to as the "4Cs," are increasingly recognized as essential for students to thrive in the 21st century (Adeoye, 2023).

Furthermore, the responses of the students in their pretest and posttest problem-solving questions were evaluated using the adapted tool from Thornhill-Miller et al. (2023), specifically assessing creativity, critical thinking, collaboration, and communication skills, as well as the promotion of 21st-century skills for the future of work and education. The experts evaluated each student's response, along with their follow-up answers, using a 5-point scale, where 1 represented novice-level performance and 5 represented proficiencies.

Data Gathering Procedure

This study meticulously adhered to a standardized operating procedure for conducting research. Upon obtaining approval from the Dean of the Graduate School, the researcher undertook the following steps:

Instructional materials, specifically the culturally driven game-based module, were developed. Once completed, the research instruments, including the pretest and posttest, were validated through expert review and then pilot-tested to ensure their reliability and effectiveness before implementation in the actual study.

A formal request had been submitted to the Schools Division Superintendent of the Division of Sultan Kudarat, specifically seeking approval to conduct the study at New Pangasinan National High School and utilize the researcher's official time for data gathering. A similar request had been submitted to the School Principal of New Pangasinan National High School, seeking approval to conduct the study and allocate a teacher's official time for administering the pretest and posttest.

A culturally driven game-based instructional module was developed to enhance students' mathematics proficiency. A panel of experts validated the module and accompanying questionnaire to ensure their acceptability. The panel included a Research Coordinator and Division Quality Assurance officer, a Mathematics Department Head from New Pangasinan National High School, two Master Teachers from Isulan and New Pangasinan National High Schools, and a Mathematics Department Head from Datu Matilindog National High School. Their combined expertise in research, mathematics education, teaching, and culturally relevant instruction strengthened the study's validity and relevance.

The control group followed the standard K-12 curriculum as prescribed by the Department of Education, maintaining traditional teaching practices. In contrast, the experimental group engaged with a self-learning

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module integrated with culturally driven game-based instruction, creating an interactive and relevant learning environment. Activities were continually refined to address students' needs and enhance effectiveness (Adeoye, 2023), aiming to boost engagement while promoting the 4Cs: creativity, critical thinking, collaboration, and communication. A post-test was administered to assess final proficiency levels, and raw scores from the pretest and post-test were tabulated for interpretation, supplemented by literature reviews. Means, standard deviations, and mean differences for each group were calculated. The significance of mean scores between the experimental and control groups was tested using a t-test.

The study took place during Grade 10 students' regular math class schedule in the third quarter (January to February) of the school year 2024-2025. After the data collection, comprehensive analysis and interpretation were conducted, visually represented in a waterfall diagram for clarity.

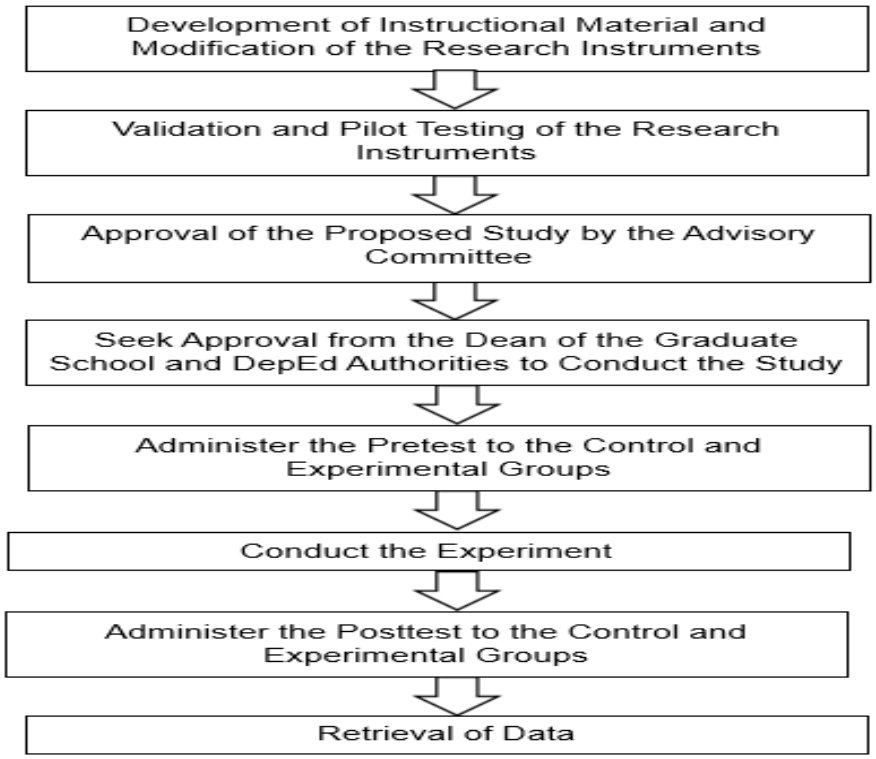

Figure 1: Diagram of the Data Gathering Procedure

Statistical Treatment of the Data

Data collection underwent organization, tabulation, analysis, and interpretation. To address the research questions, the following statistical tool was employed. The mean was utilized to determine the effectiveness of the culturally driven game-based module in content, relevance, instructional quality, acceptability, and cultural formation. Mean ranges were used to evaluate the initial and final proficiency levels of students' creativity, critical thinking, collaboration, and communication skills in mathematics. The t-test for independent samples calculated the significant differences in proficiency levels between the control and experimental groups regarding the 4C's (creativity, critical thinking, collaboration, and communication skills) during the pretest and post-test evaluation.

The t-test for independent samples was employed to determine whether there were statistically significant differences in the proficiency levels of the 4C's—creativity, critical thinking, collaboration, and communication—between the control and experimental groups during the pretest and post-test evaluations. This statistical test is appropriate for comparing the means of two independent groups to assess the impact of the intervention. In this study, it provided a basis for determining whether the observed differences in student performance could be attributed to the implementation of the culturally driven game-based module rather than to random variation or chance.

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Ethical Considerations

The researcher was expected to adhere to the following ethical considerations to secure the safety and privacy of all individuals and files involved in this study.

Before beginning the study, the researchers secured permission from both the school and the participants. A letter of intent was sent to the school to request the approval of the principal and to inform them about the involvement of students in the data collection process. Participation was entirely voluntary—no one was pressured or forced to take part. The researchers made it a priority to protect the privacy of all participants by keeping personal information confidential and using it strictly for academic purposes. Throughout the process, they followed ethical guidelines for research involving people, including informed consent, confidentiality, and respect for everyone's rights, as outlined by the American Psychological Association (2020), Babbie (2020), and Creswell & Creswell (2018).

To ensure that the researchers follow the moral principles of the laws and code of ethics, below are the ethical considerations that are to be considered in this study:

Permission and Secrecy. The participants were clearly informed about the purpose, methods, and goals of the study to help them make informed choices about their involvement (World Medical Association, 2013). The researchers also took careful steps to maintain the confidentiality of all personal information, ensuring that it was only accessible to authorized individuals directly involved in the research.

Permission to withdraw. Participation in the study was completely voluntary. The researchers made it clear that participants could withdraw at any point without any consequences or obligations (Babbie, 2021). If a participant chose to stop their involvement, their participation ended immediately, and no additional data were collected from them.

Reduction of Harm. The researchers took proactive steps to minimize any potential psychological, emotional, or physical risks to the participants. Care was taken to ensure that the entire process was safe, respectful, and non-threatening, creating a supportive environment throughout the study (Sieber & Tolich, 2013).

Informed Consent. An Informed Consent Form (ICF) was provided to all participants to ensure that their agreement to join the study was both voluntary and well-informed. The ICF clearly explained the study's purpose, procedures, potential risks and benefits, and the rights of the participants (National Human Genome Research Institute, 2022).

RESULTS AND DISCUSSION

Level of Acceptability of Culturally Driven Game-Based Instruction

Table 1. Level of Acceptability of the Culturally Driven Game-Based Instruction in terms of Content

Content	Mean	SD	Verbal Description
1. The module aligns with Education Curriculum goals.	4.40	0.55	Highly Acceptable
2. The objectives of the module are defined and stated.	4.40	0.55	Highly Acceptable
3. The sequence of activities is appropriate to the audience.	4.20	0.45	Highly Acceptable
4. The directions are specific and understandable.	4.20	0.45	Highly Acceptable
5. The module follows good instructional usage.	4.60	0.55	Highly Acceptable
6. The module contains the right assessment tool for learners.	4.40	0.55	Highly Acceptable

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7. The exercises and tasks are sufficient for every class session.	4.60	0.55	Highly Acceptable
8. The lessons are realistic and logical order.	4.40	0.55	Highly Acceptable
9. The module allows individualized and experimental learning.	4.40	0.55	Highly Acceptable
10. The content provides a drive for further enhancement.	4.80	0.55	Highly Acceptable
Mean	**4.40**	**0.52**	**Highly Acceptable**

As shown from the result, the evaluators assessment confirms that the content of Culturally Driven Game-Based Instruction is well-structured and highly acceptable, as reflected in the overall mean of 4.40 (*SD=0.52*). It implies that the content of the Culturally Driven Game-Based Instruction meets the expected standards, demonstrating clarity, relevance, and effectiveness in delivering culturally integrated learning experiences. The evaluators' consistent assessment suggests that the instructional material aligns well with educational objectives, making it a suitable tool for learning.

This result supports recent findings on the value of indigenous game-based learning. Almonte and Andal (2023) found that incorporating culturally relevant games enhanced interactive learning among Grade 10 students, especially during group discussions and think-pair-share activities. Their study reinforces the idea that integrating indigenous games into instruction boosts engagement and aligns with educational goals echoing your findings that culturally integrated content is both effective and appropriate for learning.

Table 2. Level of Acceptability of the Culturally Driven Game-Based Instruction in terms of Instructional Quality

Instructional Quality	**Mean**	**SD**	**Verbal Description**
1. The module contains easily understandable directions for users.	4.40	0.55	Highly Acceptable
2. The module includes non-threatening positive feedback.	4.80	0.45	Highly Acceptable
3. The module is interactive and easy to navigate.	4.20	0.45	Highly Acceptable
4. The module contains a variety of exercises for active learning.	4.80	0.45	Highly Acceptable
5. The material techniques are appropriate.	4.40	0.55	Highly Acceptable
6. The module stimulates promising teachers and students' interest and curiosity.	4.40	0.55	Highly Acceptable
7. The module shows strong relevance to the user's experiences.	4.40	0.55	Highly Acceptable
8. The module shows evidence of effectiveness.	4.40	0.55	Highly Acceptable
9. The module facilitates easy integration into the course.	4.60	0.55	Highly Acceptable
10. The module's concepts are in simplified form.	4.40	0.55	Highly Acceptable
Mean	**4.48**	**0.52**	**Highly Acceptable**

The evaluators' assessment confirms the high instructional quality of the Culturally Driven Game-Based Instruction (CDGBI), with a consistent "highly acceptable" rating and an overall mean of 4.48 (SD = 0.50). These results suggest that the module is well-structured, clear, and effectively integrates cultural elements to enhance student engagement. Its interactive design aligns with recognized best teaching practices, positioning it

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as an effective and culturally responsive instructional tool. Supporting this, Sitzmann's (2011) meta-analysis found that learners using game-based methods achieved significantly better outcomes—11% higher factual knowledge, 14% higher skill-based knowledge, and 9% better retention—than those in traditional settings. This further validates the CDGBI's potential to improve learning through culturally grounded, interactive approaches.

By incorporating culturally relevant game-based elements, both studies demonstrate that such instructional materials can effectively meet educational objectives, providing clarity and relevance in delivering integrated learning experiences.

Table 3. Level of Acceptability of the Culturally Driven Game-Based Instruction in terms of Relevance

Relevance	**Mean**	**SD**	**Verbal Description**
1. The activities are appropriate and relevant to the students' experiences and needs.	4.20	0.45	Highly Acceptable
2. The content provides an impetus for further research.	4.40	0.55	Highly Acceptable
3. The module provides evidence of effectiveness through pretest and posttest results.	4.60	0.55	Highly Acceptable
4. The learning tasks are related to the expected content and skills to be developed among students.	4.40	0.55	Highly Acceptable
5. The module meets the minimum requirements set for the course.	4.60	0.55	Highly Acceptable
6. The module is suitable for individual use.	4.20	0.45	Highly Acceptable
7. The module gives the teachers and the students an opportunity for developing desired creativity skills, critical thinking skills, collaboration skills and communication skills.	4.80	0.45	Highly Acceptable
8. The module is attuned to latest trends and interest.	4.20	0.45	Highly Acceptable
9. The module can enhance creativity skills, critical thinking skills, collaboration skills and communication skills of the mathematics concepts.	4.60	0.55	Highly Acceptable
10. The modules' package is appropriate for developing analytical skills.	4.20	0.45	Highly Acceptable
Mean	**4.42**	**0.50**	**Highly Acceptable**

The evaluators' assessment indicates that the relevance of the Culturally Driven Game-Based Instruction is highly acceptable. The results indicate a consistently high level of approval for the relevance of the Culturally Driven Game-Based Instruction, as evidenced by an overall mean score of 4.42 (SD = 0.50). This suggests that the evaluators perceive the instructional approach as meaningful and well-aligned with students' interests and experiences. The minimal variation in responses further reflects a uniform agreement among the evaluators, reinforcing the strong acceptability of its relevance in educational settings.

This result aligns with previous studies highlighting the benefits of culturally relevant, interactive game-based learning in enhancing student engagement and outcomes. Madsen (2017) explored how indigenous video games like *Invaders* and *Never Alone* promote "survivance" a blend of survival and resistance by immersing players in cultural narratives, deepening their understanding of indigenous identities. Similarly, the high acceptability rating of your CDGBI indicates that evaluators found its content meaningful and well-connected to students' interests and cultural experiences.

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Table 4. Level of Acceptability of the Culturally Driven Game-Based Instruction in terms of Presentation

Presentation	**Mean**	**SD**	**Verbal Description**
1. The module is presented with clarity, focus and proper organization.	4.40	0.55	Highly Acceptable
2. The information is presented in ways that are familiar to students.	4.20	0.45	Highly Acceptable
3. All references are visually and functionally consistent throughout the module.	4.40	0.55	Highly Acceptable
4. The module is easy to navigate.	4.80	0.45	Highly Acceptable
5. The layout of the module is well-organized without distracting elements.	4.20	0.45	Highly Acceptable
6. The visual quality of texts, images and illustrations is good.	4.40	0.55	Highly Acceptable
7. The module uses items that are instructionally sensitive and educationally available.	4.60	0.55	Highly Acceptable
8. The cover page is related to the title of the module.	4.40	0.55	Highly Acceptable
9. The module is well-designed.	4.20	0.45	Highly Acceptable
10. The module is presented effectively and user-friendly.	4.20	0.45	Highly Acceptable
Mean	**4.38**	**0.50**	**Highly Acceptable**

The evaluators rated the presentation of the Culturally Driven Game-Based Instruction (CDGBI) as highly acceptable, with a mean score of 4.38 (SD = 0.50), reflecting its clear, organized, and visually engaging design. The low response variation indicates strong agreement on its effectiveness. Park and Wen's (2016) findings support this, showing that culturally tailored game-based learning enhances engagement by aligning with students' values and preferences—reinforcing CDGBI's relevance and impact.

Table 5. Level of Acceptability of the Culturally Driven Game-Based Instruction in terms of Cultural Formation

Cultural Formation	**Mean**	**SD**	**Verbal Description**
1. It showcases societal diversity through various activities, with the module designed to be effective and user-friendly.	4.60	0.55	Highly Acceptable
2. The material is suited for developmental needs and accommodates diverse cultural backgrounds, abilities, and learning styles.	4.20	0.45	Highly Acceptable
3. Content integration refers to how and to what extent the material incorporates traditions and information relevant to students' cultural backgrounds.	4.60	0.55	Highly Acceptable
4. The module is inclusive and devoid of racial, cultural, ethnic, linguistic, gender, and physical biases.	4.60	0.55	Highly Acceptable
5. It uses familiar objects and context to facilitate learning.	4.80	0.45	Highly Acceptable

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6. The material translates into the importance of cultural relevance to the students.	4.60	0.55	Highly Acceptable
7. The material translates into the importance of cultural relevance to the students.	4.20	0.45	Highly Acceptable
8. The content and the learning activities are adjusted, taking into consideration the diverse cultures of the students.	4.40	0.45	Highly Acceptable
9. The material provides students with activities to demonstrate the relationship between mathematics and culture.	4.20	0.55	Highly Acceptable
10. The cultural perspective in mathematical concepts can lead students to reflect in their own culture.	4.20	0.45	Highly Acceptable
Mean	**4.44**	**0.50**	**Highly Acceptable**

The evaluators' assessment confirms that the cultural formation of the Culturally Driven Game-Based Instruction is highly acceptable. The findings show a consistently strong approval, as reflected in the overall mean score of 4.44 (SD = 0.50), indicating a positive and uniform evaluation. Therefore, the findings suggest that the Culturally Driven Game-Based Instruction effectively incorporates cultural elements, demonstrating its relevance in promoting cultural understanding and engagement in learning.

The favorable evaluation of cultural integration in Culturally Driven Game-Based Instruction (CDGBI) aligns with research emphasizing the benefits of game-based learning in enhancing student engagement and academic performance. Tokac et al. (2019) found that game-based learning significantly improves students' mathematics achievement, supporting the effectiveness of interactive, game-based approaches. Although their study did not focus on culturally driven games, their findings reinforce the potential of culturally integrated games to foster engagement and academic success.

Table 6. Summary Level of Acceptability of Culturally Driven Game-Based Instruction in Mathematics

Factors		**Mean**	**SD**	**Verbal Description**
1.	Content	4.44	0.52	Highly Acceptable
2.	Instructional Quality	4.48	0.52	Highly Acceptable
3.	Relevance	4.42	0.50	Highly Acceptable
4.	Presentation	4.38	0.50	Highly Acceptable
5.	Cultural Formation	4.44	0.50	Highly Acceptable
MEAN		**4.43**	**0.51**	**Highly Acceptable**

The Culturally Driven Game-Based Instruction in Mathematics received an overall mean of 4.43 (SD = 0.51), indicating a highly acceptable rating. This suggests that integrating culturally responsive, game-based learning strategies enhances student engagement, improves instructional quality, and enriches learning experiences. Teachers are encouraged to incorporate culturally relevant materials to promote deeper understanding and active participation in mathematics.

The study's findings on the effectiveness of Culturally Driven Game-Based Instruction (CDGBI) align with broader research on culturally responsive and game-based learning. Meylani (2025) found that gamification and game-based learning enhance student motivation, problem-solving, and academic achievement, supporting the

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positive evaluations of CDGBI and its potential to improve instructional quality and engagement in mathematics.

Pretest Proficiency Levels of Both Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication

Table 7. Summary of the Pretest Proficiency Level of Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication Skills

Skills	Control		Experimental
	PL	VD	VD
Creativity Skills	1	Novice	Novice
Critical Thinking Skills	2	Beginner	Beginner
Collaboration Skills	1	Novice	Novice
Communication Skills	1	Novice	Novice

Note: PL = Proficiency level; VD= Verbal Description

The pretest results show that both the control and experimental groups had low proficiency levels in the four assessed skills. In creativity, collaboration, and communication, both groups scored a "Novice" level (1), indicating minimal ability in generating ideas, working together, and expressing thoughts. In critical thinking, both groups were rated "Beginner" (2), reflecting initial attempts at logical reasoning with notable errors. These findings highlight the limited proficiency of students before the Culturally Driven Game-Based Instruction (CDGBI) intervention, suggesting a need for strategies to enhance these skills. Integrating CDGBI offers a promising approach to fostering growth in these areas through an engaging and culturally relevant learning experience.

Nguyen and Nguyen (2018) found that game-based learning helps novice learners improve collaboration and communication by providing an engaging, interactive environment. Similarly, Lai (2015) emphasized that critical thinking requires structured support, particularly for beginners. Both studies highlight the value of interventions like Culturally Driven Game-Based Instruction in developing these essential skills.

Significant Difference of the Pretest Results of the Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication

Table 8. Significant Difference of Pretest Results of the Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication Skills

Variables	Control		Experimental		*t* (31)	*P*
	M	*SD*	*M*	*SD*		
Creativity Skills	1.76	0.60	1.73	0.58	0.17	0.86
Critical Thinking Skills	1.94	0.65	1.88	0.65	0.38	0.70
Collaboration Skills	1.68	0.59	1.71	0.61	0.20	0.84
Communication Skills	1.72	0.62	1.72	0.62	0.01	0.99

Note: n = 32; M = Mean; SD = Standard Deviation; p>0.05

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The analysis shows that there were no statistically significant differences in the pretest scores between the control and experimental groups across all four 21st-century skills: creativity, critical thinking, collaboration, and communication, as indicated by the p-values, all of which are greater than the significance threshold of 0.05 ($p > 0.05$). Therefore, null hypothesis is accepted.

For creativity skills, the t-test yielded t(31) = 0.17, p = 0.86, indicating that the mean scores of the control (M=1.76, SD=0.60) and experimental (M=1.73, SD=0.58) groups were not significantly different. Similarly, for critical thinking skills, t(31) = 0.38, p = 0.70, further demonstrating no initial gap between the two groups.

The results for collaboration skills (t(31) = 0.20, p = 0.84) and communication skills (t(31)=0.01, p=0.99) reinforce the finding that both groups started with comparable proficiency levels before the implementation of Culturally Driven Game-Based instruction.

Li and Tsai (2023) found that game-based learning improves motivation and cognitive development in STEM, with substantial gains in critical thinking and problem-solving after students engage with the intervention over time. This aligns with the pretest results of the current study, where students had similar skill levels before experiencing Culturally Driven Game-Based Instruction. Similarly, Dewi et al. (2020) highlighted that traditional games promote critical thinking by offering culturally relevant contexts, though advanced problem-solving skills develop only after exposure to these activities. This supports the pretest results, where students had not yet engaged with the game-based activities designed to enhance their skills.

These findings justify the validity of the study by confirming that both groups had equivalent baseline competencies before the intervention. The lack of significant differences in pretest scores confirms that any advancements seen in the posttest results are because of Culturally Driven Game-Based Instruction (CDGBI) rather than preexisting variations between the groups.

Posttest Proficiency Levels of Both Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication

Table 9. Summary of the Posttest Proficiency Level of Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication Skills

Skills	Control		Experimental	
	PL	VD	PL	VD
Creativity Skills	2	Beginner	4	Proficient
Critical Thinking Skills	2	Beginner	4	Proficient
Collaboration Skills	2	Beginner	3	Intermediate
Communication Skills	2	Beginner	4	Proficient

Note: PL = Proficiency level; VD= Verbal Description

The posttest results reveal a significant improvement in the proficiency levels of the experimental group across the four assessed skills compared to the control group. In creativity, critical thinking, and communication skills, the experimental group attained a proficiency level of 4, categorized as "Proficient," indicating a strong ability to generate ideas, apply logical reasoning, and effectively communicate with clarity and accuracy. Conversely, the control group remained at a proficiency level of 2, described as "Beginner," suggesting minimal progress in these areas.

In terms of collaboration skills, the experimental group improved to a proficiency level of 3 ("Intermediate"), showing progress in teamwork and integrating perspectives, though individual contributions were not always

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distinct. The control group remained at level 2, indicating limited collaboration and more individual efforts.

These findings align with Panadero and Jonsson (2013), who studied the impact of formative assessment on student outcomes, including collaboration and communication. Their research shows that structured interventions like game-based learning and collaborative tasks significantly enhance engagement, critical thinking, and collaboration—similar to the improvements seen in the experimental group.

These findings suggest that the Culturally Driven Game-Based Instruction applied in the experimental group was effective in enhancing students' creativity, critical thinking, collaboration, and communication skills, whereas the conventional approach used in the control group resulted in only minimal development in these areas.

Significant Difference in the Posttest Results of the Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication

Table 10. Significant Difference of Posttest Results of the Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication Skills

Variables	Control		Experimental		*t* (31)	*P*
	M	*SD*	*M*	*SD*		
Creativity Skills	1.93	0.39	3.64	0.32	19.26	<.001*
Critical Thinking Skills	2.22	0.57	3.56	0.33	11.51	<.001*
Collaboration Skills	2.00	0.43	3.33	0.41	12.66	<.001*
Communication Skills	1.97	0.42	3.45	0.37	14.87	<.001*

Note: $n = 32$; *M* = Mean; *SD* = Standard Deviation; $*p<0.05$

The analysis indicates that there is a significant difference between the posttest results of the control and experimental groups in terms of creativity, critical thinking, collaboration, and communication skills in Mathematics. Therefore, the null hypothesis is rejected.

The posttest scores show that the experimental group significantly outperformed the control group in all assessed skills. In creativity, the experimental group (M = 3.64, SD = 0.32) scored higher than the control group (M = 1.93, SD = 0.39), t(31) = 19.26, p < .001, indicating the strong impact of culturally driven game-based learning. The experimental group also outperformed the control group in critical thinking (M = 3.56, SD = 0.33 vs. M = 2.22, SD = 0.57), t(31) = 11.51, p < .001, collaboration (M = 3.33, SD = 0.41 vs. M = 2.00, SD = 0.43), t(31) = 12.77, p < .001, and communication skills (M = 3.45, SD = 0.37 vs. M = 1.97, SD = 0.42), t(31) = 14.87, p < .001. These results demonstrate the effectiveness of culturally relevant game-based instruction in enhancing creativity, critical thinking, collaboration, and communication.

The notable enhancements in creativity, critical thinking, collaboration, and communication skills among students who experienced culturally driven game-based instruction align with existing research on culturally responsive teaching, which highlights its positive influence on student engagement and self-efficacy in mathematics.

Carr (2021) found that culturally responsive teaching significantly improved elementary students' self-efficacy in mathematics, enhancing their critical thinking and problem-solving as they engaged more deeply with content connected to their cultural experiences. Rahaman (2024) similarly found that incorporating culturally relevant materials in Class 12 classrooms boosted student motivation, participation, and engagement, which are crucial for collaboration and communication. Both studies support the current findings, suggesting that culturally

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responsive, game-based instruction effectively enhances students' 4C skills by making learning more relevant and engaging.

Significant Difference between the Mean Gain Scores of Control and Experimental Groups Regarding Creativity, Critical Thinking, Collaboration and Communication

Table 20. Mean Gain Scores of the Control and Experimental Group in Terms of Creativity, Critical Thinking, Collaboration and Communication Skills

Variables	Control		Experimental		*t* (31)	*P*	Cohen's *d*
	M	*SD*	*M*	*SD*			
Creativity Skills	0.17	0.62	1.91	0.64	11.00	<.001*	2.71
Critical Thinking Skills	0.28	0.84	1.68	0.80	6.84	<.001*	1.71
Collaboration Skills	0.32	0.81	1.62	0.69	6.96	<.001*	1.74
Communication Skills	0.25	0.82	1.73	0.75	7.50	<.001*	1.88

Note: $N = 64$; $^{a}n = 32$; $^{b}n = 32$; M = Mean; SD = Standard Deviation; $df = 62$; $*p<0.05$

The analysis reveals a significant difference in mean gain scores between the control and experimental groups in creativity, critical thinking, collaboration, and communication skills. The null hypothesis is rejected, confirming that culturally driven game-based instruction positively impacted skill development. The experimental group showed greater improvement in all skills, with creativity scores (M = 1.91, SD = 0.64) significantly higher than the control group (M = 0.17, SD = 0.62), t(62) = 11.00, p < .001.

Similarly, in critical thinking, the experimental group (M = 1.68, SD = 0.80) showed a significantly higher mean gain than the control group (M = 0.28, SD = 0.84), t (62) = 6.84, p < -.001. For collaboration skills, the experimental group (M = 1.62, SD = 0.69) exhibited significantly greater improvement than the control group (M = 0.32, SD = 0.81), t (62) = 6.96, p < -.001. Similarly, in communication skills, the experimental group (M = 1.73, SD = 0.75) showed a significantly higher mean gain than the control group (M = 0.25, SD = 0.82), t (62) = 7.50, p < -.001.

The significant improvement in creativity in the experimental group aligns with Lee, Meyer, and Crutchfield's (2021) findings, which emphasize that environments fostering engagement, cultural relevance, and exploration enhance creativity. The culturally driven game-based instruction likely created such an environment, supporting students' ability to generate innovative ideas and solve mathematical problems creatively. The improvement in critical thinking skills also supports Dole, Bloom, and Kowalske's (2016) research, which found that active learning strategies, such as problem-based and inquiry-driven instruction, significantly boost critical thinking. Similarly, the culturally driven game-based instruction in this study enhanced students' analytical and reasoning abilities by connecting mathematical problem-solving to their cultural background.

The significant improvement in collaboration skills in the experimental group aligns with Thomas et al. (2016), who found that peer-led learning models, like the Peer Enabled Restructured Classroom (PERC), enhance collaboration and academic performance. Similarly, culturally driven game-based instruction facilitated collaborative problem-solving, improving teamwork and group interaction. Hu (2021) explored how digital games enhance student engagement and skills, finding that interactive learning tools boost comprehension and self-efficacy. This aligns with the study's findings, where culturally driven game-based instruction improved communication skills by fostering active participation and collaborative problem-solving, key components of effective communication.

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The findings clearly demonstrate that the experimental group showed markedly higher gains in creativity, critical thinking, collaboration, and communication skills than the control group. The significant effect sizes observed in all variables indicate that culturally driven game-based instruction played a crucial role in improving students' 21st-century skills in mathematics.

SUMMARY OF FINDINGS

Promoting the 21st-century skills like creativity, critical thinking, collaboration, and communication (the 4Cs) is crucial in education to equip students for the challenges of an ever-evolving world. These competencies extend beyond conventional academic knowledge, empowering students to think critically, solve problems innovatively, and collaborate efficiently in diverse and interconnected settings.

Level of Acceptability of Culturally Driven Game-Based Instruction

This study examined the level of acceptability of CDGB instruction based on content, instructional quality, relevance, presentation, and cultural formation. The results revealed that the instructional approach was highly acceptable in all areas, suggesting that CDGB instruction is a well-structured and highly suitable teaching method for Mathematics education.

Significant Difference of the Pretest Results of the Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication

It examined the initial proficiency levels of both the control and experimental groups through a pretest conducted before the intervention. Findings showed that both groups had identical proficiency levels, with creativity, collaboration, and communication skills rated as Novice (Level 1), while critical thinking skills were rated as Beginner (Level 2). These results indicate that prior to implementing CDGB instruction, students demonstrated minimal proficiency in these four skills, emphasizing the need for instructional improvements.

Significant Difference of the Pretest Results of the Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication

To further analyze the pretest results, both the control and experimental groups had comparable skill levels before the intervention, showing no significant differences. This suggests that students in both groups started with similar abilities in applying creativity, critical thinking, collaboration, and communication skills in mathematical contexts.

Posttest Proficiency Levels of Both Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication

The control group remained at the Beginner (Level 2) proficiency in all four skills, suggesting that conventional teaching methods did not lead to substantial improvements. In contrast, the experimental group exhibited significant growth, attaining a Proficient (Level 4) rating in creativity, critical thinking, and communication skills, and an Intermediate (Level 3) rating in collaboration skills. This notable difference suggests that CDGB instruction played a crucial role in enhancing students' learning outcomes.

Significant Difference in the Posttest Results of the Control and Experimental Groups in Terms of Creativity, Critical Thinking, Collaboration and Communication

After implementing culturally driven game-based instruction, the posttest results showed a notable improvement in the experimental group over the control group. Students in the experimental group exhibited enhanced creativity, critical thinking, collaboration, and communication skills, suggesting that incorporating culturally relevant games significantly enriched their learning experience.

Significant Difference Between the Mean Gain Scores of Control and Experimental Groups Regarding Creativity, Critical Thinking, Collaboration and Communication

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The last research objective examined whether a significant difference existed in the mean gain scores between the control and experimental groups. The findings revealed that the experimental group achieved a considerably higher mean gain score, reinforcing the effectiveness of culturally driven game-based instruction in enhancing students' creativity, critical thinking, collaboration, and communication skills in mathematics.

CONCLUSION

The study revealed that culturally driven game-based instruction significantly improved students' creativity, critical thinking, collaboration, and communication skills in mathematics. The experimental group outperformed the control group in posttest results, confirming the effectiveness of integrating traditional Filipino games into instructional strategies. The module was also rated as highly acceptable in terms of content, relevance, instructional quality, presentation, and cultural formation. These findings affirm the value of incorporating culturally relevant, student-centered approaches to enhance engagement and develop 21st-century skills.

While the study demonstrated promising outcomes in enhancing students' creativity, critical thinking, collaboration, and communication skills through culturally driven game-based instruction, it was limited to a specific group of Grade 10 students in one rural public school. Therefore, the results may not be fully generalized to different grade levels, urban school settings, or diverse student populations. Additionally, the instructional focus was confined to selected circle-related topics in mathematics, which may not reflect the broader applicability of the instructional approach across other mathematical domains.

To further validate the long-term effectiveness of the culturally driven game-based instruction, it is recommended that a retention test be conducted two months after the post-test. This follow-up assessment would help determine whether the improvements in 4C's skills were sustained over time and provide insights into the lasting impact of the instructional intervention.

Conflict of Interests

The authors declared no conflict of interest.

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