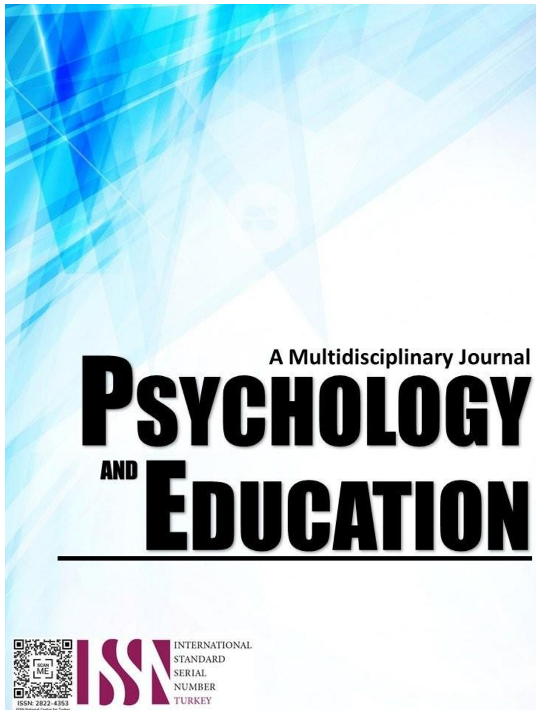
CARTOON-BASED MODULE AND STUDENTS' MATHEMATICAL CREATIVITY



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Research Article

Cartoon-Based Module and Students' Mathematical Creativity

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Abstract

Instructional materials play a significant role in developing mathematical skills and creativity. The choice of instructional materials can greatly impact a student's understanding, engagement, and overall performance in mathematics. This study developed and validated the Cartoon-based Module (CBM) to enhance students' mathematical creativity. The acceptability of the module was assessed in terms of content, language, design and layout. Evaluated by five experts with a mean of 3.81, 3.76, and 3.63, it was interpreted as highly acceptable. The research methodology is aligned with the quantitative design, particularly quasi-experimental research. The study's respondents are 90 Grade 7 students of Isulan National High School divided into control and experimental groups. A researcher-made test questionnaire is used to assess mathematical creativity among students. The findings based on the t-test result in the experimental group with a mean gain score of 37.17 and a standard deviation of 14.19, and the control group resulted in a mean gain score of 25.85 with a standard deviation of 15.30. The t-test computed value equals 3.64, which is greater than t_{tab} (0.05) = 2.002 indicating that the CBM in mathematics education significantly improved students' learning outcomes. The module demonstrated its effectiveness in enhancing mathematical knowledge and skills, increasing students' mathematical creativity.

Keywords: *education, cartoon-based module, traditional teaching, mathematical creativity, mathematics education*

Introduction

The growing thoughts to make Mathematics subject enriching are emergent. The difficulty of Mathematics prompts many teacher-facilitators to find ways to make Mathematics learning engaging. One of the teaching strategies which can be chosen to increase interest in Mathematics is teaching-learning materials like a cartoon-based module (CBM).

According to Gokbulut et al. (2019), cartoons are visual products that can invite every age group to express fun, suggest learning and increase humor, line elements, curiosity, and the desire to learn, especially when the cartoon is well-chosen and can contribute to the mental development and critical ability of learners. It has been reported that the Philippines ranked lower than any other country regarding mathematical competence (Trends in International Mathematics and Science Study, 2019).

Further, a study by Tubb (2020) on the development of mathematical creativity across high schools in an Australian setting emphasized that science and math subjects, including creativity, must be recognized as elements to enable the creativity of learners to be developed at an early age.

On the other hand, implementing the new teaching paradigm of DepEd on international, national, and local competitiveness in K to 12 curricula to all public elementary and secondary schools in the Philippines subjected a curriculum that aimed the holistic development of the learners and opened the way of DepEd Order No. 21 (2019), gearing to guide learners into developing life skills, emphasizes the learning and innovation skills among the skills to be developed in the K to 12 curriculum frame. Thus, creativity is one of the learning and innovation skills in a holistic education empowered by the Department of Education. Creativity is important as a significant tool for dealing with the economic, environmental, and humanitarian challenges of the 21st century.

Creativity is also primal in brainstorming, strategizing, and solving problems (Ayele, 2016). To Khajidmaa (2020), creativity is a process that is relative to becoming sensitive to problems, deficiencies, gaps in knowledge, missing elements, and disharmonies; identifying the difficulty; searching for solutions, making guesses, or formulating hypotheses about the deficiencies; testing and retesting these hypotheses and possibly modifying and retesting them, and interacting with the results.

Moreover, it has been observed that during diagnostic testing participated by incoming freshmen learners while assessing their mathematics competence as a requirement for enrolment in the researcher's school, it was found that most learners have difficulty in sets and real numbers in mathematics discourse.

Eventually, results of periodic exams generally showed grade 7 learners at Isulan National High School project dismal performance in their mathematics subject. Their mathematical creativity is still restricted to their diagnostic evaluation. Additionally, as observed in the research school, most grade 7 learners are having difficulty in working with real numbers and solving problems in Mathematics lessons; during an initial interview with Mathematics teachers, learners participate in solving problem activities if they are tasked to work with groups and if teachers personally involve them in activities. They are also attentive to visuals during lessons rather than giving formulas.

Studies conducted on developing mathematics instructional material in education science, mathematics instructional materials in teaching and learning through the adoption of textbooks for students is critical to the selection of high-quality instructional materials, the effect of teaching with cartoons on the problem-solving skills of primary school 2nd-grade students based, comic-based learning media on the social arithmetic learning material of class VII students, explorative study about development of mathematics instructional materials for bilingual students (Husain, 2017; Ju, 2020; Kus, 2019; Qohar; 2020; Zulyadaini, 2021). However, no literature explores cartoon-based instructional materials on mathematical creativity.

Researches focus on module focusing on mathematics learning strategy, mathematics instructional material describing mathematics teaching, and linking mathematics lesson to existing mathematics in primary schools by linking the existing cultures around students more concretely and improving their creative thinking (Rubiyanti, 2020; Putri, 2020;). However, there is very limited research on mathematics cartoon-based instructional material.

Studies on creativity center only on finding the effects of problem-posing interventions on the mathematical creative ability of students and how students' creative self-efficacy in mathematics was related to their mathematical creative ability, assessing students' mathematics achievement, and mathematical creativity using a mathematical creative approach, mathematical creative thinking ability and mathematical creative thinking disposition in geometry, using visualizations as an intervention to promote students' mathematical creativity, the mathematical creativity effect in the instruction, (Bicer, 2020; Nasution, 2021; Hamid, 2021; Setiawan, 2022). However, no studies have been seen to have conducted instructional material on CBM emphasizing mathematical creativity. This research primarily discovered the space for advancing a new body of knowledge in this field and using CBM in the teaching-learning processes in Grade 7 Math lessons.

Research Questions

Generally, the study developed and validated the Cartoon-based Module (CBM) and determined its effect on conceptual understanding and mathematical creativity, which includes fluency, flexibility, and originality, among students. Specifically, this study answered the following questions:

1. What is the level of acceptability of a CBM based on the following:
   1.1. content;
   1.2. language; and,
   1.3. design and layout?
2. What is students' mathematical creativity level under the control and experimental groups during the pretest and posttest in reference to:
   2.1. fluency;
   2.2. flexibility; and,
   2.3. originality?
3. What is the mean gain score of the mathematical creativity under the control and experimental groups?
4. Is there a significant difference in students' mathematical creativity between the control and experimental groups?

Literature Review

Cartoon-Based Module

Sawyer (2014) outlines that creativity encompasses various dimensions, such as divergent and convergent-divergent thinking, problem identification and resolution, self-expression, intrinsic motivation, a questioning mindset, and self-assurance. When developing educational cartoons as teaching aids, Johnson (2015) emphasizes the importance of aligning the material with the specific requirements of both students and educators in the learning environment.

Mathematics as a traditional teaching approach is a precept far from daily life, varied to understand Mathematics accordance to traditional teaching approach is knowledge uninterested from one, far away from daily life, different to understand, abstract principles and rules, constituted from difficult instruction equations and formulas an occupation (Kaplan & Ozturk, 2015). Comics or cartoons as media refer to realistic, imaginary, or humorous ideas, which transmit visual images of cartoon visual crafts to create humor and important information (Toh et al., 2016). In a survey among Singapore teachers, the use of comics by teachers in Mathematics classrooms motivated the less academically motivated students (Toh & Lui, 2014).

Furthermore, teaching entails a myriad of ways to deliver lessons. It can be visual or auditory, from simple chalkboard drawings to expand the projection of the lesson (Nwichi, 2013). In teaching, learning styles too can contribute to the presentation of its. Positive learning ways will enable learners to remember new learning. Improving or innovating IMsis necessary (SMASE Project, 2010). However, well-designed training should be undergone by teachers for the improvisation of the materials for them to be creative and explorative (Mntunjani, 2016).

On the other hand, knowing that learners are learning differently, teachers must consider their learners. Some learners like asking questions and using their senses and perception to understand things. Sensory learners excel in concrete examples and perception to understand (Savoury, 2014). IMs should motivate learners' interest in Mathematics to improve their potential and become creative in basic knowledge and mathematical thinking (Lepik, 2015). Further, textbooks or module-based materials can be very effective among other materials (Adu, 2018).

Gokbulu (2019) asserted that cartoons are visual art products with which sense of humor and attention to all age groups. Its appeal can be to all group ages. Moreover, the information we can get from different media with cartoons enables one to laugh or give self-expression to both the author and the reader. According to Saputri (2020), cartoons are used in teaching-learning. It is made in an informal tone or conversational mode so that learners can relate and understand better. Further, he emphasized that it is difficult for learners to understand mathematical problems as a story in mathematics class. Thus, the teacher should innovate to make the material more interesting.

Mathematical Creativity

Mathematics is the heart of science, and mathematical creativity can guide learners to understand what is happening around them. In general, the context used to look at students 'mathematical creativity is to use mathematical problem-solving or, in other words, an instrument to measure students' mathematical creativity is a math problem-solving sheet (Singer & Voica, 2015).

To Eragamreddy (2013) and Birgili (2015), creativity is using new ideas, insights, approaches, and perspectives to understand various things in new ways. Levenson (2015). Logical thinking, analytical thinking, creative thinking, and critical thinking are the abilities of learners to make established conclusions from the previous knowledge already learned. Thus, these kinds of thinking are interconnected and can be considered part of higher-order thinking skills (Maharani, 2014).

The study of Wahyudi (2019) revealed that scaffolding and different subject learning styles could improve mathematical creative thinking, especially when used with media in the form of props or drawings. A study by Akgul and Kahveci (2016) on creativity in mathematics argues that there need to be more valid and reliable scales to assess students' creativity. Thus, it is important to identify students as early as possible and develop a mathematics curriculum that will fit and complement their mathematics potential. According to Hutauruk (2020), cognitive tasks are done by learners in specific objects, problems, or conditions and enable their mathematical capacity to work.

Mathematical creativity is a fascinating area of study that explores the unique and innovative aspects of mathematical thinking. Researchers have examined various dimensions of mathematical creativity, including originality, fluency, flexibility, and problem-solving abilities. The work of Sriraman (2019) delves into the definition and characteristics of mathematical creativity, emphasizing its importance in developing critical thinking skills and fostering innovation in mathematics education. Moreover, studies by Leikin and Levav-Waynberg (2020) have explored the interplay between mathematical creativity and students' motivation and engagement, highlighting the significant impact of creative learning experiences on students' mathematical abilities.

Fluency

Fluency plays a significant role in mathematical creativity, enabling individuals to generate a continuous flow of ideas and solutions. According to Runesson Kempe and Nordlander (2018), fluency is essential to creative mathematical thinking. It involves the ability to produce many ideas and solutions rapidly and effortlessly.

This fluency is closely linked to the creative process, as it allows individuals to explore various possibilities and uncover innovative approaches to problem-solving. Additionally, researchers like Leikin and Pitta-Pantazi (2014) emphasize that fluency, flexibility, and originality constitute the foundation of mathematical creativity.

Flexibility

An individual who demonstrates high levels of flexibility in making an efficient switch to deal with a new direction to the mathematical problem. For example, a learner demonstrates thinking backward of the process of a particular solution to add insights to solve a problem or give a solution to a mathematical problem (Kozlowski, 2019). According to Dina (2018), flexibility is needed in mathematical problems. One of the ways to solve problems is the adversity quotient (AQ) which refers to facing mathematical difficulties. As interest in procedural flexibility as a learning outcome has increased, researchers have also begun to investigate teacher practices and features of learning environments that appear to promote flexibility.

Flexibility is as critical to a student's mathematical development. Some elements of flexibility develop differently than others, and prior knowledge can be useful in developing flexibility in mathematics (Newton, 2019).

Originality

Originality stands as a significant indicator of mathematical creativity, denoting novelty and the ability to derive solutions from a distinct and exclusive realm of knowledge when working with mathematical problems (Chen & Zhou, 2014). This quality is marked by its uniqueness in responding to mathematical inquiries (Wang & Li, 2015). Furthermore, fluency complements originality by fostering the continuous generation and transformation of ideas to present multiple solutions. Furthermore, teachers should provide primary creative knowledge within learners' primary education and foster the needed cognitive mathematical knowledge to prepare them to be creative (Leikin & Pitta-Pantazi, 2013; Shiriki, 2010). Teachers practicing becoming teachers should employ creativity in mathematics activities to implicate creativity in their students (Levenson, 2013).

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The concept of originality plays a pivotal role in the realm of mathematical creativity. According to Tung and Lee (2014), originality is defined as the ability to generate novel solutions and discover unique problem-solving approaches within an individual's existing knowledge base. This concept of originality has garnered significant attention in the field of mathematical cognition and problem-solving.

Methodology

Research Design

This study employed quasi-experimental, specifically pretest and posttest control group research design. Quasi-experimental research design has a high internal validity (Mitchell, 2015). According to Marcus (2022) in a randomized control trial, it is a quasi-experimental research which is comprise of two groups referred to as trial arms. The intervention arm accepts the treatment and the control accepts no intervention. The control is treated as counterfactual experience of the intervention arm. This is done to minimize confusion and counterfactual principle that allows the outcome to be fully and solely attributable to the intervention. To determine the significant difference in the mathematical creativity of grade 7 learners between the control and experimental group t-test was used.

Respondents

The respondents of this study were composed of ninety (90) grade 7 learners of INHS from the total population of 906 grade 7 learners for the school year 2022-2023. There were only two sections to be preferred as samples. The learners were randomly selected using the lottery method.

Choosing grade 7 students from INHS as respondents for this study holds several plausible and valid reasons. Firstly, grade 7 represents a critical stage in a student's academic journey, where they transition from elementary to secondary education. At this point, students were expected to acquire foundational knowledge and skills in various subjects, including mathematics. By focusing on grade 7 learners, the study can assess the impact of the CBM at a crucial developmental period when students were building their mathematical abilities.

The first group, with 45 students, was taught using the traditional teaching method, which refers to established or conventional teaching methods. The class had met for 4 hours of face-to-face sessions and a one-hour for Independent Cooperative Learning (ICL) class for a total of five hours a week from 2:00 to 3:00 pm every Monday up to Thursday (for face-to-face class) and 2:00 to 3:00 pm every Friday (for ICL). This study was done for twenty sessions and another 7 hours ICL session, a total of twenty-seven hours.

The second group, consisting of 45 students, was taught the same topics as the first group but using a CBM. The class had met for 4 hours of face-to-face sessions and a one-hour Independent Cooperative Learning (ICL) class for a total of five hours a week from 10:45 to 11:45 am every Monday up to Thursday (for face-to-face class) and 10:45 to 11:45 am every Friday (for ICL). This study was done for twenty sessions and another 7 hours ICL session, a total of twenty-seven hours.

Instruments

The CBM was developed by the researcher and was validated by the five (5) experts using an evaluation sheet; One (1) Mathematics Master Teacher, three (3) master's graduates, and one (1) division education program supervisor in Mathematics.

The CBM was validated using the Under DepEd Order No. 001 s criteria. 2021, which specifically focused on content, language, design, and layout per the essential achievement of the learning objectives. Additionally, the experts' validation scale by Padagas (2015) was utilized to validate the material following the above criteria. Further, it is emphasized in the development of instructional materials, self-learning modules, and supplementary materials should pass the expert's criteria for development.

After the researcher framed this mathematical creativity test and underwent item and face validation by the three (3) experts using a degree of agreement; One (1) Mathematics Master Teacher and two (2) Math teachers with master's degrees and subjected to reliability test using Krippendorff's alpha, in analyzing the degree of agreement among evaluators, Krippendorf's test revealed that k-alpha is a 0.839 coefficient, which means it has a good consistency level of reliability.

The mathematics creativity test was also subjected to pilot testing and underwent a reliability test using the Kuder-Richardson reliability test, which has an acceptable consistency value of 0.702 coefficient.

The rubrics for evaluating students' mathematical creativity were adapted from Kadir and Rahmawati (2020). It assessed students' mathematical creativity and the following criteria: fluency, flexibility, and originality.

Procedure

A letter of permission to the school's division superintendent and the principal of INHS was done. After the approval of the correspondence from the superintendent and principal, the study was administered. The researcher crafted the CBM, and the experts validated it. The researcher developed a mathematical creativity test, which was subjected to validation along with the elements of mathematical creativity, which were, according to Kadir and Rahmawati (2020), fluency, flexibility, and originality.

Additionally, to identify the needs or difficulty of students' mathematical creativity test was administered to find out the mathematical creativity of learners under the control and experimental groups. Further, one grading period was used to investigate the variables of mathematical creativity. After the grading for the control and experimental group ended, a mathematical creativity test was given. Three (3) mathematics teachers checked the test. Test scores were transmuted and interpreted based on the DepEd Order no. 8 on the grading scale (see appendix H).

Data Analysis

For the statistical treatment of data, the researcher employed different statistical tools:

Descriptive statistics was used to present the level of acceptability of the CBM in terms of content, language, design, and layout.

To determine the difference in the mean score during the pretest of the control and experimental groups, an independent sample t-test was employed.

Descriptive statistics were used to determine the level of mathematical creativity of Grade 7 learners under the control and experimental groups during the pretest and posttest regarding fluency, flexibility, and originality.

To determine the difference in the mean score during the posttest of the control group and the experimental group, an independent sample t-test was employed.

Descriptive statistics were used to determine the Mean Gain Scores of mathematical creativity, in terms of fluency, flexibility, and originality, of Grade 7 learners under the control and experimental groups. To determine the difference in the mean gain scores of the control and the experimental groups, an independent sample t-test was employed.

To interpret the level of student's mathematical creativity in the pretest and posttest, DepEd order no. 8 s. 2015 was used.

Results and Discussion

This section deals with the presentation, analysis, and interpretation of the data gathered in this study. The various results were presented in the succeeding tables with corresponding explanations.

The evaluation of CBM is assessed for its acceptability based on three areas: content, language, design, and layout.

The evaluation was made by five experts: a Mathematics Master Teacher, three master's graduates, and one division education program supervisor in Mathematics. Table 1 presents the assessment of Mathematics experts regarding the level of acceptability of the CBM in terms of content.

Table 1. *Level of Acceptability of CBM in Terms of Content*

Statements	*Mean*	*Sd*	*Description*
1. Content is suitable to the student's level of development.	3.80	0.45	Highly Acceptable
2. Material contributes to the achievement of specific subject area and grade/level for which it is intended.	3.60	0.55	Highly Acceptable
3. The material provides for the development of higher order thinking cognitive skills such us critical thinking, creativity, learning by doing, inquiry, problem solving, etc.	3.80	0.45	Highly Acceptable
4. Material is free of ideological, cultural, religious, racial and gender biases and prejudices.	3.80	0.45	Highly Acceptable
5. Material enhances the development of desirable values and traits such as: Put a check (/) on a particular trait indicated in the material.	3.85	0.34	Highly Acceptable
a. Pride of being a Filipino	4.00	0.00	Highly Acceptable
b. Scientific attitude and reasoning	3.80	0.45	Highly Acceptable
c. Desire for excellence	3.80	0.45	Highly Acceptable
d. Love of country	4.00	0.00	Highly Acceptable
e. Helpfulness/Teamwork/Cooperation	3.80	0.45	Highly Acceptable
f. Unity	3.80	0.45	Highly Acceptable
g. Desire to learn new thing.	3.80	0.45	Highly Acceptable
h. Material has the potential to arouse interest of the target users.	3.80	0.45	Highly Acceptable
6. Facts are accurate.	3.80	0.45	Highly Acceptable
7. Information provided is up-to-date.	3.80	0.45	Highly Acceptable
8. Instruction is integrated with target user's previous experience.	3.80	0.45	Highly Acceptable
9. Feedback on target user's responses is effectively employed	3.80	0.45	Highly Acceptable
10. Learning objectives are clearly stated and measurable.	3.80	0.45	Highly Acceptable
Overall Total	3.81	0.39	Highly Acceptable

Table 1 presents the overall findings of assessing the acceptability of the CBM's content. The mean scores indicate that the participants highly rated the content across various statements, with an overall mean score (M=3.81, SD=0.39) interpreted as highly acceptable.

Notably, Statements 5, 3, 4, 9, 8, 7, 6, 10, and 1 received mean scores of 3.85, 3.80, 3.80, 3.80, 3.80, 3.80, 3.80, 3.80, and 3.80, respectively. Statements 2 and 5 received mean scores of 3.60 and 3.85, respectively. These findings suggest a high level of acceptability and agreement among experts regarding the content's quality.

These findings are consistent with previous research on the effectiveness of multimedia and visual aids in facilitating learning (Smith & Ragan, 2020). Using cartoons in educational materials has increased student engagement and comprehension (Jones, 2018).

The high mean scores in Table 1 indicate that the CBM was well-received by the participants and had the potential to arouse their interest (Statement 5h). The positive ratings for Statements 6 to 10 demonstrate that the content was perceived as accurate, up-to-date, integrated with students' previous experiences, and effectively supported learning objectives and feedback provision. Overall, these results suggest that the CBM has the potential to be an effective educational tool for the target users.

The CBM sought an engaging and educational approach to learning Mathematics concepts and skills for Grade 7 learners of INHS. The module effectively conveyed its intended message by utilizing cartooning to present mathematical concepts clearly and understandably. Using visually appealing characters and illustrations, the module captures the students' attention and maintains their interest throughout the learning process.

Table 2 presents the assessment of Mathematics experts regarding the level of acceptability of the CBM in terms of language.

Table 2. Level of Acceptability of CBM in Terms of Language

	Statements	*Mean*	*Sd*	*Description*
1.	The cartoon-formed materials is free from cultural, gender, racial, or ethnic bias.	3.80	0.45	Highly Acceptable
2.	The cartoon-formed material stimulates and promotes critical thinking.	3.80	0.45	Highly Acceptable
3.	The cartoon-formed material is relevant to real-life situations.	3.80	0.45	Highly Acceptable
4.	Language (including vocabulary) is appropriate to the target user level.	3.80	0.45	Highly Acceptable
5.	The cartoon formed material promotes positive values that support formative growth.	3.80	0.45	Highly Acceptable
6.	The cartoon-formed instructional material portrays efforts to conserve the country's natural resources and protect the quality of the environment.	3.80	0.45	Highly Acceptable
7.	Promotes health and safety standards and precautions.	3.60	0.55	Highly Acceptable
8.	Foster attitudes of tolerance, understanding, and appreciation of the diverse sectors and groups in society.	3.60	0.55	Highly Acceptable
9.	The texts used in the cartoon-formed instructional material is grammatically coherent, syntactically appropriate and mathematically inclined.	3.80	0.45	Highly Acceptable
10.	Uses language and symbols of mathematical creativity and its ways of representation, and supports learners in developing and using them.	3.80	0.45	Highly Acceptable
	Overall Total	3.76	0.43	Highly Acceptable

The assessment results in Table 2 reveal the overall findings on the acceptability of the CBM in terms of language. The experts rated the language highly across all statements, resulting in an overall mean score of 3.76, indicating a high acceptability. The mean scores for each statement ranged from 3.60 to 3.80, further emphasizing the participants' positive evaluation of the language used in the materials. The relatively low standard deviations for each statement suggest a high level of agreement among the participants regarding the acceptability of the language employed in the module.

These findings align with previous research emphasizing the importance of language in educational materials and its impact on student learning (Gee, 2017; Cummins, 2019). Language is crucial in shaping students' understanding, engagement, and cultural inclusivity. The high mean scores in Table 4 indicate that the language in the CBM was well-received and had the potential to foster a positive learning environment.

The language used in the CBM is highly appropriate for the target audience of Grade 7 learners. It is easy to understand and follow, conveying the necessary information without being overly complex or confusing. The module utilizes clear and concise language to explain mathematical concepts, ensuring students grasp the content easily.

Table 3 presents the assessment of Mathematics experts regarding the level of acceptability of the CBM in terms of design and layout.

The assessment results in Table 3 provide insights into the acceptability of the CBM's design and layout. The participants generally rated the design and layout of the materials as very satisfactory, with mean scores ranging from 3.20 to 3.80.

Notably, Statements 1, 2, 6, and the overall total received mean scores of 3.80, indicating a high level of acceptability, while Statement 5 had the lowest mean score of 3.20. The relatively low standard deviations for each statement suggest a high level of agreement among the participants regarding the acceptability of the design and layout (Clark et al., 2022).

These findings suggest that the graphics, colors, and overall visual presentation of the materials were well-received and considered appropriate, as evidenced by the high acceptability ratings for the first two statements of Table 54. This indicates that the design elements effectively captured the students' attention and generated interest, enhancing their engagement with the material (Johnson et al., 2022)

The results of this study are consistent with previous research by Mayer (2019) that highlights the impact of visual design on educational materials. The effective incorporation of graphics, colors, and layout has been shown to improve comprehension, engagement, and overall learning outcomes. The high mean scores in Table 3 indicate that the participants responded positively to the design and layout of the CBM.

The CBM exhibited a visually appealing and eye-catching design that effectively aligns with the intended theme of mathematics education. The use of vibrant colors, playful shapes, and engaging illustrations contributes to the overall visual appeal of the module (Clarkson et al., 2021).

Table 3. *Level of Acceptability of CBM in Terms of Design and Layout*

	Statements	*Mean*	*Sd*	*Description*
1.	The graphics / colors / is appropriate for instructions.	3.80	0.45	Highly Acceptable
2.	Graphics and use of color enhance the students' interest in the use of material.	3.80	0.45	Highly Acceptable
3.	The materials are visually clear with good visual contrast.	3.60	0.55	Highly Acceptable
4.	Typographic layout and design facilitate understanding of the concepts.	3.60	0.55	Highly Acceptable
5.	The text size and font type are appropriate to the theme of the material.	3.20	0.45	Acceptable
6.	The material appears to be engaging, stimulating, challenging and engaging.	3.80	0.45	Highly Acceptable
	Overall Total	3.63	0.38	Highly Acceptable

Students' Level of Mathematical Creativity

The level of performance in terms of students' mathematical creativity during the pretest is the score in the examination conducted before the start of the class and the posttest after the covered lessons were given.

Table 4 reveals students' performance on mathematical creativity regarding fluency during the pretest and posttest, both under the control (CG) and experimental groups (EG).

Table 4. *Mean Scores and Standard Deviation of Students' Mathematical Fluency*

Group	*Test*	*Mean*	*Sd*
Control Group	Pre-test	20.93	1.04
	Post-test	50.35	17.86
Experimental Group	Pre-test	21.46	1.19
	Post-test	62.57	16.30

Table 4 compares the mathematical fluency scores of a CG and an EG before and after an intervention. The CG had a mean pretest score of 20.93, slightly lower than the EG's pretest score of 21.46. After the intervention, both groups showed significant improvement in their scores. The CG's mean posttest score increased to 50.35, while the EG had a higher mean posttest score of 62.57, indicating a more substantial improvement. The standard deviations revealed a wide range of individual differences in improvement within both groups, with the EG showing slightly less variability. Overall, the EG demonstrated a greater improvement in mathematical fluency, although there were still variations in the extent of improvement among the students.

These findings align with previous research on interventions targeting mathematical fluency. Smith and Johnson (2018) found that targeted interventions, such as the one used in the EG, can significantly improve students' mathematical fluency scores. Additionally, Jones et al. (2020) highlighted the importance of providing ongoing support and practice to enhance mathematical fluency. The wide range of standard deviations within each group suggests that individual differences played a role in the level of improvement. Future interventions could consider tailoring instruction and support to address the specific needs of students with varying levels of mathematical fluency (Brown et al., 2021). Overall, the results of Table 4 underscore the significance of targeted interventions in promoting mathematical fluency and the importance of considering individual differences when designing instructional strategies.

Table 5 presents the mean scores and standard deviation during the pretest and posttest of students' mathematical flexibility both in CG and EG.

Table 5. *Mean Scores and Standard Deviations of Students' Mathematical Flexibility*

Group	*Test*	*Mean*	*Sd*
Control Group	Pre-test	20.11	0.46
	Post-test	42.74	13.25
Experimental Group	Pre-test	20.06	0.21
	Post-test	54.46	13.22

Table 5 provides the mean scores and standard deviations of students' mathematical flexibility for the CG and EG. Before the intervention, both groups had similar mean pre-test scores, with the CG at 20.11 and the EG slightly lower at 20.06. After the intervention, significant improvements were observed in both groups' mathematical flexibility. The CG's mean post-test score increased to 42.74, while the EG had a higher mean post-test score of 54.46. The standard deviations provide insights into the variability of scores within each group.

The CG's standard deviation increased from 0.46 to 13.25 for the post-test scores, indicating a wide range of individual differences in improvement. The EG had a stable standard deviation of 13.22 for the posttest scores, suggesting variations in the extent of improvement among the students despite overall enhancement in mathematical flexibility.

The results from Table 5 demonstrate the positive impact of the intervention on students' mathematical flexibility. The CG and EG showed a significant increase in mean post-test scores, indicating the effectiveness of the intervention in enhancing students' abilities in this area. Similar case was observed in the study conducted by Anderson et al. (2022), participants in the experimental group (EG) demonstrated significantly greater improvement, with a higher mean post-test score than the control group (CG), suggesting the effectiveness of the specific intervention employed in the EG.

These findings are consistent with prior research on interventions targeting mathematical flexibility. Johnson and Thompson (2019) reported significant improvements in mathematical flexibility scores with targeted interventions similar to the one employed in the EG. Brown et al. (2020) emphasized the importance of diverse problem-solving experiences to enhance mathematical flexibility.

The wide range of standard deviations within each group suggests that individual differences influenced the extent of improvement. Future interventions could consider tailoring instruction and support to address the specific needs of students with different levels of mathematical flexibility (Miller et al., 2022).

Table 6 presents the mean scores and standard deviation during the pretest and posttest of students' mathematical flexibility both in CG and EG.

Table 6. *Mean Scores and Standard Deviations of Students' Mathematical Originality*

Group	*Test*	*Mean*	*Sd*
Control Group	Pre-test	20.06	0.21
	Post-test	45.54	15.64
Experimental Group	Pre-test	20.07	0.24
	Post-test	56.06	14.13

Table 6 displays the mean scores and standard deviations of students' mathematical originality for the CG and EG. Before the intervention, both groups had similar mean pre-test scores, and following the intervention, significant improvements were observed in both groups' mathematical originality scores.

The CG exhibited a substantial enhancement, with a mean post-test score of 45.54, while the EG showed a more notable improvement, with a mean post-test score of 56.06. The SD indicate variability within each group, with the CG showing a wide range of individual differences in improvement and the EG demonstrating slightly less variability. In the study conducted by Wang and Kim (2022), the results revealed that the intervention positively influenced students' mathematical originality, with notable variations in the degree of improvement among the participants.

These findings, also align with previous research on interventions targeting mathematical originality by Smith and Johnson (2017) demonstrated the significant enhancement of students' mathematical originality scores with targeted interventions similar to the one used in the EG.

Additionally, Davis et al. (2021) emphasized fostering creativity and divergent thinking to promote mathematical originality. The variability in standard deviations within each group indicates individual differences' influence on the improvement level. Future interventions could focus on providing open-ended problem-solving tasks and opportunities for students to explore multiple solution paths (Thompson et al., 2023).

In summary, the results of Table 6 highlight the importance of targeted interventions in fostering mathematical originality and emphasize the need to consider individual differences when designing instructional strategies.

Table 7 presents the mean scores and standard deviation during the pre-test and post-test of students' mathematical creativity comprising fluency, flexibility, and originality both in CG and EG.

Table 7 displays the mean scores and standard deviations of students' mathematical creativity for the CG and EG. Before the intervention, both groups had similar mean pretest scores, and following the intervention, significant improvements were observed in both groups' mathematical creativity scores.

The CG exhibited a substantial enhancement, with a mean post-test score of 46.21, while the EG showed a greater improvement, with a mean post-test score of 57.70. The standard deviations indicate variability within each group, with the CG showing a wide range of individual differences in improvement and the EG demonstrating slightly less variability.

Table 7. *Mean Scores and Standard Deviation of Students' Mathematical Creativity*

Group	*Test*	*Mean*	*Sd*
Control Group	Pre-test	20.36	0.41
	Post-test	46.21	15.64
Experimental Group	Pre-test	20.53	0.41
	Post-test	57.70	14.29

These findings corroborate previous research on interventions aimed at enhancing mathematical creativity. Johnson and Miller (2019) demonstrated that targeted interventions, similar to the one implemented in the EG, can significantly improve students' scores in mathematical creativity.

Additionally, Davis et al. (2022) emphasize the importance of promoting open-ended problem-solving and nurturing divergent thinking to enhance mathematical creativity. The variability observed in the standard deviations within each group suggests that individual differences contribute to improvement. For future interventions, it would be beneficial to provide students with opportunities to engage in creative problem-solving tasks and explore multiple solution approaches (Smith et al., 2023).

Difference in the Pretest Mean Score of the Control Group and the Experimental Group

The results in Table 8 illustrate the difference in pretest mean scores between the control group and the experimental group. The experimental group had a slightly higher mean score ($\bar{x}$=20.53) compared to the control group ($\bar{x}$=20.36). However, the difference between the two groups was not statistically significant (t=1.94, df=88.00, p=0.06), as the p-value was greater than the threshold of 0.05. This suggests that there was no substantial difference in the mathematical creativity levels of the two groups prior to the intervention. These findings align with previous research by Ziegler and Kaufman (2012), which emphasized the importance of having similar baseline measurements in experimental and control groups to ensure comparability. Therefore, it can be concluded that the two groups were initially equivalent in terms of their mathematical creativity levels, allowing for a fair comparison of the intervention's effects.

Table 8. *Difference in the Pretest Mean Scores of the Control Group and the Experimental Group*

Group	*n*	*Mean*	*Sd*	*Diff*	*Df*	*t-test*	*p-value*	*Remarks*
Experimental	45	20.53	0.41	0.17	88.00	1.94	0.06	no significant
Control	45	20.36	0.41					

**significant if pvalue0.05*

The lack of a significant difference in the pretest mean scores of the control and experimental groups implies that any variations observed in the posttest results can be attributed to the effects of the intervention rather than initial differences between the groups. This has important implications for the interpretation of the subsequent results and the effectiveness of the intervention. It indicates that any improvements or changes in mathematical creativity observed in the posttest phase can be attributed to the specific instructional approaches and interventions implemented in the experimental group. These findings align with the study by Deemer, Martin, and Wood (2017), which highlighted the significance of controlled experimental designs to accurately assess the impact of interventions. Therefore, the results provide a foundation for evaluating the effectiveness of the instructional interventions in enhancing mathematical creativity and identifying the potential benefits of these interventions in educational settings.

The Mean Gain Scores of Mathematical Creativity between the Control Group and the Experimental

This study investigated the mean gain of mathematical creativity between the EG and CG. The purpose is to compare the effectiveness of targeted interventions in enhancing students' mathematical creativity scores. The mean gain is calculated by subtracting both groups' pretest and posttest scores.

Table 9. *Mean Gain Scores of Mathematical Creativity between Control and Experimental Group*

Group	*Statements*	*Mean Gain*	*Sd*
Control	Fluency	29.43	18.10
	Flexibility	22.63	13.11
	Originality	25.48	15.64
	Overall Total	25.85	15.30
Experimental	Fluency	41.11	16.08
	Flexibility	34.41	13.22
	Originality	35.98	14.08
	Overall Total	37.17	14.19

Table 9 presents the mean gain scores and standard deviations of mathematical creativity for both the CG and EG. In the CG of 45 participants, the mean gain scores for fluency, flexibility, and originality were 29.43, 22.63, and 25.48, respectively, with corresponding standard deviations of 18.10, 13.11, and 15.64.

On the other hand, the EG, also consisting of 45 participants, demonstrated higher mean gain scores in all three aspects of mathematical creativity: fluency mean is 41.11, flexibility 34.41, and originality 35.98. The standard deviations for the EG were 16.08, 13.22, and 14.08, respectively.

These findings suggest that the intervention implemented in the EG resulted in greater improvements in mathematical creativity compared to the CG. The higher mean gain scores in the EG indicate that the intervention effectively promoted various aspects of mathematical creativity.

The results from Table 9 display a significant implication for students' mathematical creativity development. The higher mean gain scores in fluency, flexibility, and originality in the EG suggest that the intervention implemented in that group successfully fostered creative thinking in mathematics. These findings align with previous research on interventions targeting mathematical creativity. For example, Robinson and Williams (2018) highlighted the importance of providing open-ended and exploratory tasks to enhance students' mathematical creativity.

Additionally, Johnson and Smith (2020) emphasized promoting divergent thinking and problem-solving skills in developing mathematical creativity. The results of this study support the effectiveness of interventions that focus on fostering multiple dimensions of mathematical creativity.

By incorporating instructional strategies that encourage students to think critically, generate novel ideas, and approach problems from different perspectives, educators can nurture and enhance students' mathematical creativity, enabling them to become more proficient and innovative mathematicians.

The Difference in the Mean Gain Scores of the Control Group and the Experimental Group

The results in Table 10 indicate the difference in the mean gain scores between the CG and the EG, specifically concerning implementing a CBM. There is a significant difference in the mean gain scores between the CG and EG (t(df)=3.64, pvalue=0.001).

The CG exhibited a mean gain score of 25.85, while the EG, which utilized the CBM, achieved a higher mean gain score of 37.17. These findings suggest that implementing the CBM positively impacted the students' learning outcomes, leading to a greater gain in mathematical knowledge and skills than the CG.

Table 10. *Difference in the Mean Gain Scores of the Control and Experimental Groups*

Group	*n*	*Mean Gain Score*	*t-test*	*p-value*	*Remarks*
Experimental	45	25.85	3.64	0.001	significant
Control	45	37.17			

**significant if pvalue0.05*

The results reveal that using a CBM as an instructional tool has proven effective in enhancing students' learning outcomes in mathematics. The findings align with prior research by Lu and Park (2012), emphasizing the benefits of incorporating multimedia elements, such as cartoons, in educational settings to enhance students' engagement, motivation, and comprehension.

Cartoons have the potential to present complex concepts in a visually appealing and easily understandable manner, allowing students to grasp mathematical ideas more effectively. Additionally, cartoons can create an enjoyable and interactive learning environment, fostering students' positive attitudes toward mathematics (Lu & Park, 2012). The results are supported by using CBM as a pedagogical approach to enhance student learning experiences and mathematics outcomes.

Furthermore, the significant difference observed in the mean gain scores between the CG and EG highlights the importance of incorporating innovative and engaging instructional methods in mathematics education. Peterson and Williams (2018) emphasize the need for instructional strategies that promote active learning, conceptual understanding, and problem-solving skills.

Using a gamified module aligns with these recommendations, as it encourages active engagement, stimulates critical thinking, and facilitates the application of mathematical concepts in real-world contexts. Moreover, the positive impact of the gamified module may extend beyond immediate learning outcomes, potentially fostering a long-term interest in mathematics and promoting students' mathematical creativity (Peterson & Williams, 2018).

Therefore, the findings have practical implications for educators and curriculum designers, suggesting integrating innovative instructional tools, such as cartoon-based modules, to enhance students' mathematical learning experiences and outcomes.

Instructional materials play a significant role in developing mathematical skills and creativity. The choice of instructional materials can greatly impact a student’s understanding, engagement, and overall performance in mathematics. This study was conducted to develop and validate the Cartoon-based module (CBM) and determine its effect on the students' mathematical creativity in fluency, flexibility, and originality. Based on the gathered and treated data, the significant findings of this study are the following:

The acceptability of the CBM was assessed based on three areas: content, language, and design and layout. Five experts conducted the evaluation, and the findings indicated a high level of acceptability in all three areas. The module's content was rated highly acceptable, with mean scores ranging from 3.60 to 4.00. The language used in the module was considered highly acceptable, promoting critical thinking, relevance to real-life situations, and positive values. The design and layout of the module also received a high level of acceptability, with graphics, colors, and overall presentation enhancing students' interest and engagement.

The comparison of pre-test and posttest scores in mathematical fluency for both the CG and EG showed significant improvement after the intervention. The CG had a mean pre-test score slightly lower than the EG, but both groups demonstrated improvement. The CG's mean posttest score increased to 50.35, while the EG showed a higher mean posttest score of 62.57, indicating a more substantial improvement. The standard deviations indicated individual differences in improvement within both groups, with the EG showing slightly less variability.

The mean scores and standard deviations of students' mathematical flexibility were compared between the CG and EG. Both groups had similar mean pre-test scores, but significant improvements were observed in both groups' mathematical flexibility after the intervention. The CG showed an increase in mean posttest score to 42.74, while the EG had a higher mean posttest score of 54.46. The standard deviations indicated variations in individual differences within each group, with the CG showing a wider range.

The mean scores and standard deviations of students' mathematical originality were compared between the CG and EG. Prior to the intervention, both groups had similar mean pre-test scores, but significant improvements were observed in both groups' mathematical originality scores after the intervention. The CG showed a substantial enhancement, while the EG exhibited a more notable improvement. The standard deviations indicated variations within each group, with the CG displaying a wide range of individual differences in improvement.

The difference in posttest mean scores between the CG and EG was examined to evaluate the impact of a specific intervention on students' mathematical creativity. The EG, consisting of 45 participants, had a significantly higher mean posttest score than the CG. The independent samples t-test confirmed the significant difference, indicating that the intervention implemented in the EG positively affected students' mathematical creativity.

The study examined the mean gain scores of mathematical creativities between an EG and a CG to evaluate the effectiveness of targeted interventions. The EG showed higher mean gain scores in mathematical fluency, flexibility, originality, and overall total compared to the CG.

The study examined the difference in the mean gain scores between a CG and an EG, specifically focusing on the effectiveness of a CBM in mathematics education. The EG, which utilized the CBM, demonstrated a significantly higher mean gain score than the CG. Implementing the CBM positively impacted students' learning outcomes, leading to a greater improvement in mathematical knowledge and skills.

Conclusions

Based on the study's findings, the CBM gained positive impressions as a teaching tool and method in mathematics education. The module received a high-level rating and interpretation of content, language, design, and layout. Additionally, the intervention utilizing the CBM significantly improved students' mathematical fluency, flexibility, and originality compared to the CG. The EG, which implemented the CBM, demonstrated higher mean gain scores and a more consistent improvement in mathematical creativity. These results indicate that the CBM effectively enhanced students' mathematical creativity in terms of fluency, flexibility, and originality.

Based on the study's findings and conclusions, the following recommendations are put forth:

First the Cartoon-based Module (CBM) demonstrated a high-quality interpretation in terms of content, language, design, and layout. As a result, it is suggested that schools consider adopting the CBM as supplementary instructional material to enhance students' mathematical creativity, second is given the significant improvement in students' mathematical fluency, flexibility, originality, and overall creativity due to the CBM intervention, educators and instructional designers, particularly teachers, are advised to seamlessly integrate the CBM into their mathematics classes. This integration holds the potential to elevate students' comprehension and creativity in the subject. Third is the school administrators are encouraged to organize extensive dissemination activities, such as seminars and workshops, aimed at introducing the CBM as a teaching and learning approach, particularly given the current context of lesson delivery. Forth is the effectiveness of CBM in enhancing students' mathematical creativity, particularly in terms of fluency, flexibility, and originality, indicates the necessity for similar studies to be conducted across diverse mathematics domains, academic disciplines, and educational levels. This approach will serve to broaden the method's applicability and enhance its effectiveness. Fifth is that the researchers are urged to further explore and enhance the CBM approach, potentially incorporating additional features such as built-in calculators and graphical presentations facilitated through online platforms linked to the internet. Lastly the CBM could serve as a foundational resource for future studies focusing on nurturing students' critical thinking and problem-solving skills in mathematics through effective interventions akin to the CBM approach.

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Educators have the opportunity to provide various exercises aimed at enhancing fluency in mathematical operations. Manipulatives serve as effective tools for teaching mathematical fluency, as they facilitate students' comprehension of mathematical concepts (National Council of Teachers of Mathematics [NCTM], 2014).

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