GAME-BASED CONCEPTUAL APPROACH IN IMPROVING CONCEPTUAL UNDERSTANDING OF GRADE 7 STUDENTS

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Abstract

The teaching-learning process has been profoundly changed by pedagogy and information technology. The study employed a game-based conceptual approach to assess students' conceptual grasp of mathematics in order to improve the teaching-learning process. The research methodology is aligned with the quantitative design, particularly quasi-experimental research. The study's respondents were 60 grade 7 students in one of the public high schools in Senator Ninoy Aquino in Sultan Kudarat, Philippines. A researcher-made test questionnaire was used to assess the conceptual understanding of grade 7 students in mathematics, and the Evaluation of Instructional Technology Materials (EITM) was used to evaluate the game-based conceptual approach. After the intervention was administered, it was found that there was no significant difference between the two approaches. Based on the t-test result of the mean gain scores of the experimental and control groups, the result of the experimental group had a mean gain score of 16.60 and a standard deviation of 3.136, and the control group had a mean gain score of 15.03 with a deviation standard of 5.417. Since the t-computed value equals 1.37, which is less than $_{ttab}$ (0.05) = 2.002. The results revealed that the experimental group may likely have the same progress in conceptual understanding compared to the control group. This means that teaching topics in Mathematics 7 with a game-based conceptual approach is comparable to teaching them with a procedural approach. Moreover, a game-based conceptual approach may be a substitute for a procedural approach to teaching students mathematics 7. The use of the Game-Based Conceptual Approach and procedural approach are methods of improving the conceptual understanding of the students.

Keywords: *game-based conceptual approach, procedural approach, conceptual understanding, mathematics education, quasi-experimental*

Introduction

Game-based learning is more than just designing games for students to play on the surface; it is also about establishing learning activities that gradually teach subjects and drive users to reach goals. In the mountainous area of Senator Ninoy Aquino, Sultan Kudarat the Datu Ampak Kawan National High School was located and the electricity there was newly installed. Then, the Department of Education provided them smart televisions in every classroom to provide quality education and games using multimedia was really new to the students.

Throughout history, several methods have been used to teach mathematics. Ages, but the utilization of educational materials has been found to be the most purposeful method of teaching mathematics. The reason for this is that educational resources reduce abstract mathematical concepts to the bare minimum of verifiable facts for the student's comprehension of the material, aside from relieving a teacher's stress goes through with instructing the idea. Olaoye et al. (2021) attested on Sunday to the truth that educational resources, when utilized appropriately in the teaching and learning circumstances, can spark and maintain the attention required for appropriating conceptual thinking and ensuring that students retain what they have learned.

Game-based learning is designed to balance theoretical content and learning through the use of games. Game-based learning allows students to explore rigorous learning environments and concepts and targeted learning outcomes (Chen et al., 2018).

Games are a crucial aspect of human culture and society and promote motivation and engagement (Bozkurt et al.,2018). This is why the mechanics of gaming are increasingly transferred to generally game-free contexts, such as primary and secondary school education (Ioannou, 2019), adult and higher education (Huang et al., 2019), healthcare and fitness (e.g. Orji et al.,2018), the workplace (Passalacqua et al., 2020), or consumer behavior (Tobon et al., 2020), to promote desired motivational, behavior and learning outcomes (Zainuddin et al., 2020).

Because of these positive effects, gamification is increasingly adopted in various use cases to promote behavioral change, for example towards engagement in pro-environmental behavior (Du et al., 2020), physical activity or knowledge transfer. It enhances students' learning effectiveness and attitudes more effectively than traditional PPT teaching and influences their dietary habits.

Research Questions

The study determined the effectiveness of the game-based conceptual approach in improving the conceptual understanding of grade 7 students at Datu Ampak Kawan National High School. Thus, the following research questions are examined:

1. What is the level of acceptability of the game-based conceptual approach among experts in terms of:
    1.1. relevance to curriculum;
    1.2. organization and structure; and

   1.3. instructional quality?
2. What is the level of conceptual understanding of the students under the control group based on their pretest and posttest mean scores?
3. What is the level of conceptual understanding of the students in the experimental group based on their pretest and posttest mean scores?
4. Is there a significant difference between the pretest scores of the control and experimental groups?
5. Is there a significant difference between the mean gain scores of the experimental and control groups?

Literature Review

Game-based Learning

Game-based learning is not superior to other learning approaches in terms of educational potential, but that it has a greater potential to enhance motivation and increase student interest in the subject matter (Pho et al., 2015). Contrasting with this assertion, other researchers have established that students are better able to retain knowledge learned through game-based approaches than that encountered through other learning approaches, but that this is dependent on the domain in question; interdisciplinary topics that require skills such as critical thinking, interpersonal communication, and debating are those that are associated with the greatest game-based learning advantage (Kucher, 2021).

The gap between a comprehensive overview and analysis of theoretical foundations in gamification research requires a systematic investigation of the theories used to explain, design, and evaluate gamification to guide future theoretical and empirical research Innovation (Patrício et al., 2018), or energy conservation (Johnson et al., 2017), motivating effects of gamification, serious games, and game-based learning are consistently accompanied by positive behavioral outcomes. These include engagement and participation (Ekici, 2021; Jarnac de Freitas & Mira da Silva, 2020), social collaboration and teamwork and measurable performance improvements in academic and work tasks.

Wanner (2015) described quiz show-style games such as the popular TV game show Jeopardy! as a non-digital information literacy game commonly used effectively in teaching and learning. PowerPoint games to promote active learning in a managerial accounting course.

According to Boctor (2013), the process by which the game-based learning approach supports learning comprises two steps: First, games can motivate students to combine knowledge from various disciplines and utilize it in decision-making processes; and second, students can test how game outcomes change based on the choices and decisions they make. The result affirmed by the study of quiz-style instruction, a game-based learning strategy, impacts students' information literacy development (Wanner, 2015).

According to Jazuli et al. (2017), most pupils need practical help comprehending and using mathematics. They contend that the challenge is brought on by traditional teaching methods that could enhance pupils' talents more effectively. They conducted an experimental investigation to see if contextual learning can enhance conceptual comprehension and problem-solving abilities. Pretest and posttest have been used to examine these two problems, and the findings have been compared using a control group that underwent traditional learning. The findings demonstrated that the contextual learning technique greatly impacts conceptual understanding and the capacity to solve mathematical problems. Many attempts have been made to harness the learning potential of games to deliver educational content in areas such as Mathematics, Language, and Sciences (Jabbar et al., 2015)

Procedural Approach

Study by Aljezawi and Albashtawy (2015), who created a PowerPoint pedagogical game in the form of a quiz similar to the popular game show Jeopardy! and employed as a tool for learning and evaluating students for a range of academic offers. The result of the study may serve as motivation for the teacher to conduct a face-to-face class because the result shows that a game-based conceptual approach is not an ultimate substitute for a procedural approach.

Methodology

Research Design

The pretest and posttest control groups design were used to evaluate the student's achievement, particularly their conceptual understanding, which is necessary for the completion of this study. Quasi-experiment was used for this study since it aims to evaluate intervention, which are game-based conceptual approach and procedural approach. The results were compared to determine the changes that can occur through the experimental treatment between the two groups employing different teaching approaches. These focused on improving conceptual understanding of grade 7 Mathematics through interactive games and procedural approaches. The experimental group involves O1 x O2, and the control group involves O3 and O4 where O1 is the pretest of the experimental group, O2 is the posttest of the experimental group, O3 pretest of the control group, O4 is the posttest of the control group, and x is the intervention was applied to the experimental group. The two groups were compared through this design to determine the changes between the two approaches in improving conceptual understanding of grade 7 students.

Respondents

The respondents of the study were the Grade-7 Anthurium and Sunflower students of Datu Ampak Kawan National High School (DAKNHS), Division of Sultan Kudarat, Region XII, particularly Grade 7 Junior High School students for the School Year 2022-2023. The respondents of the study were chosen through the result of their General Percentage Average (GPA) in Mathematics 7 of the First Quarter of the school year 2022-2023. Which was having a GPA of 81%. There were only two available sections of grade 7 in this school. Thus, they were automatically selected as the respondents of the study. There were sixty (60) students only as respondents to the study, and they would answer the test questions prepared by the researcher before and after the experimentation.

The sixty students were divided into two groups wherein thirty (30) students were in the procedural approach (control group), and the other thirty (30) students were in the game-based conceptual approach (experimental group). The 30 students from Grade 7 Sunflower were under a procedural approach. On the other hand, the 30 students from Grade-7 Anthurium were on the game-based conceptual approach. The respondents of the study are officially enrolled and a grade 7 students at Datu Ampak Kawan National High School for the School Year 2023-2024.

Instruments

The data-gathering instrument was a prepared test questionnaire designed to obtain the necessary data from the respondents. The research instruments assessed the conceptual understanding of Grade 7 students in mathematics, which was measured using their pretest and post-test scores. A researcher-made test utilized which composed of thirty (30) questions particularly the topic includes translates Verbal Phrases to Mathematical Phrases and Mathematical Phrases to Verbal Phrases, it also includes illustration and differentiates the terms related to algebra, evaluates algebraic expressions in every variables given, addition and subtraction of polynomials, derive the exponent according to its laws, multiply and divide a polynomial, to find the algebraic methods and uses models of the following: (1) multiplication of two binomials; (2) sum and difference of two terms and its product; (3) square of two terms or binomial ; (4) cube of two terms/binomial; (5) product of a two terms and a three terms, solve problems expressions of algebra, distinguishes between equations, expressions, inequalities, illustration of one variable of a linear equation and an inequality, location of the solution of the inequality and linear equation in one variable, and resolves an inequality and linear equation in one variable involving graphs and algebraic ways. It was anchored on the DepEd No. 34 for the School Year 2022-2023 The Most Essential Competencies (MELCs) of the DepEd Grade 7 Mathematics Module. Students' performance in Grade 7 Mathematics was assessed using their pretest and post-test scores obtained from the results of the researcher-made test before and after the experiment. To give meaning to the results of their pretest-posttest scores, inferential statistics were used to analyze and interpret the results.

The researcher mostly adapted and modified these research instruments to serve their purpose in the study, and validity and reliability tests were conducted. The construction of the research instrument is considered vital. So, constant monitoring and checking of the progressive drafts of the research instrument were secured by ensuring that the researcher's adviser checked the research instrument for possible refinement, organization, and integration of the suggestions from time to time.

The responses of the three (3) validators were tabulated and computed using Excel; then, the overall mean score came up with 4.50, which was interpreted as very good. The interpretation guide for the validation results is presented below to give meaning to the computed results.

Mean Score Range	Interpretation
4.21 – 5.00	Very Good
3.41 – 4.20	Good
2.61 – 3.40	Average
1.81 – 2.60	Poor
1.00 – 1.80	Very Poor

The researcher used a teacher-made instrument as a tool for a game-based conceptual approach to the conduct of the study. The criteria and rating scale are presented below to evaluate the Instructional Technology Materials, a researcher-made instrument.

Numerical Rating	Range Value	Verbal Interpretation
5	4.21-5.00	Highly Acceptable
4	3.41-4.20	Acceptable
3	2.61-3.40	Moderately Acceptable
2	1.81-2.60	Fairly Acceptable
1	1.00-1.80	Not Acceptable

The evaluation of Instructional Technology Materials (EITM) of Cajandig (2021) determined its degree of agreement among experts to validate the instrument was determined by the reliability coefficient using Krippendorff's test revealed a coefficient, k-alpha = 0.7036, which means a high level of reliability.

The evaluation of the instructional technology materials of the three validators resulted in a mean score of 4.88, which means the materials used were interpreted as highly acceptable.

After the validity test of the research instruments, they were distributed to the selected students of a pilot-testing school for the School

Year 2022–2023 to determine their internal consistency. Students who participated in the pilot testing were not included as study respondents and had already passed the subject. The answers of the fifty (50) students involved in the pilot testing were encoded in the Microsoft Excel Software. Kuder-Richardson Formula 20 was utilized to analyze the reliability test of the researcher's questionnaire. It resulted in a coefficient of $r = 0.811$ and the internal consistency interpretation of high correlation. The correlation coefficient (r) was utilized to determine the reliability test of the responses and the internal consistency or homogeneity of the measuring equipment. It also served as the basis for the test instrument's acceptance.

For good research, validity and reliability are the two most important and fundamental things to look at when evaluating any measuring tool or instrument. Validity is about what and how well an instrument measures. Reliability is how confident you can be in the data you get from using an instrument, or how well a measuring tool controls for random error. It must be emphasized that well-constructed research instruments are those that undergo validity and reliability tests.

Procedure

Careful planning and procedures were made to gather the necessary data for this study. Upon the approval of this study and permission from the graduate school to conduct the study, a certificate and transmittal from the graduate school were secured, seeking the approval of the School Head to allow the researcher to conduct the study in the respondent school. Upon getting the approval of the school head to establish the study at the respondent school, a communication letter was sent to the school of the respondent to secure his/her approval and allow the researcher to immerse with the selected student-respondents, particularly in the grade 7 sections Anthurium and Sunflower. After determining the control and experimental groups, the test was administered to both groups to assess the level of their conceptual understanding and determine whether the two groups were comparable. During the experimentation, the two groups were isolated from each other to avoid contamination of information.

After 8 weeks session of teaching, the respondents employed two teaching approaches. They were the game-based conceptual approach and procedural approach. The posttest was administered to measure the conceptual understanding of the respondents in solving math problems. The procedural approach was for the control group. The teacher imposed the traditional teaching method, the chalk-and-board approach. In contrast, the game-based conceptual approach for the experimental group used various games digitally based, specifically PowerPoint game-based, during the discussion. After the equivalence test, the control and experimental groups were given a researcher-made test to determine their pretest scores.

The results taken from the pretest scores were used to assess whether the two groups were comparable and had the same level of academic achievement before the experimentation process. The results of the pretest scores were tabulated using Microsoft Excel, computed, and analyzed. After administering the Pretest, a series of experiments using the intervention was administered to the experimental group, while the traditional method was used for the control group. After the experimentation, a post-test was administered to assess the conceptual understanding of the control and experimental groups. The post-test scores of the two groups, the control and experimental groups, were tabulated and computed using Microsoft Excel to analyze the results. Retrieving all the research instruments administered to the students in the control and experimental groups was the last stage of the data-gathering procedure.

Data Analysis

The relevant data from the control and experimental groups were collected, tabulated, and subjected to appropriate statistical tools to answer the study's research questions. This study used the mean of the subjects' pre-test and post-test scores to determine the level of conceptual understanding of the control and experimental groups in solving the problems. T-test was used to determine the significant difference between mean gain score of the experimental and control group.

Results and Discussion

Acceptability of Game-Based Conceptual Approach

The instructional technology materials, a researcher-made instrument, have been validated by the three (3) expert validators using the Evaluation of Instructional Technology Materials (EITM). The responses of the three (3) validators have been tabulated and computed using Excel to get the overall mean score.

Table 1 presents the assessment of mathematics experts regarding the level of acceptability of the game-based conceptual approach regarding relevance to the curriculum, organization and structure, and instructional quality.

Table 1. *Level of Acceptability of Game-Based Conceptual Approach in Terms of Relevance to Curriculum, Organization and Structure, and Instructional Quality*

Statements	Mean	Sd	Description
Relevance to Curriculum	4.89	0.19	Highly Acceptable
Organization and Structure	4.89	0.19	Highly Acceptable
Instructional Quality	4.87	0.17	Highly Acceptable

The result of the acceptability of game-based conceptual approach in terms of relevance to curriculum indicated that the level of acceptability with the mean of 4.89 with a standard deviation of 0.19 and interpreted as highly acceptable. It implies that the content is

consistent with learning standards in mathematics based on the curriculum, consistently up-to-date, and complete in terms of scope and without missing important information. And it shows that the material in the content facilitates innovative teaching and learning complex concepts, in addition to Gee's argument about the benefits of game-based learning in enhancing student-learning outcomes Day-Black et al., (2015) also support the use of games as an innovative and very effective as a teaching-learning strategy. Pho et al., (2015) stated that game-based learning is not superior to other learning approaches in terms of educational potential, but that it has a greater potential to enhance motivation and increase student interest in the subject matter.

The organization and structure of the Game-Based Conceptual Approach garnered a mean of 4.89 and a standard deviation of 0.19 and were interpreted as "highly acceptable". Then, the materials were presented with clarity, focus, and organization; it was easy to understand and employed appropriate vocabulary; the information was presented in ways familiar to students and easy to use or navigate. It incorporated materials that were appropriate and engaging for students of the community. The material includes an overview and clear instructions on its utilization. The results on the acceptability of the game-based conceptual approach in terms of organization and structure given by the validators were highly acceptable. It shows that the teacher-made instrument incorporates appropriate and engaging materials for the students; the material offers appropriate and easy-to-control, self-exploratory, and intuitive to use.

Wanner (2015) described quiz show-style games such as the popular TV game show Jeopardy! as a non-digital information literacy game commonly used effectively in teaching and learning. PowerPoint games to promote active learning in a managerial accounting course.

The acceptability of the game-based conceptual approach in terms of instructional quality; having a mean of 4.87 with a deviation standard of 0.17, it was evident that the instrument is highly acceptable. It reveals that the material is a teaching tool that follows educational standards, targets students, and helps students to achieve the learning objectives effectively; the material provides multiple learning styles, incorporates strategies for engaging, and is suited for all students, such as open-ended problems to stimulate student critical thinking, to explore, assessment methods are appropriate to expected learning outcomes, and the features enhance the learning experience and facilitate achievement of objectives.

Conceptual Understanding Using Procedural Approach

Table 2 reveals the mean scores of conceptual understanding of the control group (procedural approach) during the pretest and posttest.

Table 2. *Level of Conceptual Understanding of the Control Group*

Control Group	Mean Score	Equivalent Rating	Interpretation
Pretest	9.30	31.00	Beginning
Posttest	24.33	81.10	Approaching Proficiency

Based on table 2 the pretest and posttest mean scores of the control (procedural approach) group results in 9.30 and 24.33, respectively. It also indicates that the students under experimentation with no interventions lack prior knowledge in solving the problems, as indicated by their rating result of 31.00 with the description as a "beginning" during the pretest.

After they were exposed to the teaching approach, namely the procedural approach, the students improved their conceptual understanding as indicated by their rating result of 81.10. However, the description was "approaching proficiency" during the posttest.

Conceptual Understanding Using Game-Based Conceptual Approach

The mean scores of conceptual understanding of the experimental group (game-based conceptual approach) during the pretest and posttest.

Table 3. *Pretest and Posttest Mean Scores of the Experimental Group*

Experimental Group	Mean Score	Equivalent	Interpretation
Pretest	9.53	31.77	Beginning
Posttest	26.13	87.10	Proficient

The pretest and posttest mean scores of the experimental group (game-based conceptual approach) result were 9.53 equivalent to 31.77% interpreted as "beginning" and 26.13 on their posttest equivalent of 87.10% and interpreted as "proficient." It also indicates that the students are under experimentation with no interventions needed to gain prior knowledge to solve a certain problem. At the end of the experiment, the mathematical proficiency of the experimental group was higher than that of the control group. The results in the experimental group, as indicated by their rating result of 9.53 during the pretest and after they underwent the teaching approach, namely the game-based conceptual approach, improved the students.

According to Boctor (2013), the process by which the game-based learning approach supports learning comprises two steps: First, games can motivate students to combine knowledge from various disciplines and utilize it in decision-making processes; and second, students can test how game outcomes change based on the choices and decisions they make. The result affirmed by the study of quiz-style instruction, a game-based learning strategy, impacts students' information literacy development (Wanner, 2015). Game-based learning allows students to explore rigorous learning environments and concepts and targeted learning outcomes (Chen et al., 2018).

Mean Score Difference of the Control Group and Experimental Group in their Pre-test Score

The t-test result of the mean scores of conceptual understanding of the control group and experimental group during the pre-test.

Table 4. *The t-test result of the Pre-Test Scores between the Control Group and Experimental Group*

Pretest	N	Mean Score	SD	Df	t-computed value	t-tabular value
Control Group	30	9.34	2.66	29	0.621	2.002
Experimental Group	30	9.68	2.40			
Mean Difference	0.34				No Significant	

Two-tailed @ α = 0.05(level of significance)

The result in the table above is the t-test results on the pre-test scores of the control and experimental groups. It was indicated in the table that the mean score of the pre-test of the control group was 9.34 with and standard deviation of 2.66, and the mean score of the experimental group was 9.68 and a standard deviation of 2.40. It also resulted in a mean difference of 0.34 and a t-computed value of 0.621 is less than the t tab(0.05) = 2.002. There is enough evidence to claim that the difference between the pretest scores of the control group and experimental group is attributed to chance, this implies that both groups may likely have the same achievement in math 7 before the intervention is introduced to the students. It denotes that both the control group and experimental group were comparable before the experimentation.

Mean Gain Scores on Conceptual Understanding of the Experimental and Control Groups

The table below shows the mean gain scores on conceptual understanding of the experimental and control groups.

Table 5. *The t-test result of the Mean Gain Scores of the Experimental and Control Groups*

Groups	N	Mean Gain Score	SD	Df	t-computed value	t-tabular value
Experimental	30	16.60	3.136	58	1.37	2.002
Control	30	15.03	5.417			
Mean Gain Difference	1.57				No significant difference	

Two-tailed @ α = 0.05(level of significance)

As shown in table 5 reveals the t-test result of the mean gain scores of the experimental and control groups. Based on the results, the experimental group with a mean gain score of 16.60 and a standard deviation of 3.136, and the control group resulted in a mean gain score of 15.03 with a deviation standard of 5.417. Since the t-computed value equals 1.37, which is less than ttab (0.05) = 2.002.

The results reveal that the experimental group may likely have the same progress in conceptual understanding compared to the control group. This means that teaching topics in Mathematics 7 with a game-based conceptual approach is comparable to that of a procedural approach. Moreover, a game-based conceptual approach may be a substitute for a procedural approach to teaching students with mathematics 7.

The result corroborates the findings of studies by Aljezawi et al., (2015), who created a PowerPoint pedagogical game in the form of a quiz similar to the popular game show Jeopardy! and employed as a tool for learning and evaluating students for a range of academic offers. The result of the study may serve as motivation for the teacher to conduct a face-to-face class because the result shows that a game-based conceptual approach is not an ultimate substitute for a procedural approach.

Conclusions

Based on the results, the following conclusions are hereby formulated:

The acceptability of the game-based conceptual approach in terms of relevance to curriculum, organization and structure, and quality of instruction was appropriate and engaging for the students, the content was consistent with learning standards, the materials provided multiple routes for students to explore the concepts and highly accepted as a tool to have a better teaching-learning process. It motivates student's interest as they could explore, interact and collaboratively share bright ideas.

After taking the pretest, the students who were exposed to the procedural method scored noticeably higher on the posttest. The traditional or procedural approach should be used by the teachers as well; this model can help the students learn as well.

Prior to the intervention, the students in the control group required more information on their conceptual understanding, and once the method was put into practice, their conceptual understanding increased. Teachers have an obligation to make sure that a game-based conceptual approach is incorporated into the teaching-learning process since it advances students' learning and increases their enthusiasm for mathematics.

Students that were exposed to the game-based conceptual approach performed better conceptually and received higher posttest scores. Prior to the start of the class, the control and experimental groups' pretest results in math were similar. When taking the pretest, neither group demonstrated any significance. To better understand the subject, the procedural technique and the game-based conceptual approach should both present in teaching and learning process.

In the posttest, the students who were exposed to the game-based conceptual approach performed better and, similarly well as the students who were exposed to the procedural or traditional approach, which also performed better. Even up to these days procedural approach still important in teaching-learning process, and game-based conceptual approach also important since it helps the students learn well and increase their interest in learning mathematics.

From the findings and conclusions derived from the study, the following recommendations were presented:

First, the Game-Based Conceptual Approach was one of the teaching methods, to improve conceptual understanding and can be used to promote active learning. Second, mathematics teachers can also use procedural approaches to follow steps in sequence to solve mathematical problems or reach a mathematical goal to improve the level of conceptual understanding among students. Third, the use of the Game-Based Conceptual Approach supports learning and motivates students to explore and discover new possibilities in a fun and interactive way. Fourth, the use of the Procedural Approach and Game-Based Conceptual Approach are both effective and to better grasp the subject. And lastly, conduct further studies about using procedural and game-based conceptual approaches in teaching mathematics and other subject areas to improve 21st-century skills such as creativity and critical thinking.

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