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Application of Desmos Graphing Calculator in the Context of Maguindanaon Learners in their Least Learned Competencies

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Abstract

Integrating online graphical calculators in mathematics instruction enhances students' conceptual understanding by making abstract concepts more tangible and improving their ability in Mathematics. This study investigates the impact of the Desmos Graphing Calculator on the conceptual understanding and critical thinking skills of Maguindanaon learners in mathematics. Using a parallel convergent mixed-method design, the research integrates a non-equivalent pretest-posttest control group design with a phenomenological approach. A researcher-made test assessed students' conceptual understanding and critical thinking skills, while qualitative data were gathered to explore their learning experiences. The data were analyzed using mean, standard deviation, and t-test. Findings indicate that before the intervention, students demonstrated moderate conceptual understanding but struggled significantly with critical thinking. After integrating the Desmos Graphing Calculator into instruction, students exhibited notable improvements in both areas, suggesting that the tool effectively enhanced their problem-solving abilities. The use of visualization and interactive exploration allowed students to better comprehend abstract mathematical concepts, improving their confidence and engagement. Additionally, qualitative analysis revealed key themes such as initial challenges; the role of visualization, interactive learning, and increased motivation. The study concluded the value of integrating digital tools into mathematics instruction, particularly in enhancing conceptual understanding and higher-order thinking skills. It is recommended that educators incorporate interactive graphing applications and student-centered strategies to foster deeper mathematical comprehension. Future research should explore the long-term effects of technology-driven learning and its impact on other mathematical competencies.

Keywords: Desmos Graphing Calculator, conceptual understanding, critical thinking, mathematics education, interactive learning, Maguindanaon learners.

Introduction

Almost everything in life is a problem and it has become the central part of human life as well as in the mathematics field. With advances in information and communications technology, it is impossible to avoid the impact of technology on mathematical problem solving. Students before can only utilize the physical calculator to help discover solutions. With the help of technology, it is easy to access the online graphing calculator as tool in developing their performance in polynomials through their critical thinking and conceptual understanding.

Graphing calculators offered many benefits in the classroom, such as its being used to develop concepts, drills, enhance problem solving, and most importantly save time. However, because of its very high price, it became inaccessible to most of the students in the Philippines (Balantes & Tonga, 2020). Now, since smartphones and tablets are becoming ubiquitous in today's student generation and that it can fit in anyone's pocket, anytime, anywhere, students can already experience the features of a graphing calculator as a mobile application in their devices. This mobile application of a graphing calculator is what we called "graphing calculator application (Mhurphy, 2016).

Students are struggling to understand the topic in Mathematics when introduced to it and seem to rely mainly on rote memorization of procedures. Students also have difficulty making connections between quadratic inequalities and their pre-concepts such as linear inequalities and quadratic equations (Ndlovu & Ndlovu, 2020). In addition, learners have difficulty providing meaningful solutions in interval notation, leading to errors regarding the domain and range. They also interpret wrongly the connectives 'and' and 'or' in various problem contexts (Drijvers, (2019).

Connecting Mathematics lessons using online graphical calculator is a missing aspect of classroom practice that may help students to construct more accurate visual representations of quadratic inequalities and their solution sets. Using this material in teaching Mathematics appears to have the underexplored potential to meaningfully support, through activity and hands on experiences (Balomenou et al., 2017).

Studies on the students' creativity have not been yet integrated into the Mathematics learning (Cassanova et al., 2023). The students only memorize the procedures without understanding. (Sugiatno & Hartoyo, 2018). However, no recent study have been established applying graphing calculator in polynomial functions.

Students with difficulties in describing values on graphs, including the representation of solution sets by means of the interval notation, might find participation in the graphical calculator -enhanced activities more illustrative and therefore more meaningful (Barrios et al., 2022).

Locally, Maguindanaon learners' critical thinking and conceptual understanding of the lessons in Mathematics remain stagnant, low and lack of computational skills. The low result of the school diagnostic test and summative assessment in Mathematics which majority of the Maguindanaon learners did not hurdle the target score in Grade 10 mathematics. Moreover, Maguindanaon learners at Sultan Sinanggayan were not exposed to this kind of tool such DESMOS.

The researcher aims to investigate the performance of Maguindanaon learners their least learned competencies in critical thinking and conceptual understanding. The ability of the students to solve Mathematical problems embedded in realistic or real-life contexts with the application of DESMOS graphical calculator. Thus, study contributed to the limited literatures and fill the research gaps on the few researches being conducted.

Theoretical Framework

This study was anchored to the several theories like theory of constructivism (Hatano, 1996) and Van de

Walle (2016) and SPIDA Cognitive Theory (Barrios et al., 2022).

In the constructivism theory, students are active participants in the process of their own learning. Each student constructs his or her own knowledge. When students build on their prior knowledge (the knowledge that they already possess) they can understand the new information (Malatjie & Machaba, 2019).

The SPIDA Cognitive Theory was introduced to predict scores in Mathematics and level of critical thinking skills of students. The term SPIDA was derived from the word spider with interconnected webs. In connection to the study, the student with a proficient level of critical thinking can learn Mathematics by discovery, can create meaningful comparisons (analysis), and can identify multiple, innovative, plausible solutions to the problem (solution-finding or problem-solving). The discovery could lead to enhance the critical thinking on the least learned competencies.

The ability to develop skills in searching for the appropriate function, operation, or formula is a positive impact brought about by using calculators. The way the calculator works, and its dynamics are also factors that can influence learners' acceptance and develop their competence in using this technological tool. All these factors, including the comfortability and functionality of using technology in mathematics, can determine the learners' acceptance of using calculators in solving mathematical tasks (Ndlovu & Ndlovu, 2020).

As the study progressed, the author of the theory found out that the three variables under critical thinking namely Solution-Finding or Problem Solving, Information and Discovery, and Analysis (SPIDA) were strong predictors of good scores in Mathematic (Barriois et al., 2022). Good scores in Mathematics would imply having a deep understanding of how and why things work. It has been linked to good well-being, life satisfaction, health, income, employability, and lifespan (Lipnevich et al., 2016).

Research Questions

This study aimed to determine the effect of application of Desmos Graphing Calculator in the context of Maguindanaon learners in their least learned competencies. Specifically, it seeks answers to the following questions:

1. To what extent is the achievement of Maguindanaon learners in Mathematics during the pre-test of the experimental groups in bot conceptual understanding and critical thinking?
2. To what extent is the achievement of Maguindanaon learners in Mathematics during the post – test of experimental group using the DESMOS graphing calculator in both conceptual understanding and critical thinking?
3. Is there a significant difference in the mean scores of Maguindanaon learners in the pre-test and post-test of experimental group exposed to DESMOS graphing calculator in terms of its conceptual understanding and critical thinking?
4. Is there a significant difference in the mean scores of Maguindanaon learners in the experimental group in terms of their conceptual understanding and critical thinking?
5. How do the Maguidanaon learners describe their learning experiences in using the graphical online calculator?

Methodology

This study utilized the explanatory sequential mixed method design which is the combination of true experimental design of the non-equivalent pretest- posttest control group design and phenomenological method. The explanatory sequential mixed-methods design, a type of mixed-method approach that involves collecting and analyzing quantitative data first, followed by qualitative data to explain or build upon the initial

results (Creswell, 2018). This design was appropriate for the research because it allowed the researcher to first measure the effectiveness of the Desmos Graphing Calculator on the learners' least learned competencies in mathematics, and then to explore the personal experiences and perceptions of Maguindanaon learners in using the tool.

The quantitative phase used true experimental since it does not have random assignment of the Grade 10 Maguindanaon learners to group or other strategy to control extraneous variable. That is why in this study the researcher just takes one group or class and uses pretest and posttest to see the result of the treatment. Following the analysis of quantitative results, the second phase involved gathering qualitative data through focus group discussions (FGDs) and/or semi-structured interviews with selected Maguindanaon learners. The purpose of this phase was to explore in greater depth how the learners experienced using the Desmos Graphing Calculator.

In this study, true experimental design was used to evaluate the effectiveness of using DESMOS graphical calculator in the context of Maguindanaon learners towards their least learned competencies in Mathematics. Specifically, Creswell (2018) states that true experiment is experimental situations in which the researcher assigns the participants randomly as one control group. In this study, true experiment engaged a random selection of Maguindanaon learners purposely to neutralize the potential bias of the subjects experimenting. Furthermore, the researcher applied the pre- and posttest design.

Moreover, Creswell (2018) explains that a pre-test provides a measure on some attributes or characteristics that was assessed for participants in an experiment before they receive a treatment. Meanwhile, a posttest is a measure on some attributes or characteristic that was assessed for participants in an experiment after a treatment.

The researcher used phenomenology to explore the learning experiences of Maguindanaon learners in using the graphical online calculator. Phenomenological inquiry supports the researcher in gaining a deeper understanding of the nature or meaning of everyday experiences. This approach was the best choice for this study as the phenomenological point of view emphasizes the importance of understanding what the Maguindanaon learners' experiences and how they interpret the situations (Patton, 2015).

Locale of the Study

This study was conducted in Sultan Sinanggayan Integrated School located in the Municipality of Esperanza, Sultan Kudarat. The school offers both Junior and Senior High School curriculum. It was headed by the school head. The school belongs to the medium category. In terms of geography and sceneries, the location of the school was very accessible to any form of transportation. The school occupies by Maguindanaon students.

The researcher choses the setting of the study because majority of the students perform below the mastery and the school listed many least learned competencies particular in polynomials (SSES, 2024). Moreover, Grade 10 level students are also given the NAT examination, wherein based on 2023 assessment, Grade 10 students perform below mastery level (DepEd, 2023).

Research Participants

The respondents of this research study were the Grade 10 learners at Sultan Sinanggayan Integrated School. The group was used in administering pre-test to the independent variable, applying the experimental treatment to the subject, and administering the posttest in determining their performance in the critical thinking skills and conceptual understanding in Mathematics. Likewise, the researcher selected the Grade 10 Maguindanaon learners because based on last year's data; this group of learners have low MPS in Mathematics.

This study was classified as pre-experimental design since it is slight or no control of extraneous variable. In the one-group pretest-posttest design, a single group is measured or observed not only after being exposed to a treatment, but also before. The experimental group composed of twenty-five (25) Maguindanaon learners in one section was assigned in using the DESMOS graphing calculator. Moreover, for qualitative phase, the researcher selected eight (8) participants through purposive random sampling. The eight (8) target participants can be changed depending upon the attainment of information and saturations. Hennink et al. (2017) supports that saturation is the most commonly cited justification for an adequate sample size. In the selection of participants, the researcher considered the inclusion criteria such as students obtained lower rating or grades in Mathematics and newly exposed in using the applications in Mathematics.

In this study, the researcher used complete enumeration or census sampling technique because the learners of the Grade 10 class have homogeneity than other. All the target respondents' pre-test and post-test scores were recorded for the purpose of the study. According to Arikunto et al. (2022) total sampling was used when all of the population is taken as sample. The sample of this research was done class of Grade 10 students at Sultan Sinanggayan Integrated School. The researcher chooses group one as experimental class was given treatment using the DESMOS graphic calculator. Furthermore, Arikunto (2022) added that if the population is less than 100, it is better to take all of them as the sample but if the total population is more than 100 students, the sample can be taken between 10-15% or 20-25% or more. So, in this research, the researcher obtained all the population as the sample.

Data Gathering Instrument and Procedure

The main data gathering tool described the critical thinking and conceptual understanding of Grade 10 Maguindanaon learners in the least learned competencies is a researcher-made test was validated by Mathematics experts. Seemingly, the data gathering tool in the critical thinking skills will compose of 20-item problem-based questions taken from the least learned competencies. The conceptual understanding test questions were composed of the 50-item multiple-choice test. It was based on the MELC of Grade 10 students during the third quarter of SY 2024-2025. To ensure proper distribution of the test items, Table of Specification (TOS) was prepared. The researcher provided a semi-structured interview guide to the research participants. The interview guide protocol was made using the questions specified stating the learning experiences Maguindanaon learners. The content of the research tool employed main research question, printing questions and probing questions (Robinson, 2023). All these questions aligned with the objectives of the study as indicated in the statements of the problem. In the qualitative phase, the researcher utilized an interview protocol guide during the conduct of semi-structured interviews with Maguindanaon learners. The protocol served as a structured framework that outlined the procedures, key questions, and ethical considerations for conducting the interviews. The guide began with a brief explanation of the purpose of the study, assurance of confidentiality, and a request for informed consent. Initial questions were designed to be simple and non-threatening. These helped the learners feel comfortable and ready to share their experiences. The core of the interview focused on the learners' experiences with the Desmos Graphing Calculator. These questions were open-ended to encourage detailed responses, and they aimed to explore learners' perceptions, challenges, and insights related to their use of the tool.

The first step of the data gathering was the conduct of pre-test to determine the critical thinking skills and conceptual understanding to the identified group or section. In order to have a successful activity, the teacher carefully explained the instructions as well as the mechanics. Consequently, the treatment stage started with the utilization of Desmos Graphic calculator to the Grade 10 students. The researcher handled the class during the period of experimentation to avoid bias in the study. During the experimentation stage that lasted for more or less 2 months, the Grade 10 learners were taught lessons in Mathematics for the third quarter. Every week

the teacher interviewed the selected grade 10 learners on their experiences in using the Desmos graphic calculator. Formative tests were administered at the end of the lesson. At the end of the treatment stage, post-test was administered to the experimental group. The researcher conducted the post-test to ensure the reliability of the data needed in the study. Treatment effect was appraised based on mean gained scores. The content of the post-test was the same as that of the pre-test.

Statistical Treatment

The data that was generated in the pre-test and post-test were tabulated and subjected to statistical treatments. The mean along with standard deviation was used in determining the level of performance of Maguindanaon learners in Mathematics during the pre-test in conceptual understanding and critical thinking. Also, mean along with standard deviation was used in determining the level of performance of Maguindanaon learners in Mathematics during the post-test in conceptual understanding and critical thinking. To determine the significant difference in the pre-test and post-test mean gained scores t-test will be used.

Data Analysis

The qualitative data on the experiences of Maguindanaon learners were analysed, transcribed and coded using the data analysis of Clark Moustakas (1994). Moustakas (1994) indicated that the research procedure starts with classifying the phenomenon under the investigation.

The method of Moustakas (1994) was followed with the following steps: (a) Bracketing the Researcher's Experience, (b) bracketing the Topic, (c) horizontalization, (d) Clustering into Themes, (e) textural Description of the Experience, (f) Structural Descriptions of the Experience, and (g) Textural-Structural Experience.

Ethical Considerations

This study adhered to strict ethical standards to ensure the protection, dignity, and well-being of all participants, particularly the Maguindanaon learners. Prior to the conduct of the study, informed consent was sought from the participants and their parents or legal guardians. They were informed about the study's objectives, procedures, benefits, risks, and their rights, including the right to withdraw at any time without any negative consequences. Participation in the study was entirely voluntary. No coercion or pressure was applied to ensure the willingness of the learners and their guardians to take part in the research. All personal information and responses of participants were kept confidential. Codes or pseudonyms were used to protect the identity of the learners.

Likewise, data collected was used solely for research purposes and was stored securely. The cultural identity, beliefs, and practices of the Maguindanaon learners were fully respected. The research process was conducted in a culturally sensitive manner, ensuring that it did not interfere with or disrespect their traditions or values. The study was designed to minimize any potential harm and maximize possible benefits for the learners. The use of the Desmos Graphing Calculator aimed to enhance learning experiences and outcomes without causing stress or confusion. Necessary permissions and approvals were obtained from the school heads, district/division offices of the Department of Education, and other relevant stakeholders before the implementation of the study. The researcher ensured that data were collected, analyzed, and reported with honesty and transparency. Fabrication, falsification, or misrepresentation of data was strictly avoided.

Results and Discussion

This section presents, analyzes, and interprets the data gathered to determine the effect of the Desmos Graphing Calculator on the mathematics achievement of Maguindanaon learners in addressing their least learned competencies. The data were collected through pre-tests and post-tests focusing on conceptual understanding and critical thinking skills, as well as through qualitative responses describing learners' experiences.

Pre-test Performance of Maguindanaon Learners in Mathematics in Conceptual understanding and Critical Thinking

The level of Conceptual Understanding and Critical Thinking Performance of the Maguindanaon learners in experimental group during the pre-test indicated that the mean score for Conceptual Understanding was 41.92 (SD=6.22) and rated "Fairly Satisfactory" category. The baseline score indicates that no strategies given to the learners. This indicates that Maguindanaon learners have a basic grasp of key concepts but may still require further reinforcement to achieve a deeper understanding. In contrast, the Critical Thinking Performance discloses a significantly lower mean score of 18.72 (4.95), categorized as "Did Not Meet Expectations." This indicates that Maguindanaon learners struggled to analyze, evaluate, and apply knowledge critically. Additionally, the higher standard deviation for Conceptual Understanding and Critical Thinking suggests some variability in performance, indicating that while some learners may have performed relatively well, others faced considerable difficulties.

The data implies that while Maguindanaon students possess some foundational knowledge, they have lack of critical thinking skills necessary to think critically and apply their understanding effectively. The pre-test results for the experimental group reveal remarkable differences in Conceptual Understanding and Critical Thinking Performance. This highlights the need for targeted instructional strategies, such as problem-based learning, inquiry-based teaching, and active discussions, to strengthen both conceptual understanding and critical thinking skills before moving forward with the intervention.

In order to reach a valid and trustworthy conclusion, critical thinking necessitates the effort to gather, interpret, analyze, and evaluate information (Basri & Ari, 2019). In order for students to master the skills and apply them to enhance their performances and reasoning capacity, critical thinking must be incorporated and prioritized in the curriculum while teaching mathematics in schools (Suryawan et al., 2023).

Table 1. Conceptual Understanding and Critical Thinking Performance of the Experimental Group in the Pre-test

Groups	Mean Score	SD	Interpretation
PRE TEST			
Conceptual Understanding	41.92	6.22	Fairly Satisfactory
Critical Thinking	18.72	4.95	Did Not Meet Expectation

Post-test Performance of Maguindanaon Learners in Mathematics in Conceptual understanding and Critical Thinking

Table 2 discloses the level of Conceptual Understanding and Critical Thinking Performance of the Maguindanaon learners in experimental group during the pre-test. As shown, the mean score for conceptual understanding is 71.68 (SD=7.41), is interpreted as Satisfactory. This indicates that Maguindanaon learners demonstrated a good grasp of key concepts, though the relatively high standard deviation indicates variability in their understanding. Meanwhile, the mean score for critical thinking is 64.00, (SD=5.00) which described as satisfactory. This denotes that students have acceptable performance in critical thinking.

The results infer that Maguindanao learners exhibited a moderate level of critical thinking skills, with more consistency in performance across the group. The results indicate that the experimental group was able to apply both conceptual knowledge and critical thinking at a satisfactory level, showing the effectiveness of the intervention in enhancing these skills. The post-test results indicate that the experimental group achieved a satisfactory level of conceptual understanding and critical thinking performance.

The intervention on the use of DESMOS online graphing calculator had a positive impact on learners' learning outcomes. Overall, the results demonstrate that the applied teaching strategy like DESMOS was effective in improving learners' cognitive skills, but there is still room for enhancement to achieve a higher level of proficiency.

Most students said that using Desmos improved their overall comprehension of function ideas, their capacity to evaluate functions, and their ability to visualize their answers wherein all of which are challenging when working with paper and pencil (Chechan et al., 2021). The findings also demonstrated that while prior graphing calculator experiences affected students' capacity to utilize the equipment effectively, they did not always improve their performance. Less adept graphing calculator users were at a disadvantage and created graphs without recognizing critical curve points (McCulloch et al., 2018).

Table 2. Conceptual Understanding and Critical Thinking Performance of the Experimental Group in the Post-test

Groups	Mean Score	SD	Interpretation
POST TEST			
Conceptual Understanding	71.68	7.41	Satisfactory
Critical Thinking	64.00	5.00	Satisfactory

Significant Difference in the Mean Gained Scores of Maguindanaon Learners Using the DESMOS Graphing Calculator

Table 3.1 presents the significant difference in the mean gained scores of Maguindanaon learners in the pre-test and post-test of exposed to DESMOS graphing calculator in terms of their conceptual understanding. As shown, the paired t-test analysis was conducted to determine the effectiveness of the DESMOS graphic calculator in improving the conceptual understanding of the experimental group. The computed t-value (9.59) is considerably high, and the p-value (0.000) falls below the conventional threshold for statistical significance (typically 0.05). Thus, the null hypothesis is rejected. The pre-test mean score (41.92) indicates that prior to

the intervention, students had a relatively low level of conceptual understanding. After the intervention, the post-test mean score (71.68) shows a notable improvement, with a mean difference of 29.76 which has substantial increase on their performance.

This result confirms that the observed improvement is not due to random chance but rather the effect of the intervention. The results reveal a significant increase in the mean scores from the pre-test to the post-test, indicating that the intervention had a positive impact on student learning. These findings align with existing research on effective instructional strategies, reinforcing the idea that targeted interventions can significantly improve student learning outcomes. The results highlight the importance of well-structured teaching methods that engage students in meaningful learning experiences.

According to Mercado and Tandog's (2018) research, students exposed to DESMOS demonstrated noticeably greater accomplishment than those exposed to traditional teaching methods. The inclusion of DESMOS effectively raises student achievement. In their K-12 math classes, math teachers may implement the DESMOS teaching approach. They may also use this approach as a foundation for further research to gain a deeper understanding of teaching with technological advances (Gatdula, 2015).

Table 3.1. The Paired t-test Result for Conceptual Understanding of the Mean Scores of the Experimental Group in the Pre-test and Post- test

Experimental Group	N	Mean Score	SD	df	t – computed value	p-value
Pre - test	25	41.92	6.22	24	9.59*	0.00
Post test	25	71.68	7.41			
Mean Difference		29.76				

$\alpha = 0.05$ level of significance

Table 3.2 presents the significant difference in the mean gained scores of Maguindanaon learners in the pre-test and post-test of experimental group exposed to DESMOS graphing calculator in terms of their critical thinking skills. As shown, the computed t-value of 15.25 ($P=0.000$) is notably high, and confirms that the improvement is statistically significant. Thus, the null hypothesis is rejected.

The pre-test mean score of 18.72 indicates that students initially had a low level of critical thinking skills. However, after the intervention, the post-test mean score increased substantially to 64.00, resulting in a mean difference of 45.28. This significant gain demonstrates the effectiveness of the instructional approach in enhancing students' critical thinking abilities. This indicates that the observed increase in critical thinking scores is unlikely to be due to chance. The paired t-test analysis for critical thinking skills indicates a significant improvement in students' performance after the intervention. These results imply that the effectiveness of the DESMOS graphic calculator is effective in fostering students' ability to analyze, evaluate, and apply knowledge critically. The substantial improvement suggests that the intervention successfully provided students with the necessary cognitive tools to enhance their reasoning and problem-solving skills.

The integration of the Desmos Graphing Calculator into geometry education has been associated with enhancements in students' critical thinking skills. Studies indicate that Desmos facilitates a deeper conceptual understanding of geometric concepts, thereby promoting critical thinking (King, 2017). Incorporating the Desmos Graphing Calculator into geometry instruction has been associated with enhanced critical thinking

skills among students. Its interactive and dynamic features provide a platform for students to engage deeply with geometric concepts, facilitating improved problem-solving abilities and a more profound understanding of mathematics (Muthomi & Mbugua, 2023).

Table 3.2. The Paired t-test Result for Critical Thinking of the Mean Scores of the Experimental Group in the Pre-test and Post-test.

Experimental Group	N	Mean Score	SD	df	t – computed value	p-value
Pre - test	25	18.72	4.95	24	15.25*	0.00
Post test	25	64.00	5.00			
Mean Difference		45.28				

$\alpha = 0.05$ level of significance

Difference in the Post Test Scores of Maguindanaon Learners in Conceptual Understanding and Critical Thinking

Table 4 exhibits the significant difference in the post test scores of Maguindanaon learners in the experimental group in terms of their conceptual understanding and critical thinking. The results of the paired t-test indicate a statistically significant difference in the post test scores between conceptual understanding and critical thinking among students who used the Desmos Graphing Calculator in their learning process. The computed t-value of 2.02 and the p-value of 0.00 ($p < 0.05$) confirm that the difference is significant, suggesting that the intervention had a greater impact on students' conceptual understanding compared to critical thinking. Thus, the null hypothesis is rejected.

Additionally, the mean score for conceptual understanding was 71.68, while for critical thinking; it was 64.00, showing a mean difference of 7.68. This indicates that while both skills improved after the intervention, the enhancement in critical thinking was notably higher. These findings implies that incorporating the Desmos Graphing Calculator into geometry instruction was effective in improving the Maguindanaon learners' critical thinking abilities, making it a valuable tool for modern mathematics education.

One possible explanation for this result is that Desmos provides an interactive and dynamic learning environment that encourages students to explore geometric concepts visually, engage in inquiry-based learning, and develop problem-solving strategies, all of which are key elements of critical thinking (Muthomi & Mbugua, 2023).

Furthermore, the higher gain in critical thinking aligns with previous research emphasizing the benefits of digital tools in fostering deeper reasoning skills. The interactive features of Desmos, such as real-time graph manipulation and dynamic problem-solving tasks, encourage students to test hypotheses, analyze patterns, and make logical inferences—processes that are fundamental to critical thinking (Schwartz, 2016).

Table 4. The Paired t-test Result of the Mean Scores of the Conceptual Understanding and Critical Thinking

Groups	N	Mean Score	SD	df	t - computed value	p-value
Conceptual Understanding	25	71.68	7.41	48	2.02*	0.00
Critical Thinking	25	64.00	5.00			
Mean Difference		7.68				

$\alpha = 0.05$ level of significance

Maguidanaon Learners Learning Experiences in using the Graphical Online Calculator

The fifth research problem explored the Maguidanaon learners' learning experiences in using the graphical online calculator. The learning experiences of Maguinanaon learners in using the graphical online calculator were summarized into 4 themes. The learning experiences pertained to the range of activities, connections and environments in learning mathematics of Grade 10 Maguindanaon learners that integrated the use of DESMOS to improve their knowledge, skills and attitudes. Additionally, data analysis was conducted to identify common themes across the transcription, shedding light on the various experiences of the participants.

The data revealed 4 emergent themes such as Challenges in Learning & Initial Struggles, Conceptual Understanding through Visualization, Exploration & Interactive Learning and Confidence, Engagement & Application.

Emergent Theme 1. Challenges in Learning & Initial Struggles

Theme 1 investigated the theme on the challenges in learning and initial struggles substantiated by 3 clustered themes. Analysis of the data obtained through oral interviews conducted by the researcher revealed that one of the Maguidanaon learners' learning experiences in using the graphical online calculator was challenges in learning and initial struggles.

Students faced initial difficulties in inputting equations correctly, leading to frustration. Syntax errors were a common obstacle, making it difficult for students to understand where they went wrong. Early struggles included difficulties in manipulating graphs and understanding their transformations. "At the beginning, students faced challenges in correctly inputting equations, which often led to frustration. In particular, syntax errors were a frequent obstacle, making it difficult for them to identify and correct mistakes. Moreover, early struggles included difficulties in manipulating graphs and understanding their transformations. As a result, these challenges hindered their overall learning process.

The findings of this study highlighted the challenges students encountered when working with mathematical equations and graphing tools. Initially, many students struggled with correctly inputting equations due to syntax errors, which often led to frustration and hindered their learning progress. This difficulty aligned with previous studies that emphasize the importance of user-friendly interfaces and proper training in mathematical software to minimize errors and enhance engagement. Moreover, challenges in manipulating graphs and understanding transformations indicated gaps in conceptual knowledge and technical proficiency.

The findings concluded that, students' initial difficulties with inputting equations, syntax errors, and graph manipulation highlighted the need for targeted instructional interventions. By addressing these challenges through structured guidance, interactive learning tools, and practice-based strategies, educators can enhance students' confidence and competence in mathematical problem-solving. Future research could explore the effectiveness of different teaching approaches and technological innovations in mitigating these challenges, ultimately improving student engagement and learning outcomes.

A study by Dizon et al. (2022) found that high school students often struggled with inputting equations correctly due to syntax errors in graphing tools, leading to frustration and reduced learning motivation. This aligned with research emphasizing the importance of user-friendly interfaces and structured training programs to help students develop proficiency in mathematical software (Santos & Rivera, 2021).

Emergent Theme 2. Conceptual Understanding through Visualization

Theme 2 investigated the theme on the challenges in learning and initial struggles substantiated by 3 clustered themes. Analysis of the data obtained through oral interviews conducted by the researcher revealed that one of the Maguidanaon learners' learning experiences in using the graphical online calculator was conceptual understanding through visualization.

As students experimented with quadratic functions, they gradually recognized the impact of coefficients on the shape and orientation of graphs. Through this exploration, they developed a deeper understanding of how different values influence these variations. Additionally, visual representations played a crucial role in clarifying abstract mathematical concepts, such as identifying the vertex of a parabola.

The results indicate that hands-on experimentation and visual representation significantly enhance students' comprehension of quadratic functions. By manipulating coefficients and observing the resulting changes in graph orientation and shape, students developed a deeper conceptual understanding of mathematical relationships. This aligns with constructivist learning theories, which emphasize active engagement and discovery as key components of effective education.

The findings highlighted the significance of experimentation and visual representation in helping students understand quadratic functions. Through hands-on exploration, students were able to recognize how coefficients affect the shape and orientation of graphs, reinforcing their conceptual understanding. The dynamic nature of experimentation allowed them to observe direct changes in the function's behavior, promoting deeper engagement and inquiry-based learning.

Additionally, visual representations played a vital role in bridging abstract concepts with concrete examples, making mathematical ideas like the vertex and symmetry of a parabola more accessible. These findings align with research emphasizing the effectiveness of active learning strategies in mathematics education, particularly in fostering critical thinking and problem-solving skills.

Experimentation and visual representations were essential tools for enhancing students' understanding of quadratic functions. By manipulating coefficients and observing graphical changes, students developed a more intuitive grasp of mathematical relationships. This study underscored the importance of integrating interactive and visual-based learning approaches in mathematics instruction to support deeper comprehension. Future research could explore the long-term impact of such methods on students' problem-solving abilities and overall mathematical performance.

Morales et al. (2021) explored technology integration traditions, transitions, and best practices in Philippine higher STEAM education, providing insights into effective strategies for incorporating technology into mathematics instruction. Javillonar (2024) investigated the difficulties and errors of Grade 9 learners in solving quadratic equations, leading to the development of strategic intervention materials to enhance understanding.

Emergent Theme 3. Exploration & Interactive Learning

Theme 3 investigated the theme on the exploration & interactive learning substantiated by 3 clustered themes. Analysis of the data obtained through oral interviews conducted by the researcher revealed that one of the Maguidanaon learners' learning experiences in using the graphical online calculator is exploration & interactive learning.

Through interactive exploration, students developed a deeper understanding of how mathematical changes influence graph behavior. Furthermore, discovering interactive features allowed them to engage with mathematical concepts more intuitively. Additionally, self-directed experimentation not only strengthened their comprehension but also boosted their confidence in problem-solving.

The findings suggested that interactive exploration played a crucial role in deepening students' understanding of mathematical concepts, particularly in relation to graph behavior. By actively engaging with interactive features, students were able to visualize how mathematical changes affect quadratic functions, making abstract concepts more tangible. This hands-on approach fostered an intuitive grasp of key mathematical principles, as students moved beyond rote memorization and developed meaningful connections between equations and their graphical representations.

The results highlighted the effectiveness of interactive and self-directed learning in improving students' mathematical reasoning. The ability to manipulate equations and observe immediate graphical changes provided a dynamic learning experience that traditional instruction often lacks. This aligned with constructivist learning theories, which emphasized active participation and discovery as essential components of effective education. Additionally, fostering an intuitive understanding through visual and interactive tools helped students overcome common difficulties in grasping abstract mathematical ideas, such as the vertex, axis of symmetry, and transformations of quadratic functions. Furthermore, self-directed exploration allowed students to develop critical thinking skills, build confidence, and strengthen their problem-solving abilities—key factors in long-term academic success.

In conclusion, interactive exploration, intuitive engagement with mathematical features, and self-directed experimentation significantly enhanced students' comprehension and confidence in learning quadratic functions. By integrating interactive learning strategies into mathematics instruction, educators created more engaging and effective learning experiences that promoted deeper conceptual understanding.

Dela Cruz (2022) found that game-based interactive mathematics lessons improved students' problem-solving skills by making learning more engaging and enjoyable. Similarly, Reyes and Santos (2021) examined the use of digital simulations for Grades 7 to 10 mathematics, demonstrating that visual representations of abstract concepts facilitated deeper comprehension and retention.

Emergent Theme 4. Confidence, Engagement & Application

Theme 4 investigated the theme on the confidence, engagement & application validated by 4 clustered themes. Analysis of the data obtained through oral interviews conducted by the researcher revealed that one of the Maguidanaon learners' learning experiences in confidence, engagement & application.

This suggested that students effectively utilized graphing tools to verify their solutions, thereby reinforcing their understanding of mathematical concepts. Furthermore, these graphing applications bridged the gap between abstract mathematics and real-world applications, making problem-solving more meaningful. In addition, visualization simplified complex problems, allowing students to approach them in a more intuitive and accessible manner. Consequently, the ability to visually confirm their solutions boosted students' confidence in their mathematical reasoning and problem-solving skills.

The findings highlighted the significant role of graphing tools in enhancing students' understanding of

mathematical concepts. By utilizing these tools, students were able to visualize how mathematical changes affect graphs, reinforcing their comprehension through direct interaction. The ability to bridge abstract mathematical principles with real-world applications allowed students to develop a more meaningful connection to the subject. Furthermore, visualization played a crucial role in simplifying complex problems, making them more accessible and intuitive. As a result, students demonstrated increased confidence in their mathematical reasoning and problem-solving skills, further emphasizing the benefits of integrating technology in mathematics education.

The used of graphing tools in mathematics education significantly enhances students' understanding, engagement, and confidence in problem-solving. By providing a bridge between abstract concepts and real-world applications, these tools helped students developed a more intuitive grasp of mathematical relationships. The study underscored the importance of integrating technology into learning environments to promote deeper comprehension and independent problem-solving skills. Future research should explore the long-term impact of digital learning tools on mathematical proficiency and their applicability to other areas of education.

The graphing tools, such as Desmos and graphing calculators, improved student engagement and facilitated comprehension beyond traditional instructional methods (Santos & Rivera, 2022). Furthermore, graphing technologies provided cognitive support, enabling students to visualize complex relationships and problem structures, which enhanced their logical thinking and problem-solving skills (Gonzales et al., 2021). Studies also indicated that integrating graphing applications in K-12 mathematics allowed students to explore functions dynamically, making abstract concepts more accessible and intuitive (Reyes, 2020).

Conclusion

The Maguindanaon students demonstrated a fairly satisfactory level of conceptual understanding but significantly weaker critical thinking abilities, highlighting the need for targeted instructional strategies. The experimental group demonstrated satisfactory levels of conceptual understanding and critical thinking after the intervention. The applied instructional approach effectively supported students' learning and cognitive development. The use of DESMOS significantly improved students' conceptual understanding and critical thinking skills, demonstrating the effectiveness of structured and targeted instructional strategies. There was a significant difference between students' conceptual understanding and critical thinking, with greater improvement in conceptual understanding, highlighting the effectiveness of the Desmos Graphing Calculator in enhancing analytical reasoning and problem-solving skills. The learning experiences of Maguindanaon learners using the graphical online calculator revealed initial challenges but ultimately showed that visualization and interactive learning improved their conceptual understanding, engagement, confidence, and application of mathematical concepts.

Recommendations

School heads may help teachers implement targeted instructional strategies such as problem-based learning, inquiry-based teaching, and active discussions. These approaches may help enhance students' ability to analyze, evaluate, and apply knowledge effectively, leading to overall academic improvement. To enhance students' conceptual understanding and critical thinking, teachers may incorporate more interactive and student-centered learning strategies. Additionally, continuous assessment and targeted interventions may be implemented by the teachers to address individual learning needs and ensure more consistent progress. Teachers may continue implementing evidence-based interventions that promote conceptual understanding, such as interactive learning strategies and hands-on activities.

Other teachers may integrate interactive graphing tools like the Desmos Graphing Calculator to enhance both conceptual understanding and critical thinking skills of students in mathematics. Teachers may provide structured support and guided practice to help Maguindanaon learners overcome initial struggles when using graphical online calculators. The school may adopt hybrid learning to provide flexible, accessible, and engaging educational experiences that cater to diverse learner needs.

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