

Enhancing Students' Mathematical Resilience and Critical Thinking Skills Using e-Modules via Process-Oriented-Guided-Inquiry-Learning Approach

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Abstract The e-modules via Process-Oriented Guided Inquiry Learning (POGIL) approach deals with digital-based Mathematics learning modules on an offline platform called Kotobee application where students perform tasks via collaborative learning technique that employs guided inquiry activities within a cyclic system of exploration, concept invention, and application. The study investigated the mathematical resilience and critical thinking skills of Grade 10 students of Bacusanon National High School. It sought to: determine the level of students' mathematical resilience and identify the level of students' critical thinking skills in Mathematics before and after exposure to e-modules via the POGIL approach; find any significant difference in the student's mathematical resilience and critical thinking skills before and after the exposure to e-modules via POGIL approach; and ascertain any significant difference in the students' critical thinking skills when compared to DepEd standards. The study used a one-shot pre-experimental research design. Results showed that students were more resilient in Mathematics before the intervention. After the intervention, they became more resilient level in Mathematics. On students' critical thinking skills, descriptive statistics indicated a low proficiency level before the intervention but had increased upon exposure to e-modules via the POGIL approach. Test for difference showed that the mathematical resilience of the students exposed to the intervention was comparable. However, a significant increase was noticeable in terms of value, struggle, and growth, which were sub-variables of critical thinking skills. E-modules via the POGIL approach significantly increased students' critical thinking skills towards learning Mathematics. Lastly, the t-test indicated a significant difference in the student's critical thinking skills compared to DepEd standards.

Keywords: *mathematical resilience, critical thinking skills, process-oriented-guided-inquiry-learning approach*

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1. Introduction

Mathematics is one of the core subjects under the K to 12 Curriculum. It is considered a vital subject that uses critical thinking skills. It is also added that the performance of Filipino students in 2019 in a large-scale assessment of the National Achievement Test (NAT) has a low proficiency level in Mathematics, which led to strengthening and developing critical thinking skills. Furthermore, the achievement level attained by the DepEd division of Bukidnon in NAT Grade 10 has a fluctuating trend and is still far below the National Passing Standard of 75% with a 44.32 mean percentage score (MPS) in the Mathematics learning area [1]. Aside from the NAT result, the DepEd at National Level also revealed the latest result of the Programme for International Student Assessment (PISA), in which Filipino learners placed last among 79 participating countries and near last in Mathematics [2].

Tria [3] pointed out that the education sector is one of the highly affected by this time of COVID-19 pandemic, and it was supported by UNESCO in 2020, which stated that countries around the world have temporarily closed some educational institutions just to contain the spread of the said virus and to reduce infections. For this reason, remaining challenges emerged in adapting the new learning modality: lack of funding for the reproduction of self-learning modules (SLM); students struggling with self-studying because of some factors such as limited resources, some students are working; and lack of guidance from their parents. Hence, this study aimed to strengthen and develop critical thinking skills in this new learning landscape and to enhance students' mathematical resilience from printed self-learning modules shifts to e-modules via Process Oriented Guided Inquiry Learning (POGIL) approach that provides non-print materials using Kotobee application and POGIL activities following the three learning cycle: exploration, concept invention, and application with the help of others to train students to be

critical individuals and analytical despite the new learning landscape.

The Process-Oriented Guided-Inquiry Learning (POGIL) approach is an instructional strategy that is process-oriented, which lets students exercise essential process skills such as critical thinking capabilities, teamwork, and problem-solving abilities in class facilitated by the teacher. In addition, it uses the Guided-Inquiry questions to guide students throughout the learning cycle involving exploration, invention, and application [4]. Furthermore, Uchang and Tan [5] studied the Students' Beliefs and Mathematics Performance in a Process-Oriented Guided-Inquiry Learning (POGIL) Environment. The result shows a significant increase in the student's performance before and after the POGIL instruction. This indicates that POGIL instruction effectively changes students' performance in Mathematics.

Numerous studies have been conducted on teaching pedagogies [6-11], student preferences and readiness [12,13], student motivation and attitude [14-17], teachers' skills, competencies, and challenges [18,19,20], assessment techniques and tools [21-24] and other related factors [25-30] to enhance students learning outcome, but little was done on investigating students mathematical resilience and critical thinking skills.

Promoting the students' mathematical resilience is vital in learning Mathematics, especially in promoting overall success and attaining positive results on students' performance in Mathematics [31]. Also, according to Hafiz, Darhim, and Dahlan [32], a person with high mathematical resilience can build social relationships, learn in groups, and discuss certain topics using their knowledge independently. However, the POGIL approach allows students to continue learning in groups in a collaborative learning process using e-modules with the help of the POGIL approach despite the difficulties in a new learning landscape.

This study aimed to examine the effectiveness of using e-modules via the POGIL approach in enhancing students mathematical resilience and critical thinking skills of the Grade 10 students of Bacusanon National High School. Thus, the variables included were students' mathematical resilience, electronic modules (e-modules) via POGIL approach, and critical thinking skills.

2. Materials and Methods

The study assessed the mathematical resilience and critical thinking skills in Mathematics using E-modules via Process-Oriented-Guided-Inquiry-Learning Approach at Bacusanon National High School for SY 2022-2023. A one-shot pre-experimental research design was employed in the study. For quantitative collection of data, a one-shot pretest-posttest pre-experimental design was used. The pretest was conducted on mathematical resilience and critical thinking skills. After the pretest, the students were exposed to e-modules via Process-Oriented-Guided-Inquiry-learning (POGIL) approach, and the posttest was administered after the intervention. Then, an analysis of the quantitative data was made. The participants of this study were divided into two sets: set A is composed of twenty- three (23) students, while Set B is composed of

eighteen (18) and a total of 41 Grade 10 students in Bacusanon National High School. The participants were selected based on their capacity and capability to participate in blended learning (three days of in-person classes and two days of distance learning) using e-modules via the POGIL approach. Furthermore, the participants were officially enrolled in Grade 10 Mathematics subject for the school year 2022-2023 during the first quarter.

This study was conducted at Bacusanon National High School (BNHS) located at Bacusanon, Pangantucan, Bukidnon. Bacusanon National High is a public secondary school under the Pangantucan West district in the Division of Bukidnon of the Department of Education (DepEd). The school adopted blended learning to deliver Grade 7 to Senior High School Lessons.

The researchers sent a written communication before the conduct of the study to the School Principal of Bacusanon National High School, requesting to conduct the study.

The designed e-module via the POGIL approach was validated by three (3) experts: two (2) master teachers and one (1) Mathematics teacher from DepEd junior high school Mathematics department. This intervention used a real-life application in every lesson taught to students. This study was conducted from August 2022 to October 2022.

Prior to instruction, the pretest on mathematical resilience scale questionnaires and the pre-implementation of critical thinking rubric were administered to determine the initial level of students' mathematical resilience and critical thinking skills in Mathematics. After all the topics were covered, a posttest on the mathematical resilience scale questionnaire (same as the content on the pretest) was given to determine the student's mathematical resilience level. The same post-implementation on critical thinking skills rubric was administered to determine the students' critical thinking skills level.

The adopted Grade 10 self-learning module was modified and reinforced by POGIL Worksheet Design from Uchang and Tan [5] using an electronic module (e-module) in a Process-Oriented Guided-Inquiry Learning (POGIL) Approach.

2.1. E-modules via POGIL Approach Implementation

The e-modules via the POGIL approach were used, and blended learning (three 3 days of in-person classes and two 2 days of distance learning) was observed throughout the research period. Students who were exposed to e-modules via the POGIL approach were oriented with the features of the Kotobee application and their functions as they worked collaboratively and were assigned randomly into groups. Each group was given tasks distributed among team members; these are: the leader keeps the team focused on the task and distributes work and responsibilities; the writer prepares consolidated group reports in consultation with others; the timer reminds the team progress to work with a given period of time; and the presenter, presents group's outputs and discussion to the class. These roles rotate weekly, and individuals are prepared to complete similar tasks by themselves.

The features of e-modules via the POGIL approach involve presentation, concept development, examples or teaching videos, skill exercises/problems, application, validation, and reflection on learning and self-assessment. All e-modules via POGIL approach activities followed the three learning cycles: the exploration phase, the concept invention phase, and the application phase. In the exploration phase, students explored a model or data and found its trends or patterns, generate, and test the hypotheses to better understand or explain the data. During the concept invention phase, students defined or invented a new concept using the trends or patterns. Lastly, in the application phase, students applied in the other context to help generalize its meaning and applicability.

After the activity, each group presented their e-modules via POGIL activity outputs. The researcher focused on listening to student discussions and offered guidance without revealing the answers to the given task from the e-module. After reporting, the facilitators identified students' misconceptions and made necessary corrections. Lastly, all outputs are intact in their group portfolio, and other e-modules via POGIL approach activities were given in preparation for the following face-to-face classes.

To identify the level of mathematical resilience of the student, the researcher adopted the Mathematical Resilience Scale (MRS) with permission from the author and was pilot tested with Cronbach alpha 0.71. It is a 24-item scale developed from the construct of mathematical resilience with a reliability value of 0.87. The MRS has three affective abilities: Value (items 1-8), Struggle (items 9-17), and Growth (items 18-24). Ref [34] found that the reliability coefficient obtained for value, struggle, and growth factor on Mathematical Resilience scale are 0.94, 0.73, and 0.83 respectively. It is a 24-item Likert scale with items answered on a five-point scale from strongly agree to strongly disagree. The scoring procedure is as follows:

Rating	Scale	Descriptive Rating	Qualitative Interpretation
5	4.21-5.00	Strongly Agree	Most Mathematically Resilient
4	3.41-4.20	Agree	More Mathematically Resilient
3	2.61-3.40	Undecided	Moderately Mathematically Resilient
2	1.81-2.60	Disagree	Less Mathematically Resilient
1	1.00-1.80	Strongly Disagree	Not at all

To determine the student's level of critical thinking skills in Mathematics, the researcher adopted the critical thinking rubric by the Center for Teaching and Learning (CTL) with the version formulated by North Eastern Illinois University (NEIU). The following criteria in the rubric are Issues, Context, Perspective, Assumption, Evidence, and Implication. For every criterion where the respondent is satisfied in each of the four qualities in the rubric, it counted as one and multiplied by the assigned corresponding weight as shown below:

Scale	Rating	Qualifying Description
1	1.00-1.74	Limited Proficiency
2	1.75-2.49	Some Proficiency
3	2.50-3.24	Proficiency
4	3.25-4.00	High Proficiency

To determine the students' critical thinking quality, the researcher computed the weighted rating on each of the criteria. The consolidated ratings were considered as the students' critical thinking quality. A 4-item real-life word problems test was adopted from DepEd grade 10 Mathematics self-learning modules. The topics included in the lessons were specified in the grade 10 Mathematics curriculum guide on the Essential Learning Competencies (MELCs): arithmetic sequence, geometric sequence, and solving problems involving sequences. Then, the researcher administered the same test in their pretest and posttest.

The data collected were tabulated and analyzed using appropriate statistical tools using the software. Descriptive statistics like mean, standard deviation, frequency, and percentage were used to answer the questions on the descriptive levels. A paired-sample t-test was used to determine the significant difference in the student's mathematical resilience and critical thinking skills in Mathematics. Lastly, a one-sample t-test was used to determine the significant difference in the students exposed to the POGIL approach's critical thinking skills compared to standards used by the Department of Education.

3. Results and Discussions

This section presents the analysis and interpretation of data gathered from the participants, which are relevant for testing the study's hypotheses. The order of presentation follows the sequence of the objectives identified in the study. Tables and other figures are also shown in this part to give a convenient data analysis.

3.1. Mathematical Resilience of Students Before and After Exposure to e-modules Via POGIL Approach

Table 1 shows the student's level of mathematical resilience under value ability. It can be gleaned that the mean score before the intervention was 4.04 and after the intervention was 4.12, interpreted both as more resilient, as reflected in the table below.

It can be observed that the following indicators increased their mean and disclosed a more resilient (More R) interpretation when exposed to e-modules via the POGIL approach: "Mathematics essential for my future.", (3.93) to (4.29); "Knowing Mathematics contributes greatly to achieving my goals.", (3.93) to (4.27); "Mathematics will be useful to me in my life's work.", (4.34) to (4.46); "It would be difficult to succeed in life without mathematics.", (3.66) to (3.73); "Mathematics develops good thinking skills that are necessary to succeed in any career.", (4.07) to (4.10); Mathematics courses are very helpful no matter what I decide to study." (4.02) to (4.05). On the other hand, the following indicators decreased in their mean and showed a declined mathematical resilience interpretation (from most resilient (Most R) to more resilient (More R) when exposed to e-modules via POGIL approach: "Having a solid knowledge of mathematics helps me understand more complex topics in my field of study.", (4.10) to (3.95); and one (1) indicator disclosed a decrease in mean but remained at a more resilient level (Most R): "Thinking

mathematically can help me with things that matter to me.", (4.10) to (3.95). Despite the decrease in some of the indicators, the overall results showed that exposure to e-modules via the POGIL approach retained students' value in Mathematics at the more resilient level. This implies that students giving value to mathematical concepts is necessary when they encounter real-life problems, but students change their attitudes when they face complex topics. By this, they put more effort as needed to develop good thinking skills that are necessary to succeed in any career.

Based on the results, students displayed the importance of learning Mathematics. Students are resilient in Mathematics as they consider Mathematics essential and useful in their daily life. This means that after exposure, students are more resilient in Mathematics with the help of non-print materials. By using e-modules and guided inquiry POGIL activities, they can explore the activities from e-module with the help of others. Also, students are resilient in Mathematics when they believe that knowing Mathematics contributes greatly to achieving their goals and is essential for their future. By this, they felt that Mathematics is useful and worth studying when they solve real-life word problems related to the current situations

and considered that learning Mathematics concepts are necessary to succeed in life.

This finding is similar to the study of Bitayo [33], wherein the level of mathematical resilience undervalued both day and night shifts; students were more mathematically resilient. Also, the result of this study which mentioned that if a student greatly values either studying Mathematics or values the career choice requiring Mathematics, they will be more persistent even in the face of challenges is supported in [34]. The first aspect of mathematical resilience in their study of learning Mathematics has value and importance [35]. Students who have confidence in the benefits of learning Mathematics for their future will be more motivated to learn Mathematics despite the various difficulties. Additionally, similar results were seen when student's mathematical resilience is dominated by the indicator that most students are convinced that Mathematics is valuable and necessary to learn and to be mastered [36].

Next is the level of students' mathematical resilience before and after exposure to e-module via POGIL approach. Results exposed that the overall mean decreased after the intervention, but it remained at a more resilient level, as shown in Table 2.

Table 1. Comparison of the level of Mathematical Resilience Before and After Intervention under Value ability

Indicators	e-modules via POGIL approach			
	Before		After	
	Mean	QI	Mean	QI
Mathematics will be useful to me in my life's work.	4.34	Most R	4.46	Most R
Having a solid knowledge of Mathematics helps me understand more complex topics in my field of study.	4.24	Most R	4.12	More R
Thinking mathematically can help me with things that matter to me.	4.10	More R	3.95	More R
Mathematics develops good thinking skills that are necessary to succeed in any career.	4.07	More R	4.10	More R
Mathematics courses are very helpful no matter what I decide to study.	4.02	More R	4.05	More R
Mathematics is essential for my future.	3.93	More R	4.29	Most R
Knowing Mathematics contributes greatly to achieving my goals.	3.93	More R	4.27	Most R
It would be difficult to succeed in life without mathematics.	3.66	More R	3.73	More R
WEIGHTED MEAN	4.04	More R	4.12	More R

* negative indicators (scoring is reversed)

Legend:

Rating	Range	Descriptive Rating	Qualitative Interpretation
5	4.21-5.00	Strong agree	Most Resilient (Most R)
4	3.41-4.20	Agree	More Resilient (More R)
3	2.61-3.40	Undecided	Moderately Resilient (Mod R)
2	1.81-2.60	Disagree	Less Resilient (Less R)
1	1.00-1.80	Strongly disagree	Not at all.

Table 2. Comparison of the level of Mathematical Resilience Before and After intervention under Struggle Ability

Indicators	e-modules via POGIL approach			
	Before		After	
	Mean	QI	Mean	QI
Everyone makes mistakes at times when doing mathematics.	4.34	Most R	4.34	Most R
Good mathematicians experience difficulties when solving problems.	4.27	Most R	4.05	More R
Struggle is a normal part of working in mathematics.	4.17	More R	4.27	Most R
Making mistakes is necessary to get good at mathematics.	4.07	More R	3.88	More R
People who work in mathematics-related fields sometimes find it challenging.	3.98	More R	4.20	More R
People in my peer group sometimes struggle with mathematics.	3.90	More R	3.98	More R
People who are good at mathematics may fail a hard test about it.	3.71	More R	3.49	More R
Everyone struggles with mathematics at some point.	3.63	More R	3.63	More R
When someone struggles in mathematics, it doesn't mean they have done something wrong. *	2.27	Less R	2.22	Less R
WEIGHTED MEAN	3.82	More R	3.78	More R

* negative indicators (scoring is reversed)

Legend:

Rating	Range	Descriptive Rating	Qualitative Interpretation
5	4.21-5.00	Strong agree	Most Resilient (Most R)
4	3.41-4.20	Agree	More Resilient (More R)
3	2.61-3.40	Undecided	Moderately Resilient (Mod R)
2	1.81-2.60	Disagree	Less Resilient (Less R)
1	1.00-1.80	Strongly disagree	Not at all.

As presented in Table 2, three (3) items disclosed an increase in mean when exposed to e-modules via the POGIL approach, but two (2) indicators remained at a more resilient level (Most R): "People in my peer group struggle sometimes with mathematics." (3.98) to (4.20); "People in my peer group struggle sometimes with mathematics." and "Struggle is a normal part of working in mathematics." (4.17) to (4.27), which showed a mathematical interpretation from more resilient to most resilient when exposed to e-modules via the POGIL approach. Conversely, the following indicators that obtained a slight decrease in their means provide more resilient after exposure to e-modules via the POGIL approach: "People who are good at math may fail a hard test mathematics.", (3.71) to (3.49); "Good mathematicians experience difficulties when solving mathematics problems.", (4.27) to (4.05); and "Making mistakes is necessary to get good at mathematics." (4.07) to (3.88). However, two (2) indicators remained the same before and after the intervention: "Everyone makes mistakes at times when doing mathematics." (4.34), "most resilient level (Most R),"; and "Everyone struggles with mathematics at the some point." (3.63) "more resilient level (More R)." The result shows students in their group recognized struggles to learn Mathematics. Although they face difficulty in learning Mathematics, it does not mean they cannot learn Mathematics.

The result emphasized that three (3) indicators increased slightly in mean, four (4) indicators slightly decreased in their means, and two (2) indicators remained the same. However, the varying least mean difference on the increase and decrease of mean scores imply that students displayed tolerance to put in more hard work and perseverance when they encountered difficulties that are necessary to learn Mathematics. Interestingly, the interpretation posted an overall more resilient in their struggle ability in Mathematics when exposed to e-modules via POGIL approach. This means that after exposure, students displayed positive attitudes toward the difficulties in learning Mathematics and recognized that making mistakes when doing Mathematics is a normal part of working Mathematics, especially relative to others. Also, being more resilient in Mathematics may imply that students had experienced high levels of struggle during the pandemic. It could also probably be attributed to the fact that these students in the post-pandemic era could cope well with the difficulties

from printed self-learning modules to e-modules via the POGIL approach in learning Mathematics with the help of others and teachers that provide positive thought as a facilitator to adapt change in the new learning landscape.

This finding is similar to the study of Bitayo [33], wherein the level of mathematical resilience undergrowth, both day and night shifts, students were more mathematically resilient. Moreover, students who understand that struggle in Mathematics is common to their peer group, to all mathematics students, and even to experts in Mathematics will have more tolerance and more substantial staying power in the face of setbacks [34].

Lastly, the second aspect of mathematical resilience in learning Mathematics requires hard work and perseverance. Students with high resilience when facing difficulties learning Mathematics will respond that it takes more time and effort, so they are expected never to give up and keep trying [35].

The result of the mathematical resilience means gathered before and after intervention undergrowth ability. Gathered data revealed that students' overall growth ability in Mathematics obtained a more resilient QI, as shown in Table 3.

As presented in Table 3, the following indicators negatively stated the increase in the mean when exposed to e-modules via the POGIL approach, but the qualitative interpretation remained the same: "If someone is not good at mathematics, there is nothing that can be done to change that*." (2.78) "moderately resilient" to (3.17) "moderately resilient"; "If someone is not mathematics person, they won't be able to learn much mathematics." (2.66) "moderately resilient" to (2.90) "moderately resilient"; "some people cannot learn mathematics." (2.88) "moderately resilient" to (3.07) "moderately resilient"; "People are either good at mathematics, or they aren't*." (2.02) "less resilient" to (2.10) "less resilient"; "Only smart people can do mathematics*." (3.20) "moderately resilient" to (3.24) "moderately resilient." Conversely, the mean of the following indicators decreased when exposed to e-modules via the POGIL approach, but the qualitative interpretation is still the same: "Everyone's mathematics ability is determined at birth." (3.22) "moderately resilient" to (3.07) "moderately resilient"; "Mathematics can be learned by anyone." (4.51) "most resilient" to (4.44) "most resilient". The results show that students are more resilient in dealing with Mathematics, and some indicators present that students need confidence in their ability to learn the subject.

Table 3. Comparison of the level of Mathematical Resilience Before and After Intervention under Growth ability

Indicators	e-modules via POGIL approach			
	Before		After	
	Mean	QI	Mean	QI
Mathematics can be learned by anyone.	4.51	Most R	4.44	Most R
Everyone's mathematics ability is determined at birth.	3.22	Mod R	3.07	Mod R
Only smart people can do the mathematics. *	3.20	Mod R	3.24	Mod R
Some people cannot learn mathematics. *	2.88	Mod R	3.07	Mod R
If someone is not good at mathematics, there is nothing that can be done to change that. *	2.78	Mod R	3.17	Mod R
If someone is not a mathematics person, they won't be able to learn much mathematics. *	2.66	Mod R	2.90	Mod R
People are either good at mathematics, or they aren't. *	2.02	Less R	2.10	Less R
WEIGHTED MEAN	3.04	Mod R	3.71	More R

* negative indicators (scoring is reversed)

Legend:

Rating	Range	Descriptive Rating	Qualitative Interpretation
5	4.21-5.00	Strong agree	Most Resilient (Most R)
4	3.41-4.20	Agree	More Resilient (More R)
3	2.61-3.40	Undecided	Moderately Resilient (Mod R)
2	1.81-2.60	Disagree	Less Resilient (Less R)
1	1.00-1.80	Strongly disagree	Not at all

The table reflects that the overall mean increased from 3.04 to 3.71, which means that students remained more resilient before and after the intervention. For growth ability, students believed they could develop their Mathematics skills. Still, the decrease in means of some indicators showed that some students agreed that only brilliant students could do Mathematics, while some people could not learn it. This implies that some students need to boost their confidence and become optimistic, and they need to believe in their abilities to develop their mathematics skills in no time.

However, it can be recognized that e-modules via the POGIL approach is an excellent strategy to increase students' growth ability.

The results corroborated the following studies stating that there was an increase in growth ability. This finding is similar to the study of Bitayo [33], wherein the level of mathematical resilience undergrowth, day shifts students were more mathematically resilient, while the night shift students were moderately mathematically resilient. When a student exhibits mathematical resilience, he or she will be characterized with a growth mindset [37]. Students with a 'growth' mindset seek challenges and develop strategies in response to setbacks. A growth mindset is a belief that with desire and effort, everyone can learn Mathematics. It also emphasizes the brain's ability to develop skills and resilience when facing problems [35].

Lastly, the findings of this study are supported by the study of Ishak et al. [35], which explains that the third aspect of mathematical resilience in learning Mathematics is the confidence that they can learn the subject. Positive responses and unyielding attitudes certainly need to be supported by students' confidence so that they will be able to learn and understand Mathematics.

3.2. Students' Critical Thinking Skills in Mathematics Before and After e-modules via POGIL Approach

The summary of the critical thinking skills of the students in Mathematics before and after the intervention, indicating the frequency and percentage of the scores and qualifying description, is shown in Table 4.

Table 4. Summary of Students' Critical Thinking Skills in Mathematics Before and After Intervention

CRITICAL THINKING IN MATHEMATICS (Qualifying Description)	e-modules via POGIL approach			
	Before	%	After	%
High Proficiency	0	0	0	0
Proficiency	0	0	27	66%
Some Proficiency	4	10%	11	27%
Limited Proficiency	37	90%	3	7%
WEIGHTED MEAN	1.20		2.53	

It can be recognized that the student's critical thinking skills in Mathematics improved as time progressed on implementing e-modules via the POGIL approach. Twenty-seven (27) students, or 66%, obtained proficiency level in Mathematics after intervention knowing that no single student got the same result before the intervention.

On the other hand, the number of students with some proficiency level after the intervention increased from four (4) students, or 10% before the intervention, to eleven (11) students, or 27% after the intervention. On the limited proficiency level, there was a decrease in frequency from thirty-seven (37) students, or 90%, before the intervention, to three (3), or 7% after the intervention. The mean score showed promising results as it increased before and after the intervention. This means that students critical thinking skills in Mathematics can be improved by using e-modules via the POGIL approach.

The result of this study in Table 4 shows that the level of students' critical thinking skills before the intervention had limited proficiency. According to CTL (2005) as cited by Tajaon [38], students had limited proficiency and implies that students; fails to identify, summarize, or explain the main problem or question; fails accurately to identify and explain any empirical or theoretical contexts for the issues; fails to formulate and clearly express own point of view; fails to identify and evaluate any of the important assumptions behind the claims and recommendations made; fails to identify data and information that counts as evidence for truth-claims; and lastly fails to identify implications, conclusions, and consequences of the issue [38]. The researcher discovered that participants could not identify the problem or issues presented in the problem, and even the students could not give a complete solution or answer all the pretest questions correctly. This result might be because they are in the stage of adjustment to the new learning landscape from the past two (2) years of distance learning. Aside from that, they are not familiar with the topic yet, which leads to difficulty in learning new terms and tasks related to the topic in real-world problems.

On the other hand, the level of students' critical thinking skills in Mathematics after intervention had reached proficiency level. According to CTL (2005), as cited by Tajaon [38], students had proficiency levels which implies that students were able to; successfully identify, and summarize the main issues, correctly identify all empirical and most of the theoretical contexts relevant to all the main stakeholders in the situation; formulates a clear and precise personal point of view; identify and evaluate all the important assumptions but not the ones deeper in the background; identify all important evidence and rigorously evaluate it; and lastly identify implications, conclusions, and consequences but not all the relevant assumptions, contexts, data, and evidence [38]. After the intervention, students possess a proficiency level, which implies students could still remember the topics discussed in the first quarter, specifically: arithmetic sequence, geometric sequence, and solving problems involving sequences. The students indicated that they have already adapted to the new learning landscape with the help of others as well as teachers and practice basic Mathematics concepts with exploration, concept invention, and application, which are necessary to develop their critical thinking skills in solving real-world problems. The students were able to get a correct answer during the posttest, which was expected. Thus, there is an improvement in the student's critical thinking skills using e-modules via the POGIL approach.

3.3. Paired T-Test of Students' Mathematical Resilience

The difference in students' mathematical resilience between the pretest and posttest using e-modules via the POGIL approach. The overall comparison means it has no significant difference between the level of mathematical resilience of the students before and after intervention using e-modules via the POGIL approach, as shown in Table 5.

Table 5. Comparison of Students Mathematical Resilience between Pretest and Posttest

Mathematical Resilience	N	Mean	SD	t-value	Sig.
Pretest	41	3.66	.26	-.96	0.35
Posttest	41	3.71	.34		

Table 5 presents the t-test between the pretest and posttest. The comparison of means is indicated as follows: the pretest mean was 3.66, while the posttest mean was 3.71. Based on statistical analysis, the difference of means scores with no significant p-value (0.35) is shown. Supported by the p-value (0.35), results imply that there is no significant difference between the level of students' mathematical resilience exposed to e-modules via POGIL approach. Thus, students' level of mathematical resilience in both pretest and posttest remained in Qualitative Interpretation at more resilient level.

This means that after exposure, students remained more mathematically resilient with the help of technology using e-modules via the POGIL approach, as they can gain knowledge collaboratively to non-print learning materials using the Kotobee application guided by the Pogil activity sheet. Also, students are more mathematically resilient when they are able to recognize mistakes in their group in order to reflect and improve in the next activity. More especially when they encountered challenging problems, students completed the task with determination and willingness when they felt that Mathematics could be learned by anyone. The result might be because students become more resilient in Mathematics when they experience high levels of struggles from the past, which could probably be attributed to the fact that these students could cope well with difficulties with a positive mindset. This means that the students have improved their problem-solving skills in the posttest compared to the pretest after exposure to e-modules via the POGIL approach. This also implies that e-modules via the POGIL approach have improved the mathematical resilience of students.

Students with good mathematical resilience always exude confidence in their ability to learn Mathematics; students do not think that Mathematics is something that can only be understood by others, while some cannot even though they face obstacles and failures [35]. Students will remember that they will be able to overcome these difficulties and can understand Mathematics. Hence, students will find ways that can help them to overcome the difficulties of learning Mathematics and believe in the usefulness of the existence of Mathematics.

3.4. Paired T-Test of Students' Critical Thinking Skills in Mathematics

Reflected in Table 6 is the difference of the overall means before and after the assessment of critical thinking skills in e-module via the POGIL approach. It is shown that significant results were drawn from students' critical thinking skills. The overall comparison means it has significant differences before and after the intervention of e-modules via the POGIL approach, as shown in Table 6.

Table 6. Difference of Students' Critical Thinking Skills in Mathematics Before and After Intervention

Critical Thinking Skills	N	Mean	SD	t-value	Sig.
Before	41	1.20	.31	-16.78	.000**
After	41	2.53	.07		

Table 6 shows significant results on students' critical thinking skills in Mathematics before and after intervention using e-modules via POGIL approach. A comparison of means is indicated as follows: before intervention, the mean was 1.20, and after intervention, it became 2.53. The difference of means suggests a generally consistent increase in scores with a significant p-value (.000**) after the analysis. Supported by the p-value (.000**), the effectiveness of exposing students to e-modules via the POGIL approach in enhancing students' critical thinking skills in mathematics in this new learning landscape can be recognized. This implies that e-modules, via the POGIL approach, demonstrated skill in identifying problems and issues, recognizing context, formulating a personal points of view, and identifying and evaluating all important assumptions and evidence to make inferences. This is due to the various information-gathering techniques that e-modules via POGIL approach provides in the three learning cycle: exploration, concept invention, and application. This allows students to explore and discuss several ways to solve a problem, as well as collaborate to arrive at the final solution.

Moreover, the following literature supports the claim of the study that using the features of e-modules via POGIL approach positively affects students' critical thinking skills: Rosadi, Sunarmo and Maridi [39] concluded that the developed POGIL method is effective to be used in teaching and learning to improve the students analytical thinking skills; Irwanto et al. [33] emphasized that the POGIL method is more effective in improving students' critical thinking and problem-solving skills; Uchang and Tan [5] also support this development wherein there is a significant increase in the students' performance in POGIL instruction; Soltis et al. [40] also stated that students' critical thinking skills and problem solving were improved with the use of the POGIL strategy; and Artuz and Redoble [41] on the use of Online Process Oriented Guided Inquiry Learning (O-POGIL) actively engages students in activities that develop their critical thinking skills in mathematics.

With the supporting studies, it can be recognized that there is a remarkable positive effect of e-modules via the POGIL approach, even during this time of COVID-19 pandemic, on students' critical thinking skills in Mathematics. It enhances the students' critical thinking

skills, which can be useful for easier learning of Mathematics in this new learning landscape.

3.5. One Sample T-Test Between the Students' Critical Thinking Skills in Mathematics when compared to standards used by Department of Education

The result of the one-sample t-test of the student's critical thinking skills in Mathematics, when compared to standards used by the Department of Education when exposed to e-modules via the POGIL approach, is shown in Table 7.

Table 7. Comparison of Students' Critical Thinking Skills when compared to standards used by the Department of Education

Variable	$\mu 0$	Mean	SD	t-value	Sig.
Critical Thinking Skills	3	2.53	.45	-6.68	.000**

Since 0.000 is lesser than 0.05, the null hypothesis is rejected. Thus, there is a significant difference in students' critical thinking skills when compared to standards used by the Department of Education in critical thinking based on the DepEd Order No. 73, s. 2012. Initially, guidelines on the assessment and rating of learning outcomes under the K to 12 Basic Education Curriculum to the competencies from each learning area, including Mathematics, are organized according to 21st-century skills. The Proficiency level in DepEd standards of at least seventy-five percent or 75% in the learning outcomes are defined by the following level: knowledge; process skills; understanding; products; and performances. In fact, the result shown in Table 7, which reflects the average rating of students' critical thinking skills, which is 2.5280, is lower than the standardized score, which is not equal to 3. However, 66% of the students exceeded that 75% mark, which means there was an improvement in their critical thinking skills and they reached proficiency level as Table 4 presented. The claims of Hafni [42] also support the result that students can apply their learnings in real-world scenarios or even just in the classroom. This result shows that there are still students who belong to under limited proficiency. Although, within the span of two months, the majority of the students improved their critical thinking skills in solving real-life word problems related to the current situation and reached the DepEd standards at proficiency level. However, the students' computed means still did not reach the 75% mark, entailing improvement on the part of the implementation of the e-modules via the POGIL approach and facilitation of the learning of the students.

Based on the analysis of the study, e-modules via POGIL approach helped students display more resilience in learning Mathematics with effort, help of others, and patience. Students develop critical thinking skills by giving them the opportunity to identify problems and issues, recognize context, formulate personal points of view, and identify and evaluate all important assumptions and evidence to make inferences collaboratively. Within the span of two months, the majority of the students improved their critical thinking skills when compared to

standards used by the Department of Education. Thus, further research should be done to improve the utilization of e-modules via the POGIL approach to train the students to be critical individuals and become resilient not just only in Mathematics but in other related subjects to prepare them for the real world.

4. Conclusions and Recommendations

Based on the findings of the study, the following conclusions are drawn:

The students showed more resilience in Mathematics before using e-modules via the POGIL approach. After the intervention, a posttest on students' mathematical resilience was administered, which resulted in a more mathematical resilience level. Hence, students have a more mathematically resilient level both before and after the intervention. The level of students' critical thinking skills during the pretest is limited proficiency, and they possessed proficiency level in the posttest. The group has an improvement based on the mean scores in the pretest and posttest. There is no significant difference between the level of mathematical resilience of students before and after using e-modules via POGIL approach. It is then concluded that e-modules via POGIL approach can enhance students' mathematical resilience. Using e-modules via the POGIL approach can enhance the student's ability to think critically, which reached a significantly higher posttest score compared to pretest scores. Thus, there is a highly significant difference in the critical thinking skills of students in Mathematics before and after using e-modules via the POGIL approach. Lastly, there is a significant difference between the level of critical thinking skills of students when compared to standards used by the Department of Education. In fact, the average rating of students' critical thinking is lower than the standardized score.

Based on the findings and conclusions of the study, the following recommendations are given:

Since the results show a more resilient level for both pretest and posttest, it is recommended that teachers will look for teaching strategies that will help enhance students' mathematical resilience. Mathematics teachers are advised to utilize technology and non-print materials to maximize instruction, such as the use of e-modules via the POGIL approach to enhance the critical thinking skills of the learners since it is noted in the study that there is an increase in the critical thinking skills of the students before and after using e-modules via POGIL approach. To keep the students more resilient in Mathematics, it is recommended for parents and teachers to take part in the learning of students by giving positive views on Mathematics with effort, help from others, and patience despite having to deal with obstacles and difficulties. Mathematics educators, school administrators, and curriculum makers may initiate to incorporate e-modules via process-oriented-guided-inquiry-learning approach into the curriculum. This may enhance the critical thinking skills of the students not only in Mathematics but in other related subjects. Finally, for future researchers, it is suggested to increase the number of participants in the

utilization of e-modules via the POGIL approach to test the validity of results in a large-scale population.

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