Participatory Educational Research (PER)
Vol.11(6), pp. 242-261, November 2024
Available online at http://www.perjournal.com
ISSN: 2148-6123
http://dx.doi.org/10.17275/per.24.88.11.6

Id: 1468767

Local Language Explanation-Infused Learning Material (LLE) and Activity-Based Formative Assessment (AFA): Enhancing Mathematics Learning

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Article history
Received:
15.04.2024

Received in revised form:
13.09.2024

Accepted:
24.10.2024

Key words:
local language explanation, activity-based, mathematics learning

The study employed mixed-method research, specifically a pre-experimental case study, to explore the influence of implementing local language explanation-infused learning material (LLE) and activity-based formative assessment (AFA) on mathematics learning. The t-test for dependent samples was used to analyze the influence of LLE and AFA on students' mathematics learning. Thematic analysis of the data from informal interviews, focus group discussions, and observations was used to support the findings. The participants were 38 Grade 9 students from one of the public secondary high schools in the Philippines, identified through purposive sampling and selection criteria. The findings showed that using LLE and AFA significantly improves mathematics learning along with illustrating, modeling, and problem-solving with small to medium effect sizes. The thematic analysis results show that the use of LLE is helpful for students to study independently because they find the lessons more straightforward to understand. The use of AFA helps students enjoy learning through individual and group activities, leading to the development of analytical and critical thinking. The study recommends integrating local languages into instructional materials, providing teacher training on LLE and AFA, ensuring resources of

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	adequate sort for formative assessments, and strengthening monitoring mechanisms to enhance the implementation of these practices in the classroom.

Introduction

Achieving sustainable development goals (SDGs) requires a strong foundation in mathematics, which forms the basis of science, technology, and engineering. Despite spending $236 billion annually on math education, the Organisation for Economic Co-operation and Development's (OECD) member nations still lack mathematical skilled talents (Fadel, 2014; Olaosebikan et al., 2022). Similarly, the Association of Southeast Asian Nations (ASEAN) countries also performed below the target mathematics performance except for Singapore, which ranked number one in the Program for International Student Assessment (PISA) 2022 results (Maamin et al., 2021).

The PISA 2022 results show that the mean performance in mathematics across OECD countries fell by a record 15 points between 2018 and 2022. PISA reports also show that 40% of the students reported that in most lessons, the teacher does not show interest in individual learning or does not continually teach until all students understand the topic in the material. Furthermore, 30% reported that in most or every mathematics lesson, students are getting distracted when using digital devices, and as a result, another 25% of students get distracted by other students who use digital devices in class (OECD, 2024a).

Investigating the data in PISA 2022 results using regression analysis shows that 56 out of 81 countries performed below the OECD average performance in reading, and 55 out of 81 countries performed below the OECD average performance in mathematics. As shown in Table 1, reading performance has a strong positive correlation with mathematics performance, R = .935, p = .000, interpreted as highly significant. Further, reading performance can predict mathematics performance, R^2 = .874, F(1, 80) = 546.757, p = .000, interpreted as highly significant.

Table 1 *Regression Analysis of Reading and Mathematics PISA Result 2022*

Predictors	R	R^2	Adjusted R^2	Standard Error	F	Sig.	f^2
(Constant) Reading	.935	.874	.872	20.058	546.757	.000	6.936

Dependent Variable: Mathematics

The value of R^2 shows the percentage of mathematics performance that can be explained by the performance in reading. This means that 87.4% of the changes in mathematics performance can be attributed to students' reading comprehension. Moreover, the effect size (Cohen's f^2) indicates that reading comprehension has a large effect on mathematics performance, with f^2 = 6.936. This implies that a country with high reading performance is expected to perform highly in mathematics. For example, Singapore scored 543 in reading and 575 in mathematics, ranking one in reading and mathematics. Countries with low reading performance will also have low mathematics performance, just like the Philippines, which scored 347 in reading and 355 in mathematics, which ranked 79th and 76th, respectively (OECD, 2024b).

PISA defines reading skills as the entirety of competencies that allow the reader to comprehend and apply the knowledge found in one or more texts provided for a specific purpose (Sincer et al., 2024). Research findings show that reading comprehension significantly affects students' mathematics skills (Akin, 2022; Willcutt et al., 2013). Oral language skills, including phonological processing (LeFevre et al., 2010; Koponen et al., 2020; Vanbinst et al., 2020), vocabulary (Hornburg et al., 2018; Rinne et al., 2020), and listening comprehension (Willcutt et al., 2013; Wang et al., 2016) is also related to mathematics learning. Willcutt et al. (2013) stressed that verbal comprehension comprises vocabulary and comprehension and can explain difficulties in reading and mathematics. Sur and Ates (2022) found a significant relationship between reading comprehension and creative thinking skills. This means that the students in the Philippines are also expected to be low-performing in mathematics because they are low in reading. It implies that reading comprehension affects mathematics learning, and addressing reading comprehension and mathematics learning will benefit the students and enhance their performance in international examinations like PISA.

San Juan (2022) suggests using the Filipino language as a primary language for instruction instead of English in the Philippines. The researcher cited that the results of the National Achievements Tests (NAT) in School Year 2017-2018 and other international and local standardized tests show that many students lack competence in English in academic settings. But even though the students performed better in Filipino than in English, the government still imposed the use of English as a medium of instruction, which, as expected, will generally result in low performance in science and mathematics. Since some 94% of 15-year-old students in non-English speaking countries do not use English at home most of the time, the PISA allows countries to use non-English versions to convert the test to their local language. However, the Philippines used the English version of the PISA tests. In contrast, the East and Southeast Asia countries, and countries in the top 20 of PISA results in mathematics used non-English versions of the PISA tests, and all these countries outranked the Philippines. This means that since the countries used their local language in the PISA test, they have better reading comprehension, which contributes to the success of their students in the PISA 2022 results.

In addition, since PISA results reflect what the students have learned in the classroom, teachers are encouraged to use effective teaching and learning processes to respond to the students' different learning needs, considering reading and mathematical comprehension (Latanga, 2023). According to Godbout and Richard (2000), formative assessment is an integral part of the teaching and learning process, so teacher's assessment practices must be carefully planned to positively influence mathematics learning. Research findings show that formative assessment can positively affect students' mathematics learning (Andersson & Palm, 2017).

Further, the case studies of the Centre for Educational Research and Innovation (CERI, 2008) found that formative assessments contribute to high-performance outcomes by continuously monitoring student progress and understanding by providing ongoing feedback and adjusting instruction accordingly. The critical elements of the formative assessment that emerged were establishing a classroom culture that encourages interaction and use of assessment tools, establishing learning goals and monitoring individual learning progress, using differentiated instructional methods, using different approaches to assess student's learning, giving feedback on student learning, and most importantly, active involvement of the students in the learning process.

The related literature and studies highlighted the relationships between reading comprehension and mathematics learning and the use of formative assessments to achieve a high level of performance in mathematics. However, no investigations have focused on the combined influence of LLE and AFA in a classroom context. The LLE aims to facilitate understanding by infusing local language explanations into discussing mathematics topics in a conversational tone to ensure students comprehend the content efficiently and effectively. The objective of the AFA is to assess students for learning through active participation in activities where feedback is provided to guide students' learning process.

The study's results can benefit teachers, students, curriculum writers, educational leaders, and future researchers. The students will benefit from the learning materials infused with local language explanations and engaging activities developed as formative assessments. The teachers can also be guided by the results and be inspired to integrate local language explanations into mathematics learning materials and instruction and to design and implement activity-based formative assessments to foster a positive learning environment with engaged and participative students. The findings of the study can also enlighten curriculum writers on the importance of infusing local language explanation into the learning materials, especially in schools where English is seldom used. Educational leaders and researchers can be informed of the results of the present study and further investigate its effectiveness.

Hence, this study explored the influence of using local language explanation-infused learning material (LLE) and activity-based formative assessment (AFA) in teaching mathematics on students' mathematics learning. Specifically answered the following questions:

(1) How can the local language explanation be infused into the learning material (LLE)?
(2) What activities can be developed for the activity-based formative assessment (AFA)?
(3) How does using LLE and AFA influence students' mathematics learning?
(4) How does using LLE and AFA influence students' engagement and participation in mathematics learning activities?

Method

Research Design

The study employed a mixed-method research design, specifically, the pre-experimental case study research design (Creswell & Creswell, 2018), to answer the research questions, allowing the researchers to explore the influence of LLE and AFA on mathematics in depth both quantitatively and qualitatively, generating insights for further research. In the pre-experimental research design or one-group pretest-posttest research design, the pre-test provides a baseline measure of the outcome variable, which provides the initial level of performance of the students. After implementing the innovation (LLE and AFA), a post-test was administered to measure the outcome variable again. The qualitative part of the research design of the present study used thematic analysis from observational notes, interview responses, and FGD to provide additional strength and explain the effects of the LLE and AFA on the students' mathematics learning experiences (Saga et al., 2023).

Participants

Considering the research design employed by the study, which is the use of one group as participants, the selection process utilized a multi-stage approach. First, eligible criteria were established. Initially, the group's mean score should be lower than the other groups. The group was purposively selected to participate in the study. Subsequently, students who had at least one absence during the research implementation were not included in the final participants reported in the study. Finally, the study participants were 38 Grade 9 students from one of the public secondary high schools in the Philippines. Further, Grade 9 students were selected because they are around 14 years old and will be the following students to take the PISA when they turn 15 years old (OECD, 2024a). Moreover, at this level, not all students have equal access to high-quality mathematics education, or the resources needed to succeed in learning mathematics (Sun, 2015).

Application Process & Data Collection Tools

The study adhered to all ethical requirements and protocols in data collection. After approval to proceed with the study by the school head and superintendent, the researchers prepare the data-collection tools for data gathering. Professional mathematics teachers in selected public secondary high schools in the Philippines validated the research instruments using the validation forms from the Department of Education (DepEd). The validators should be at least a licensed teacher, have at least five years of experience in teaching mathematics in public secondary high schools, and have a master's degree.

Before conducting the actual data-gathering method, the researcher-made test was first validated. After its revision, it was pilot-tested on 50 Grade 10 students in the same school. When the results are acquired, the pilot testing scores are subjected to item analysis to determine the final items to be included in the test. For the Index of difficulty, the waste item should have at least 0.21 and above the difficulty index to retain or revise. For the discrimination index, the item should have at least 0.20 and above to be included and considered a marginal or very good item (Navarro, Santos, & Corpuz, 2012). A final draft of a 24-item researcher-made mathematics pretest and posttest were created after 36 items were discarded during the item analysis, with a Cronbach alpha of 0.75 interpreted as acceptable. Then, the researchers conducted a student orientation for the participants to discuss the students', parents', and teacher's roles in the study. When the parents give their permission, and the students agree to participate, the informed consent for the parents, students, and teacher is signed.

During the implementation, the teacher and students used validated local language explanation-infused learning materials, which covered topics in quadratic equations, inequalities, and functions from the DepEd K-12 curriculum 2016. This was implemented over 10 weeks (see Table 2). The teacher gave the AFA at the end of each topic to encourage active engagement among students.

Table 2 *Topics, Activities, and Time Allotment*

Topics	Activities	Week and time spent
Equations Transformable into Quadratic Equations	Solve equations that can be transformed into quadratic equations, including rational algebraic equations.	Weeks 1 & 2 (4 hours)
Solving Problems Involving Quadratic Equation	Solve problems involving quadratic and rational algebraic equations.	Weeks 2 & 3 (5 hours)
Quadratic Inequalities	Illustrate quadratic inequalities. Solve problems involving quadratic inequalities.	Weeks 4 & 5 (4 hours)
Quadratic Functions	Represent quadratic functions. Transform quadratic functions into the form $y = a(x - h)^2 + k$. Determine the domain, range, and graph of quadratic functions. Solve real-life problems involving quadratic functions.	Weeks 6 to 10 (11 hours)

Using the observation guide, an invited mathematics teacher from the same school served as the observer. The observation guide is a structured questionnaire that includes observations of students' mathematics performance, understanding, and participation. Additionally, it contains questions to identify learning experiences, challenges, and suggestions for improving activities related to the implementation of local language explanation (LLE) and activity-based formative assessment (AFA).

After implementing the LLE and AFA, the respondents answered the researcher-made mathematics posttest. Informal unstructured interviews and focus group discussions were also conducted after the implementation. The interview guide questionnaire was used to catch students' personal experiences using LLE and AFA. The students are given enough time to express themselves freely and think about their learning experiences. Finally, the focus group discussion (FGD) questionnaire was used to capture students' insights and learning experiences through oral and written responses. Focus Group Discussions (FGD) were conducted in small groups of 5-7 students after each lesson and at the end of the study's implementation. The observation guide questionnaire and FGD were validated for face and content validity.

Data Analysis

This study also utilized the Statistical Package for Social Science (SPSS) to analyze the data after it had been arranged in Microsoft Excel. The mean score was used to describe the data, and the percentage to describe the performance level. The performance level of the learning competencies was computed using the formula, 40 times (mean score divided by the total expected score) + 60 = PL and was classified according to the mastery level set by the Department of Education (Albano, 2019), considering the descriptive equivalent of National Achievement Tests [NAT] scores, 35% and below (very low mastery), 36 – 65 (low mastery), 66 – 85 (average mastery), 86 – 95 (moving towards mastery), 96 – 100 (mastered).

The Shapiro-Wilk test was used to assess the data's normality and ascertain whether the data was suitable for the use of a parametric test. The students' pre-test scores in the researcher-made test were found to be normally distributed ($W = .975$, $p = .555$) and suited for using a parametric test. The paired t-test for dependent samples was employed to measure whether the observed differences in the pre-test and post-test mean scores in the researcher-made mathematics test were significant. Further, Cohen's index (d) was employed to measure the effect size of LLE and AFA on students' mathematics learning. The effect size was interpreted based on Cohen's standard and the new effect size (Sawilowsky, 2009; Serrano, 2018). The

Cohen's Index Interpretation was 2.00 (huge), 1.20 − 1.99 (very large), 0.80 − 1.19 (large), 0.50 − 0.79 (Medium), 0.20 − 0.49 (small), 0.01 − 0.19 (very small). On the other hand, thematic analysis using the teacher's observations, interview responses, and focus group discussion identifies students' learning experiences. Thematic analysis was used to interpret the qualitative data to provide insights into the students' learning experiences while using the LLE and exposed to AFA. Thematic analysis was employed to interpret the qualitative data, offering insights into students' learning experiences while using local language explanations (LLE) and engaging in activity-based formative assessments (AFA).

Results & Discussion

Local language explanation-infused learning material

This study first developed the textbook *Mathematics 9: An Innovative Approach* by Repuya (2017), published by Book on Demands Philippines. The foreword of the textbook explained that the book was an innovation that caters to the reading pleasures of the new generation. Table 3 and Figure 1 show how the local language explanation was infused into the lesson (italicized).

Table 3 *Sample content in the local language explanation-infused learning materials*

Lesson	Use of English	Use of local language (Filipino)
Quadratic Equation	Quadratic equation in which the highest-degree of the unknown quantity is of second degree of the exponent is 2. Example: $x^2 + 8x + 16 = 0$ $2x^2 – 5x + 9 = 0$ The general form of the quadratic equation is $ax^2 + bx + c = 0$, where a, b and c are constants, and a is not equal to zero.	*Ang pinakamataas na exponent ng literal number na "x" ay 2. Kaya ang tawag sa equation na ito ay quadratic equation.* [The highest exponent of the literal number "x" is 2. So this equation is called a quadratic equation.] *Kaya sa quadratic equation na* [So, in this quadratic equation] $2x^2 – 5x + 9 = 0$, *at* [and] $a = 2$, $b = -5$, *at* [and] $c = 9$
Quadratic Function	It refers to a polynomial function having one or more variables in which the highest-degree is of second language. Example: $y = x^2 + 2x + 4 = 0$ The value of y varies depending on the arbitrary values of x, and can be obtained by substituting said arbitrary values for x in the given function.	*Kung ang arbitrary value ng* $x = 1$, *ang value ng y ay makukuha sa pamamagitan ng pagpalit ng 1 sa halip na x sa expression na* $x^2 + 2x + 4$, *dahil dito:* $(1)^2 + 2(1) + 4 = 7$, *kaya ang value ng* $y = 7$. *Sa paghahambing, kung ang arbitrary value ng* $x = 3$, *ang value ng y ay* $(3)^2 + 2(3) + 4 = 19$ [If the arbitrary value of x = 1, the value of y is obtained by substituting 1 for x in the expression $x^2 + 2x + 4$, so: $(1)^2 + 2(1) + 4 = 7$, the value of y = 7. In comparison, if the arbitrary value of x = 3, the value of y is $(3)^2 + 2(3) + 4 = 19$.]

Example 4

The total price of a certain commodity is given by the function $P(x) = x^2 + 8x + 16$. If x is the quantity produced, how much is the total price of the commodity if the company produced 5 items only?

Ang kabuuan na presyo ng kalakal ay $P(x) = x^2 + 8x + 16$. *Kung ang value ng x ay ang dami ng nagawa, magkano ang kabuuan na presyo ng kalakal kung 5 items lang ang nagawa ng kumpanya?*

Solution

If $x = 5$, *then* $P = (5)^2 + 8(5) + 16$

Thus, $P = 25 + 40 + 16$

$P = 81$ *(The total price is Php. 81.00)*

Figure 1. Sample problem with local language explanation.

The LLE presented like a Wattpad story wherein "Filipino-English" delivers the intended lesson without destroying the content. Students will think that the drills are mere games; the instructions and examples are articulated using the Filipino Language and presented in a very conversational tone.

The local language explanation was infused with the learning materials to highlight the mathematical concepts that should be remembered by the students. Further, local language explanations were infused with example problems to elaborate and ensure that the problem is understood. Mathematical terminologies are not translated into the Filipino language; they are explained in the Filipino language (the local language).

Developed Activities for the Activity-based formative assessments

Each AFA is a unique activity designed for a specific lesson. Activities available online and used by professional teachers to deliver their lessons are the inspiration for these learning activities. The activities were: (1) Quadratic Equations Activity Task Cards for lesson 1, (2) Quadratic Equations Puzzle Activity for lesson 2, (3) Domino Task for lesson 3, and (4) Quadratic Function Stationary Activity for lesson 4. Table 4 shows the list of the lessons and the corresponding activity title, materials used, and AFA instruction.

Table 4 *Activity-based formative assessments*

Lesson	Title	Materials	AFA Instruction
Lesson 1: Equation Transformable into Quadratic Equation	Quadratic Equations Activity Task Cards	Quadratic Equations Activity Task Cards (measures 3.5 by 2 inches and printed on a vellum board)	Each group must have a pen, an extra sheet of paper, and answer sheets. The facilitators will distribute the questionnaire containing quadratic equations. The goal of each group is to transform the given equation into its quadratic form and solve for the unknown variable. When done, a group will be asked to share their experience and describe how they arrived at their answers. If the students have queries or clarification regarding the activity, they

			may consult the facilitator.
Lesson 2: Solving Problems involving Quadratic Equation	Quadratic Equations Puzzle Activity	Puzzle Pieces (printed on a vellum board)	The facilitators will distribute each group's questionnaire of a unique quadratic equation or function-worded problems to each group. The group must brainstorm and answer the given problem to start the activity. After answering the problem, the group must present their answer to the facilitator for evaluation; if correct, the group may proceed to solve the following problem. Otherwise, they must re-answer the problem. When done, a group will be asked to share their experience and describe how they arrived at their answers. If the students have queries or clarification regarding the activity, they may consult the facilitator.
Lesson 3: Quadratic Inequalities	Domino Task	Domino Tiles (made of chipboard)	Each group must have a pen, an extra sheet of paper, and answer sheets. The facilitators will distribute the domino tiles to each group. The group must select one domino tile at a time to start the activity. The group must work together to answer the given equation in each tile. After answering the given tile, the group must present their answer to the facilitator for evaluation; if correct, they may answer the next tile. Otherwise, they must re-answer the problem. When done, a group will share their experience and describe how they arrived at their answers. If the students have queries or clarification regarding the activity, they may consult the facilitator.
Lesson 4: Quadratic Functions	Quadratic Function Stationary Activity	Activity Task Cards (measures 3.5 by 2 inches and printed on a vellum board)	Each group must have a pen, an extra sheet of paper, and answer sheets. In this activity, there are 5 stations that you must visit. Your goal is to finish the journey. Each station has a problem that must be answered correctly before you can proceed to the next station. The facilitator will evaluate the answer of each group and will determine if they may proceed or not. When done, a group will be asked to share their experience and describe how they arrived at their answers. If the students have queries or clarification regarding the activity, they may consult the facilitator

In Lesson 1, focusing on Equation Transformable into Quadratic Equation, the activity is called Quadratic Equations Activity Task Cards (Figure 2), wherein the students can apply what they have acquired in the discussion by solving problems in a series of task cards. The class is divided into eight groups, with each group having at most 5 members (the same grouping is used for all activities). Then, each group was given cards (10 cards in each set) containing problems aligned with their topic. Each group is given 25 to 30 minutes to solve all the problems in their task cards. The cards measure 3.5 by 2 inches and are printed on a vellum board so that the quality of the material remains even after being distributed to the students compared to regular paper, which is easy to fold and crumple. After all the groups solved their task cards, the teacher asked them to present their work, explaining how they arrived at their answers, and allowed them to ask the teacher and their classmates if difficulties were encountered after the presentation.

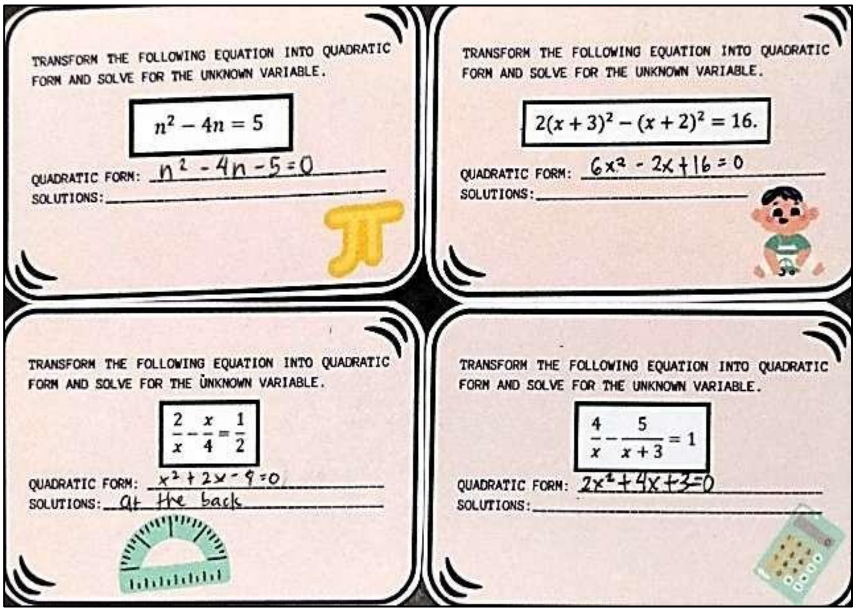

Figure 2. Quadratic Equation Task Cards Sample Activity

For lesson 2, the activity is called Quadratic Equations Puzzle Activity (Figure 3). For this activity, students solved the puzzle by answering the piece containing the questions. Each question has three other partner pieces that include the (1) transformed form of the worded problem, its (2) roots, and (3) standard form. The activity for lesson 2 has 20 puzzle pieces, equivalent to 5 questions. This activity is also based on speed and declares the winning group. In Lesson 3, the activity is called Domino Tiles Task (Figure 4). The students used modified domino tiles to apply their learning about quadratic inequalities after the cooperating teacher discussed the lesson. The groups are given five domino tiles containing the problems and the answers on both ends. The goal for this activity is to place the problem to the answer side by side until they are done placing them on their corresponding sides.

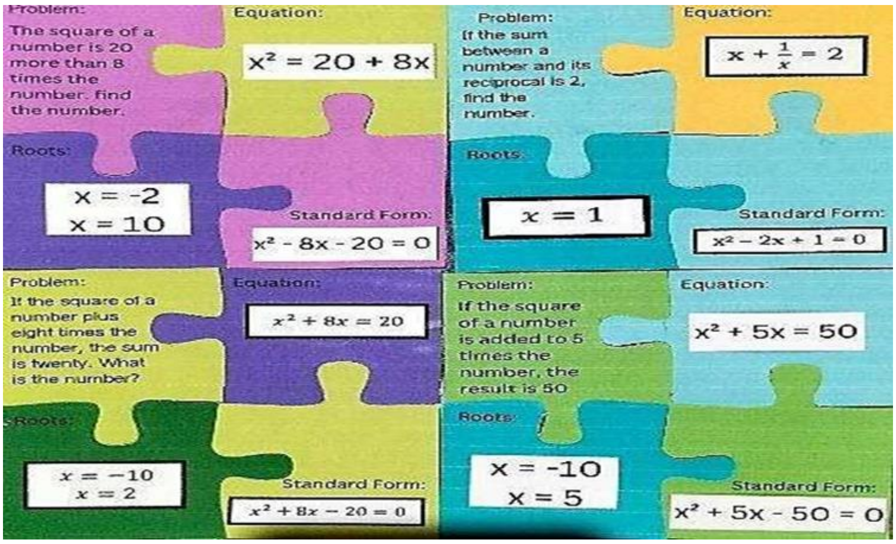

Figure 3. Quadratic Equation Puzzle Pieces Sample Activity

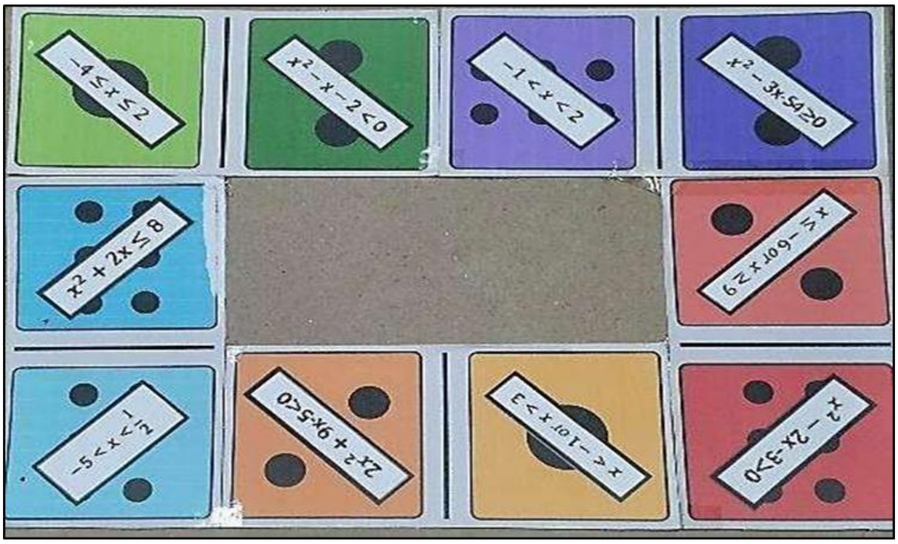

Figure 4. Domino Tiles Task Sample Activity

Finally, for lesson 4, the activity is entitled "Quadratic Function Stationary Activity." This activity has five stations containing one problem each and the students were given an activity sheet and fill it out as they solve each problem in every station. The task is to be completed within 50 minutes. The mathematical concepts involved in this activity are the axis of symmetry, maximum or minimum value, and vertex of a given function.

Influence of the use of LLE and AFA on students' mathematics learning

The participants of the study were from the low-performing class of the school, and the study was conducted to determine the influence of the use of LLE and AFA on students' mathematics learning. In this way, the study can explore the influence of LLE and AFA not only on students' cognitive skills but also on engagement and participation. The topics included are quadratic equations, inequalities, and functions. Three learning competencies were identified based on the curriculum of the Department of Education in the Philippines. Table 5 shows the pretest and posttest mean scores of the students in the researcher-made test.

Table 5 *Results on the pretest and posttest researcher-made test*

Learning Competencies	No. of items	Pre-test Mean	*SD*	*PL*	*Int.*	Post-test Mean	*SD*	*PL*	*Int.*
Illustrate quadratic function by graph	10	4.29	1.43	77.1%	*A*	5.79	1.97	83.1%	*A*
Model real-life situations using quadratic functions, and solve real-life problems involving quadratics	4	1.55	1.06	75.5%	*A*	2.05	1.03	80.5%	*A*
Over-all	24	10.66	2.53	77.8%	*A*	12.08	3.31	80.1%	*A*

Note. Table 5 shows the performance level of the students in the researcher-made test, which shows significant differences between pretests and posttests. The following is the abbreviation and corresponding meaning: *Int*. interpretation; *SD* standard deviation; *PL* performance level;

A average mastery (66% – 85%).

In the pretest, the students' means score shows that the students have average mastery in illustrating, modeling, and solving real-life problems with performance levels of 77.1% and 75.5%, respectively. Overall, the students have a performance level of 77.8%, interpreted as average mastery. The standard deviation shows that the students' scores are homogenous. In the posttest, there was an observable increase in the performance levels of the students. The students' performance level increased by 6% from 77.1% to 83.1% in illustrating quadratic function by graph. In modeling real-life situations and solving real-life problems, the students' performance level increased by 5% from 75.5% to 80.5%. Overall, the students' performance level increased by 2.3% from 77.8% to 80.1%.

To determine if there was a significant difference between pretest and posttest performance levels of the students and the effect of the use of LLE and AFA on students' mathematics learning, table 6 shows the results of the paired-sample t-tests and the effect size.

Table 6 *Results of paired-sample t-test on students' mathematics learning*

Learning Competencies	Pre-test Mean	Post-test Mean	t-value	p-value	*Int.*	*d*	*Int.*
Illustrate quadratic function by graph	4.29	5.79	3.78	.001	S	.61	*M*
Model real-life situations using quadratic functions, and solve real-life problems involving quadratics	1.55	2.05	3.24	.003	S	.53	*M*
Over-all	10.66	12.08	2.43	.020	S	.39	*S*

Note. The following is the abbreviation and corresponding meaning: *Int.* interpretation; S significant ($p < 0.05$); *d* Cohens index; *S* small (0.20 – 0.49); *M* medium (0.50 – 0.79).

Along with the competency, illustrate the quadratic function by the graph, and there is a significant difference between the pretest and posttest scores, t = 3.78, p = .001. Cohen's index shows a medium effect, d = .61. The Result is similar along the competencies, model real-life situations using quadratic functions, and solve real-life problems involving quadratics, which also found the pretest and posttest to be significantly different, t = 3.24, p = 0.003. The effect size also shows a medium effect, d = .53. Overall, there is a significant difference between the pretest and posttest scores of the students, t = 2.43, p = .020. The effect size was found to be small, d = .39.

Results showed that the scores of the students in illustrating, modeling, and solving real-life problems significantly increased. This can be attributed to the use of LLE and AFA. In using the LLE learning materials, the students were able to comprehend the lessons because of the infusion of the local language to explain the concepts. While participating in the AFA, students were exposed to problem-solving activities where they could relate the concepts to concrete and then to real-life problems. It implies that the use of LLE and AFA can improve conceptual understanding in mathematics learning and help students practice problem-solving in more engaging ways.

The result of the study confirmed the statement of Ocampo and Del Rosario (2022) about translation-based instructional material in mathematics and that using translation-based instructional material helps students improve their mathematics learning and talents in answering word problems. Additionally, using the LLE is related to Paz's (2017) study, which mentions that multilingual instruction in mathematics significantly contributes to students' performance.

Influence of the use of LLE and AFA on students' engagement and participation in mathematics learning activities

Thematic analysis was used to identify and interpret themes within the data from the interviews, journals, and FGD to answer the research question. The teacher's observation was also included in the discussion to confirm students' meaningful learning experiences. Table 7 shows the students' learning experiences on the use of LLE and AFA:

Table 7 *Students' learning experiences on the use of LLE and AFA*

Innovations	Students' learning experiences
Use of the Local Language Explanation-Infused learning materials (LLE)	Students find the lesson easier because of the use of Filipino-English instruction in mathematics.
Participation in the Activity-based Formative Assessments (AFA)	Students had fun experiences.
	Students show collaboration and teamwork.
	Students learn to think analytically.

Students find the lesson easier by using Filipino-English in mathematics

Results show that students found the lesson easier than before using the LLE. Student number 20 commends the LLE for having a Filipino explanation. Student number 19 finds it helpful in making the lesson easier because, in this way, students understand the topic's contents faster than the typical English presentation in regular books. Furthermore, Student number 16 explained that after being exposed to AFA, besides making the lesson easier, it also expanded their thinking capability [solving skills] because of the different exercises given under LLE. After introducing AFA, Student 19 finds the lesson much easier by mentioning that the topic is initially difficult but eventually becomes easy. Student number 27 found that participation is a varied experience by describing it as easy and challenging at the same time. Looking at the conclusion given by Student Number 27 explained that the overall experience was a success. Despite the hardship, the students can still solve the problems assigned to them.

The students' response to the interview questionnaire described their experience by giving positive feedback. The following are the students' interview entries about their thoughts and feelings toward the LLE and AFA:

> S20: "Aside from its module [LLE] for understanding and knowledge, it has a Filipino explanation that made us understand it more."

> S01: "I understand the lesson better."

> S19: "I find it hard at first, but when I scanned more on the LLE, I find it a little easy."

S16: "Being exposed to LLE and AFA expanded my thinking capacity, allowing me to be more active in solving mathematical problems on the spot."

S02: "It helps me."

S27: "I find it a little bit easier because the lesson is a bit hard, but we managed to solve it."

The response of the Teacher-Observer (TO) also verifies that students find the lesson easier. This is confirmed by the TO's answer to the question: Do you think the use of LLE and AFA helps the students understand the mathematics lesson? Why did you say so? The TO responds by saying, "Yes, the activities [LLE & AFA] help the students to understand the mathematics lesson better, especially equations that are transformable to quadratic equations. They tend to explore more of their understanding through activities". The TO also added her observation about the active participation of the students by answering the question: What did you observe about the student's performance in mathematics when exposed to LLE? How about their participation in mathematics lessons/activities? Saying, "Students were excited during the interventional learning activities. They were also keen in participating in the said activity".

In summary, from the responses given by the Teachers' Observer (TO) and students, it is observed that the students genuinely find the lessons easier after being exposed to the LLE and AFA. It is also evident that the active participation of the students shows their confidence, which is led by their clear understanding of the lesson. In this study, the feature of LLE of having a Filipino explanation is the key factor for making the lessons easier. This supports the study conducted by Siyang (2018), mentioning that using the mother tongue as a medium of instruction is more effective than using English. Using the language or dialect that the students are more familiar with helps them better understand the concepts in mathematics. Sometimes, language becomes a barrier to effective subject learning aside from difficulty and other factors.

Students had a fun experience

Activities conducted in the classroom help the students to have a fun experience and create excitement among them. The teacher must satisfy the students' positive emotions to ensure learning. Students who feel joy, excitement, and fun tend to learn more than their normal state. This is anchored to Maslow's Hierarchy of Needs in education, stating that "in order to succeed in the learning process, the student's basic needs need to be satisfied," which includes happiness (Alice in Methodologyland, 2020). Additionally, the study conducted by Ge (2021) supports the fun experience by stating that "positive emotions were associated with higher performance while negative emotions were associated with poorer performance and the low-intensity emotions were associated with performance between high and low levels."

Aside from learning the lessons in this study, students also had a fun experience engaging in AFA. Here is a sample of the student's interview responses that depicts their fun experience:

S20: "It is fun but also hard since the time is limited. I got the other answer wrong since I answered it a short time."

S23: "I'm happily conducting something like this, but it's really hard."

S37: "It is not all about solving quadratic formulas, but it helps us to enjoy more solving the puzzle."

S38: "It was fun and enjoyable. At the same time, we learned a lot."

From the statements, Student numbers 20 and 23 mentioned that students both have fun and challenging experiences simultaneously. Difficulties experienced by the students in engaging in AFA are caused by other factors such as time allotment and lesson difficulty. Meanwhile, Students number 37 and 38 stated that the experience of engaging in AFA causes enjoyment for various reasons.

TO also agreed that students had a fun experience while exposed to AFA by confirming in the Teacher Observation Guide Questionnaire response. The TO answered the question, "Do you think the use of Interventional Learning Activities helps the students to understand the mathematics lesson? Why did you say so?" by saying, "Yes, the activity is a big help to them since they were able to explore more of quadratic inequalities in a fun and exciting way." Additionally, the TO also replied positively, showing the fun experience of the students by stating that "Students were actively engaged in the activity." They were excited about the new learning activity as they will experience a new game about Quadratic Inequality while being assessed for learning".

From the statements, it can be deduced that fun experience helps improve the students' mathematics learning. Having a fun experience leads the students to gain more learning compared to the knowledge they get from normal day-to-day engagement in class. It clearly shows that learning is effective when positive emotions are considered. It implies that teachers should implement activity-based assessment activities in the lesson, even before and/or after the discussion, to ensure learning, participation, and engagement. A group can do these activities or perform individually. Furthermore, activities are also suggested to create a fun experience among the students.

The results of the study are similar to the study conducted by Bavi (2018) about the effect of using fun activities on students' elementary-level learning. The study found that those students who were taught fun activities outperformed those taught the traditional way. The study implies that using fun activities to provide effective student learning shows significant results.

Students show collaboration and teamwork.

Cooperative learning happens when students work together in small groups to help each other comprehend a topic (Ridwan et al., 2022). Sometimes, learning with the help of others gives us a much better result since there is collaboration and more than one brain is working to solve a problem. Learning the lesson alone shows a different result than doing it with people to help. This is anchored to the collaborative learning theory, specifically to Vygotsky’s social development theory, as cited by Erbil (2020). This learning theory argues that cognitive development is carried out via social interactions, and the learning process will continue more effectively due to interactions students engage in with peers who are more knowledgeable or adults. Results of the study show that students learned the sense of collaboration and teamwork after being exposed to AFA. The following are some of the entries of the students in the interview and FGD about their thoughts and feelings:

> FGD1: We learned to socialize, and we understood better how to work together and cooperate with each other. We learned a lot.

> FGD5: “It [AFA] helped us a lot, especially when we do groupings because it also serves as our study learning and exchange of knowledge.”

> S37: “There are groupings, and we can help each other better understand [Lesson on Quadratic Inequality].”

S15: "I learn how to solve and participate in the group."

S13 & S38: "I learned how to cooperate well with the members and try to help them with the answers."

Groups 1 and 5 in FGD stated that students learned more while in groupings. The exchange of ideas and cooperation in a group provided by the activities introduced by AFA helped the students grasp the lesson even more. Students number 15 and 37 agree that because of AFA, students' sense of collaboration and teamwork grow with the understanding of the lesson.

The TO also agrees about the developed sense of collaboration and teamwork in students by responding to the question, "How do you think the use of ILA helps the students to understand the mathematics lesson? Why did you say so?" clearly stating that "The use of interventional learning activity helped them not just to understand better the lesson but also they learned that working together will lead them to the right results." Additionally, the TO quoted that during the implementation of LLE and AFA, she observed, "A strong sense of judgment (by oneself and by group) was developed during the activity. They could express their thoughts within the group, and with that, they could make the right judgment/conclusion to arrive at a correct answer".

From the responses, it was evident that collaboration and teamwork drills learning to students' minds. Teachers should be aware of the effect of collaboration and teamwork on students because this knowledge can help enrich the teaching and learning process. Additionally, student engagement can be improved when collaboration is utilized.

The result of the study implies that group activities in classrooms must be considered for students to learn effectively. Teachers can conduct activity-based formative assessments that can be done not only individually but by group. These group activities can also be differentiated so students can choose and be comfortable with their group mates (Answer, 2019; Zens, 2021). The study by Zens (2021) stated that differentiated activities impact student engagement and motivation in class. It also helps them to complete more of their work than those who do not undergo the intervention. Moreover, Anwer (2019) mentioned that activity-based learning is more interesting than lecture-based teaching and can improve students' academic achievement.

Students learned to think analytically and critically.

Through practice, analytical thinking may be stimulated and developed. It is one of the essential skills one must possess, which involves analysis, critiquing, and evaluating problems. The development of analytic thinking skills is anchored to analytic intelligence under Sternberg's Triarchic Theory (Montaku et al., 2012). The students learned to think analytically and critically after using LLE and participating in the AFAs.

The following are some of the statements of the students and Teacher Observer on the interview, Focus Group Discussion, and observation guide questionnaire:

S25: "In this lesson, I learned how to analyze more and understand how to turn the word problem given into an equation, getting the standard form and finding the roots."

S37: "In this lesson, we learned about combining or finding and analyzing the word problem in a short time."

S38: "I learned that you must first analyze the math problem to get the correct equation and roots."

From these, Students 25, 37, and 38 mentioned that because of LLE and AFA, they learned to analyze the question first to get the correct answer. The TO also verified the development of the student's critical thinking skills by answering, "What did you observe about the student's performance in mathematics when exposed to Interventional Learning Activities? How about their participation in mathematics lessons/activities?" The TO stated that "Students were excited during the interventional learning activities. They were also keen on participating in the said activity." The TO also quoted that on AFA, "The activity itself made the students more engaged in the topic, which is problem-solving on quadratic equations." Utilizing LLE and AFA helps students develop analytical and critical thinking skills. This complies with the conceptual framework of mathematics education in the Philippines, which emphasizes critical thinking and problem solving by putting them at the very heart of the curriculum (DepEd, 2016).

Conclusions and Recommendations

Based on the results, the study concludes that using local language explanation-infused learning materials (LLE) and activity-based formative assessment (AFA) in teaching mathematics can enhance students' mathematics learning, specifically along with the competencies such as illustrating, modeling, and problem-solving. The use of LLE is helpful for students to study independently because they find the lessons more straightforward to understand. The use of AFA helps students enjoy learning through individual and group activities, leading to the development of analytical and critical thinking. The following are the recommendations of this study:

(1) Integration of local language in instructional materials and instruction to encourage independent learning and cultivate a positive learning environment.
(2) Training opportunities for teachers on integrating LLE and AFA into their teaching and assessment practices.
(3) Give teachers enough time and resources to develop activity-based formative assessments on their assigned subjects.
(4) Strengthen mechanisms to monitor the implementation of formative assessments in the classroom.
(5) Further research on the long-term effects of LLE and AFA into mathematics instructions employing quasi-experimental research design on a larger scope. In addition, investigate the effectiveness of the implemented innovation to explore any cultural or contextual factors influencing success and identify areas for improvement.

Limitations

Since the present study employed a pre-experimental design, numerous threats can affect the study's validity, such as regression to the mean (RTM), maturation of the subjects, history, and test effects (Marsden & Torgerson, 2012. Additionally, the researchers' involvement in the implementation of the activities further contributed to the study's limitations. However, the result of the study provides necessary preliminary investigation and valuable insights into the intervention's implementation and acceptability and to assess the feasibility and potential effectiveness of LLE and AFA to mathematics learning before conducting more extensive research involving larger samples and experiments (University of Michigan, 2019).

References

Akın, A. (2022). Is reading comprehension associated with mathematics skills: A meta-analysis research. *International Online Journal of Primary Education*, *11*(1), 47-61. doi:10.55020/iojpe.1052559.

Albano, E., Jr. (2019). Grade 6 NAT scores at a 'low mastery' level. *Manila Times*. Retrieved from https://www.manilatimes.net/campus-press/

Alice in Methodologyland (2020). *Maslow's Hierarchy of Needs in Education*. Retrieved from https://www.youtube.com/watch?v=ofjKQsgJz9k]

Andersson, C., & Palm, T. (2017). The impact of formative assessment on student achievement: A study of the effects of changes to classroom practice after a comprehensive professional development programme. *Learning and Instruction*, *49*, 92–102. doi:10.1016/j.learninstruc.2016.12.006

Anwer, F. (2019). Activity-Based Teaching, Student Motivation and Academic Achievement. *Journal of Education and Educational Development*, *6*(1), 154–170. doi:10.22555/joeed.v6i1.1782

Bavi, F. (2018). The Effect of Using Fun Activities on Learning Vocabulary at the Elementary Level. *Journal of Language Teaching and Research*, *9*(3), 629. doi:10.17507/jltr.0903.24

Centre for Educational Research and Innovation (CERI) (2008). *Assessment for learning: Formative assessment*. Retrieved from https://www.oecd.org/site/educeri21st/40600533.pdf

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE.

DepEd (2016). *K to 12 curriculum guide in mathematics*. Retrieved from https://depedbohol.org/v2/wp-content/uploads/2016/03/Math-CG_with-tagged-math-equipment.pdf

Erbil, D. G. (2020). A review of flipped classroom and cooperative learning method within the context of Vygotsky theory. *Frontiers in Psychology*, *11*, Article 1157. doi.org/10.3389/fpsyg.2020.01157

Fadel, C. (2014). Mathematics for the 21st century. *Organisation for Economic Co-operation and Development*. Retrieved from https://oecdedutoday.com/mathematics-for-the-21st-century/

Ge, X. (2021). Emotion matters for academic success. *Educational Technology Research and Development*, 69(1), 67–70. doi:10.1007/s11423-020-09925-8

Godbout, P., & Richard, J. (2000). Formative assessment as an integral part of the teaching-learning process. *Physical & Health Education Journal*, *66*(3), 4. Retrieved from https://www.proquest.com/scholarly-journals/formative-assessment-as-integral-part-teaching/docview/214326086/se-2

Hornburg, C. B., Schmitt, S. A., & Purpura, D. J. (2018). Relations between preschoolers' mathematical language understanding and specific numeracy skills. *Journal of Experimental Child Psychology*, *176*, 84–100. doi:10.1016/j.jecp.2018.07.005

Koponen, T., Eklund, K., Heikkila, R., Salminen, J., Fuchs, L., Fuchs, D., et al. (2020). Cognitive correlates of the covariance in reading and arithmetic fluency: importance of serial retrieval fluency. *Child Development*, *91*, 1063-1080. doi:10.1111/cdev.13287

Latanga G.B. (2023). Mathematical and reading comprehension skills: their influence on social relations among college students. *Indian Journal of Science and Technology*, *16*(3): 214-222. doi:10.17485/IJST/v16i3.1776

LeFevre, J.-A., Fast, L., Skwarchuk, S.-L., Smith-Chant, B. L., Bisanz, J., Kamawar, D., et al. (2010). Pathways to mathematics: Longitudinal predictors of performance. *Child Development*, *81*, 1753-1767. doi:10.1111/j.1467-8624.2010.01508.x

Maamin, M., Maat, S. M., & Iksan, Z., H. (2021). Analysis of the factors that influence mathematics achievement in the ASEAN countries. *Cypriot Journal of Educational Science*, *16*(1), 371-388. doi:10.18844/cjes.v16i1.5535

Marsden, E. & Torgerson, C.J. (2012). Single group, pre- and post-test research designs: Some methodological concerns. *Oxford Review of Education*, 38(5), 583–616. doi:10.1080/03054985.2012.731208

Montaku, S., Kaittikomo, P., & Tiranathan, P. (2012). The Model of Analytical Thinking Skill Training Process. *Research Journal of Applied Sciences*, *7*(1), 17–20. doi:10.3923/rjasci.2012.17.20

Navarro, R. L., Santos, R. G., & Corpuz, B. B. (2012). *Assessment of learning 1* (2nd ed.). Lorimar Publishing, Inc.

Ocampo, M. R., & Del Rosario, A. L. (2022). Explanation-Based Instructional Material in Mathematics and Problem-Solving Abilities of Grade 5 Pupils. *International Journal of Scientific and Management Research*, *5*(3), 225–241. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4068567

Paz, E. C. (2017). Effectiveness of multilingual teaching of mathematics in a tertiary level state university in Bicol Region, Philippines. Asia Pacific Journal of Education, Arts and Sciences, 4(3), 108-113. Retrieved from https://www.apjeas.apjmr.com

OECD (2024a). PISA 2022 Results (Volume I): *The State of Learning and Equity in Education*. Retrieved from https://www.oecd-ilibrary.org/sites/53f23881-en/index.html?itemId=/content/publication/53f23881-en

OECD (2024b). PISA 2022 Results (Volume II): *Learning During-and From – Disruption*. Retrieved from https://www.oecd-ilibrary.org/sites/a97db61c-en/index.html?itemId=/content/publication/a97db61c-en

Olaosebikan, T., Egbon, F. & Olayemi, K. (2022) Mathematical methods Applied to Economy and Sustainable Development Goals. *Open Journal of Modelling and Simulation*, *10*, 283-291. doi:10.4236/ojmsi.2022.103015.

Repuya, C. (2017). *Mathematics 9: An Innovative Approach*. Books on Demand Philippines Inc.

Ridwan, M. R., Hadi, S., & Jailani, J. (2022). A meta-analysis study on the effectiveness of a cooperative learning model on vocational high school students' mathematics learning outcomes. *Participatory Educational Research (PER)*, *9*(4), 396-421. doi:10.17275/per.22.97.9.4

Rinne, L. F., Ye, A., & Jordan, N. C. (2020). Development of arithmetic fluency: A direct effect of reading fluency? *Journal of Educational Psychology*, 112, 110–130. doi:10.1037/edu0000362

Saga, E., Orongan, M. & Abarca, H. (2023). A Case Study of Students' Lost Learning in Mathematics on PostRemote Learning. *International Journal of Multidisciplinary Educational Research and Innovation*, *1*(3), 109-120. doi:10.5281/zenodo.8326009.

Sawilowsky, S. S. (2009). New Effect Size Rules of Thumb. *Journal of Modern Applied Statistical Methods*, *8*(2), Article 26. doi:10.22237/jmasm/vol8/iss2/26

San Juan, D. M. (2022). *What is The best medium of instruction for Philippine Schools?* [Book]. doi:10.13140/RG.2.2.27080.80641

Serrano, I. (2018). Evaluating the social and technological benefits of an intergenerational program for older adults [MA thesis]. *University of Rhode Island*.

Sincer, S., Özek, B. Y., & Selçuk, E. (2024). Türkiye's Educational Journey: Evaluating the Skills of Mathematics, Science, Reading, and Foreign Language in The Light of

International Competition. *Participatory Educational Research (PER)*, *11*(2), 135-157. doi:10.17275/per.24.23.11.2

Siyang, E. L. (2018). The use of Mother Tongue in teaching mathematics. *International Journal of Education, Psychology and Counseling*, *3*(20), 65–72. Retrieved from http://www.ijepc.com/PDF/IJEPC-2018-20-12-07.pdf

Sun, K. L. (2015). There's no limit: Mathematics teaching for a growth mindset (Doctoral dissertation). *Stanford University*. Retrieved from https://stacks.stanford.edu/file/druid:xf479cc2194/Sun-Dissertation-Upload-augmented.pdf

Sur, E., & Ateş, M. (2022). Examination of the relationship between creative thinking skills and comprehension skills of middle school students. *Participatory Educational Research (PER)*, *9*(2), 313-324. doi:10.17275/per.22.42.9.2

University of Michigan (2019). *Pre-experimental design*. Retrieved from https://www.icpsr.umich.edu/icpsrweb/childcare/datamethods/preexperimental.jsp

Vanbinst, K., van Bergen, E., Ghesquière, P., and De Smedt, B. (2020). Cross domain associations of key cognitive correlates of early reading and early arithmetic in 5-year-olds. *Early Child. Res. Q. 51*, 144–152. doi:10.1016/j.ecresq.2019.10.009

Wang, A. Y., Fuchs, L. S., and Fuchs, D. (2016). Cognitive and linguistic predictors of mathematical word problems with and without irrelevant information. *Learning and Individual Differences*, *52*, 79-87. doi:10.1016/j.lindif.2016.10.015

Willcutt, E. G., Petrill, S. A., Wu, S., Boada, R., DeFries, J. C., Olson, R. K., et al. (2013). Comorbidity between reading disability and math disability: Concurrent psychopathology, functional impairment, and neuropsychological functioning. *Journal of Learning Disability*. *46*, 500–516. doi:10.1177/0022219413477476

Zens, A. (2021). The Impact of differentiated Learning Activities on Student Engagement and Motivation in the English Language Arts Classroom (Master's thesis). *Minnesota State University Moorhead*. Retrieved from https://red.mnstate.edu/thesis/611/