Asia Research Network Journal of Education
Vol. 5, No. 2, pp. 53-64, May – August 2025

A Collaborative Puzzle Game to Enhance Students' Fractional Knowledge

Vinessa A. Palarao, Robert F. Palarao
Nueva Vista National High School, Misamis Occidental, Philippines

Douglas A. Salazar
Mindanao State University – Illigan Institute of Technology, Illigan, Philippines
Corresponding author email: vinessa.abregana@g.msuiit.edu.ph

Received: 13 Dec 2024 Revised: 25 Apr 2025 Accepted: 2 May 2025

Abstract. This action research study investigated the effects of trigram puzzle games on the understanding of fractions among high-need 7th graders. The intervention aimed to address students' fractional knowledge and operational skills through engaging and interactive activities such as trigram puzzles. Results showed significant improvements in students' post-test scores compared to their pre-test scores, with several students achieving mastery. The Wilcoxon signed-ranks test confirmed the statistical significance of these improvements, indicating the success of the intervention. Additionally, the study explored student engagement through quantitative measures and qualitative feedback. The positive engagement scores, particularly in the cognitive domain, suggested that the collaborative nature of the trigram puzzles enhanced students' interest, participation, and deep cognitive processing. Focus group discussions further highlighted the supportive and enjoyable learning environment fostered by the trigram puzzles. In summary, the implementation of trigram puzzles games proved to be an effective strategy for improving students' fractional knowledge, addressing misconceptions, and fostering a positive learning experience. The findings suggest that incorporating trigram puzzles as interactive and collaborative activities significantly improves learning outcomes and positively influences student attitudes toward challenging concepts like fractions.
Keywords: tarsia puzzle, trigram puzzle, fractions, collaboration

1. Introduction

Mathematics focuses on developing critical thinking and problem-solving skills. These skills are intended to build a foundation for more advanced mathematics (K-12 Curriculum Guide, 2013). However, learners' achievement in mathematics has been declining over the years, as shown by PISA and TIMSS results (OECD, 2019; Mullis et al., 2019). This decline is attributed to factors including students' negative attitudes towards mathematics, and their difficulties in understanding and solving problems within the given time (Van Geel et al., 2019).

National Learning Camp (NLC) of the Department of Education are vital for addressing learning loss and promoting comprehensive student growth. The primary goal is to bridge the learning gaps that students may have accumulated throughout the school year. It aims

to strengthen students' academic performance by focusing on core subjects, such as English, Mathematics and Science. Within the NLC framework, students were assigned to Enhancement, Consolidation, or Intervention Camps based on their individual needs, fostering socio-emotional skills, personal growth, and character development in a camp-like environment. The intervention camp supports learners who are yet to grasp Foundational Mathematics. The camp offers a more relaxed and focused environment, allowing students to concentrate on their studies without the usual pressures of regular school days (DepEd Order No. 14, 2023).

Games and puzzles have been presented by many educators as a good learning tool that supports classroom instruction in mathematical learning (Gough, 1999). Effective manipulatives and games play a crucial role in promoting mathematical understanding. They support students in building, reinforcing and connecting varied representations of mathematical concepts (Debrenti, 2024). Moreover, games and puzzles are used in Mathematical programs to develop a positive attitude among the learners since both provide opportunities for building self-concept and reducing the fear of failure and error (Davies, 2009). Mathematical games, such as puzzle boards are activities that involve a challenge for students, have a set of rules to follow, have different choices, and have a set of cognitive objectives (Oldfield, 1992). Additionally, the use of puzzle board media has great potential and advantages in directing students to think more actively and critically (Ziliwu & Anas, 2024). Puzzle is regarded as a game or problem that requires ingenuity and often persistence in solving or assembling. Thus, it is accentuating problem solving as the element of a puzzle (Farlex, 2009). It is also found out that a puzzle is non-routine, out of the box problem presented in an interesting way (Klymchuk, 2017). Finally, puzzle is described as any game promoting learning and development of many cognitive, motor and social skills (Becky & Susie, 2010).

One important aspect of game-based learning is its potential to promote collaboration among students. Collaborative learning is considered an active process that can lead to a deeper understanding of content, as well as the development of essential skills such as critical thinking, communication, coordination, and knowledge construction (Dillenbourg, 1999). Central to effective collaboration is socially shared regulation, which refers to the collaborative processes students engage in as they work toward common goals. This collaborative regulation plays a crucial role in fostering a positive classroom environment where peers influence, support, and motivate one another (Nakata et al., 2020). Moreover, collaborative learning significantly enhances students' social interaction skills. According to Ghavifekr (2020), students perceive collaborative learning as an opportunity to work effectively with others and strengthen social bonds within the group. These insights highlight the value of collaborative activities—especially those embedded in educational games—in promoting both academic and interpersonal growth.

In this study, the researcher designed a puzzle activity inspired by the Tarsia puzzle, a widely recognized instructional tool known for enhancing learner engagement and vocabulary acquisition. According to Omar and Said (2019), the Tarsia puzzle not only improves students' vocabulary skills but also receives positive feedback from learners, indicating its effectiveness in classroom settings. O'Connor (2020) further highlights its educational benefits, noting that the Tarsia puzzle reinforces learning while fostering both teamwork and healthy competition. Its flexibility also supports differentiated instruction, making it suitable for various learning levels and needs. Supporting these insights, Qomaria (2021) found that approximately 83.4% of teachers surveyed agreed that the Tarsia puzzle is effective in teaching mathematics at the elementary level, as it stimulates students' enthusiasm for learning. Drawing from these findings, this study proposes the incorporation of Trigram puzzles, which is a variation inspired by the Tarsia puzzle, as a collaborative learning activity for Grade 7 students in the Intervention Camp classes at Libertad Bajo Integrated School during the National Learning Camp 2024. A detailed

description of the Trigram puzzle strategy is presented in the following section, Innovation and Strategy.

Libertad Bajo Integrated School is a small school located at Sinacaban, Misamis Occidental. The mathematics teacher faces challenges in teaching competencies for mathematics to Grade 7 students because students lack basic math skills, including operations with fractions. Competence with fractions is foundational to acquiring more advanced mathematical skills, such as algebra (Booth & Newton, 2012; Booth, Newton, & Twiss-Garrity, 2014). Achieving competency with fractions is challenging for many students, and the difficulties associated with learning fractions have been documented widely (Nunes & Bryant, 2008; Stafylidou & Vosniadou, 2004). Concepts underlying fractions have always been one of the greatest challenges to teaching and learning in the network of mathematical education. These challenges right off the bat from elementary years (Brown & Quinn, 2006), then into secondary and even tertiary education (Kamii & Clark,1995). The challenges and misunderstandings students face in understanding fractions continuously exist even during adult life which affect different areas in such wide-ranging fields (Cantoria, 2016).

In this study, the researcher aims to enhance the engagement and motivation of high-need students by incorporating a game-based approach through a collaborative activity known as the Trigram puzzle, which is designed to support the development of students' fractional knowledge.

Innovation and Strategy

The researcher designed a learning activity to address the lack of fractional knowledge and skills of high-need students in the intervention camp of NLC 2024. This learning activity employs the collaborative method to scaffold students' engagement and motivation in learning fractions. In the aspiration to keep up the camp-like environment of the National Learning Camp program of the Department of Education, the researcher incorporates puzzles games as the collaborative activity. This strategy hoped to address the lack of motivation and most importantly to increase the fractional knowledge and operational skills of the identified high-need students. Trigram puzzles pieces take the form of a triangle geometric shape. Each side of the smaller fragments contains clues that need to match the other side. There are three benefits of using the puzzle as a classroom activity: 1) It can be used to enhance comprehension of mathematical content, 2) It encourages collaborative learning and 3) It can be used to create a competitive environment in the classroom. (Stoten, 2017).

At the start of the collaborative activity, each group, ideally composed of three members, will receive a bundle of cut-out triangles. When the pieces are scattered, the group will notice that the sides are labeled with problems that involve fractions. Their task is to solve each question and find a side with the corresponding answer. Once it matches correctly, students will assemble the pieces side by side until all sides fit together to form an object. The final step is for the group to guess what object they have created. This activity not only reinforces mathematical concepts but also promotes teamwork and problem-solving skills. Figure 1 shows the unsolved and solved trigram puzzle.

Figure 1: Unsolved (right) and Solved (left) Trigram puzzle

There are six (6) trigram puzzle activities designed to help students understand and practice various fraction concepts. Each activity focuses on a different aspect of fractions. The six trigram puzzles activity are:

Trigram Puzzle Activity 1: Fractions and its Equivalent Drawings
Trigram Puzzle Activity 2: Fractions and its Reduced Form
Trigram Puzzle Activity 3: Arrange Fractions in a Number Line
Trigram Puzzle Activity 4: Addition and Subtraction of Similar Fractions
Trigram Puzzle Activity 5: Addition of Dissimilar Fractions
Trigram Puzzle Activity 6: Subtraction of Dissimilar Fractions

Each trigram puzzle will be played in a separate meeting, totaling six meetings with 45 minutes each meeting.

Research Questions

Determining the effect of collaborative learning with the use of trigram puzzle on the fractional knowledge and skills of Grade 7 students in the Intervention camp of Libertad Bajo IS during NLC 2024 is the primary goal of this action research. Specifically, this study anchored with finding answers to the following research questions:

1. What is the learners' level of engagement in collaborative learning with the use of trigram puzzles?
2. What are the experiences of the learners in collaborative learning with the use of trigram puzzles?
3. Is there a significant difference between the pre-test and post-test scores of learners after exposure to collaborative learning with the used of trigram puzzles?

Hypothesis

H_0: There is no significant difference between the pretest and posttest scores of learners after exposure to collaborative learning with the use of trigram puzzles.

2. Methods

Research Design

This study took the form of action research. Action research is a productive process in extending teaching skill and exploring more about teachers, classrooms and students. It is the most convenient research design to be employed in answering the research questions considering the participants involved and specific research context.

This study will employ a One-Group Pretest-Posttest Design, as it involves only high-need students participating in the intervention camp. This research design was used to check the effectiveness of collaborative learning with the use of trigram puzzles in improving the

fractional knowledge and operation skills of the high-need students in the intervention camp. At the end of the first and sixth sessions, a Focus Group Discussion (FGD) will be conducted to gain an in-depth understanding of students' experiences with the trigram puzzles.

Participants

This study will be conducted in Libertad Bajo Integrated School, Sinacaban, Division of Misamis Occidental during the National Learning Camp 2024. Purposive sampling was used in determining the participants. The participants in the study are one learning camp teacher-volunteer and 12 Grade 7 students in the intervention camp. These students were identified high-need students in mathematics with scores below 36 in Numeracy Screening Test given before the end of the school year.

Data Collection

The study was conducted with the permission of the Office of the School Principal. Preliminaries were held to introduce the purpose of the study. Before deciding to participate as research subjects, the chosen students were asked for their informed consent. This study employed the collection of quantitative data. The quantitative data were gathered using the results from the pre-test and post-test. A validated 20-item teacher-made test was administered to students as a pre-test to assess their conceptual understanding of fractions and their skills in adding and subtracting both similar and dissimilar fractions. Following the intervention, a post-test, composed of questions parallel to those in the pre-test, was administered to the same students. This pre-test/post-test design aimed to measure the impact of the collaborative activity with trigram puzzles on students' knowledge and skills in fractions.

The pretest and posttest were composed of five parts, each targeting a specific aspect of fractional knowledge. Parts of the test is presented in Figures 2 and 3.

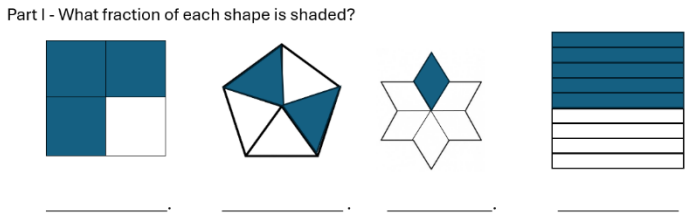

Figure 2: Pretest-Part I: Expressing visual figures as fractions

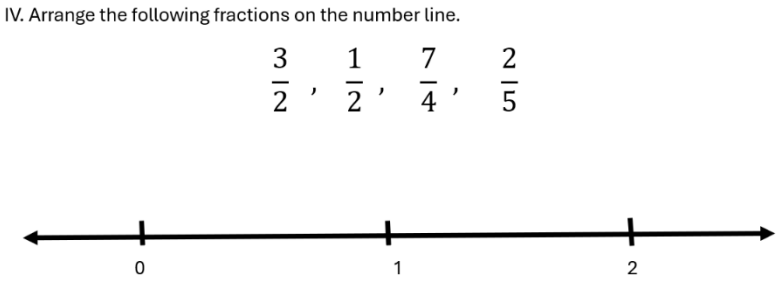

Figure 3: Posttest-Part IV: Arranging fractions on the number line

Additionally, a learner engagement tool adapted from Lam et al. (2014) was used to measure the affective, behavioral, and cognitive dimensions of students' engagement in the intervention. Responses were rated on a Likert scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). The tool was modified by the researcher and its face validity was confirmed by a master teacher in mathematics and a research coordinator in the district.

To further support the quantitative results, focus group discussions were conducted to solicit qualitative data, providing deeper insights into students' experiences and engagement during the intervention.

Data Analysis

The scores from the pre-test and post-test of individual students were compared using a bar graph to emphasize the effect of collaborative learning with trigram puzzle in their fractional knowledge and operational skills. Mean and standard deviation will be calculated for all test scores and engagement levels. From DepEd Memorandum No. 160, s. 2012, the degree of learners' numeracy abilities, the scaling of their score, and its descriptive equivalent are displayed in Table 1 and have been modified to fit. Moreover, in assessing students' engagement in the intervention, the scoring guide and interpretation were adapted from the study of Villagonzalo (2014) as shown in table 2.

Table 1: Mastery/Achievement Level

Pre-test / Post-test Scores	Descriptive Equivalent
20	Mastered
18 – 19	Closely Approximating Mastery
14 – 17	Moving Towards Mastery
8 – 13	Average
4 – 7	Low
1 – 3	Very Low
0	Absolutely No Mastery

Table 2: Scoring Guide and Interpretation of Students' Engagement

Statistical Range	Description	Implication
4.20 – 5.00	Strongly Agree	Highly Positive
3.40 – 4.19	Agree	Positive
2.60 – 3.39	Neither Agree/Disagree	Fairly Positive
1.80 – 2.59	Disagree	Negative
1.00 – 1.79	Strongly Disagree	Highly Negative

3. Results and Discussion

This study aims to investigate the effect of collaborative learning with trigram puzzles in helping students to learn fractions. Figure 2 below shows the comparison of the students' scores in the pretest and posttest.

The figure demonstrates a marked improvement in all scores compared to the pretest results, indicating that the intervention had a significant impact on the students' understanding of fractions.

A detailed examination of the posttest scores revealed that 100 percent of the students achieved a perfect score on Part I: Fractions and Their Equivalent Drawings. This suggests that the students grasped the concept of fractions and effectively learned to identify and represent them visually.

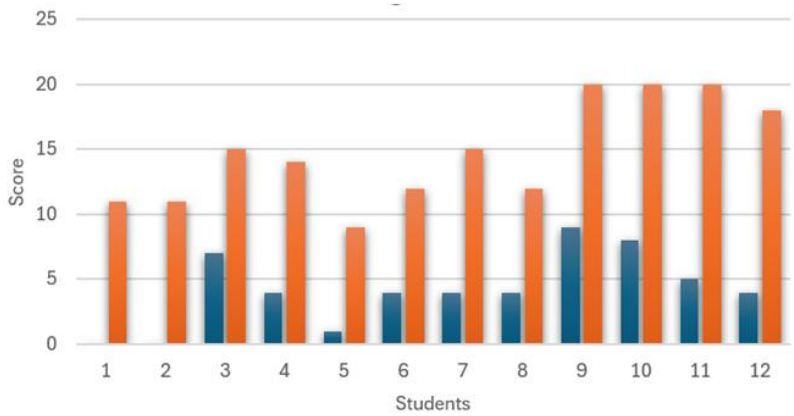

Figure 4: Pre-test (Blue) and Post-test (Orange) Scores of 7th Graders in Intervention Camp

Part III of the pretest and posttest was about arranging fractions of a number line. During the pretest, no student was able to correctly arrange fractions on a number line. However, in the posttest, all students attempted to answer this problem, and 4 out of 12 students answered it correctly. This significant improvement demonstrates that the intervention not only helped students learn to compare fractions effectively and identifying which fractions are greater or smaller.

Part IV of the test was about addition and subtraction of fractions. The pretest revealed that students tended to add or subtract both the numerators and the denominators, resulting in incorrect answers. This common misconception was significantly reduced in the posttest, with only two students attempting to add and subtract the denominators. This indicates a substantial improvement in understanding how to correctly add fractions with like denominators.

Part V of the test was about the addition and subtraction of dissimilar fractions. During the pretest, only 5 out of 12 students attempted to answer this questions, and they all provided incorrect answers. The difficulty in finding the least common denominator (LCD) was a major hurdle. In the posttest, however, all 12 students attempted the questions, and 8 of them successfully identified the correct LCD. This indicates a significant improvement in their ability to correctly add and subtract fractions by finding the correct LCD.

Two focus groups discussion were done. The first was after the first session July 9, 2024, and the second is after the posttest, July 18, 2024. Students described how they felt about the learning process and the intervention during these discussions.

First focus group discussion (July 9, 2024)

During this session, students shared their experiences and initial reactions to the activities focused on fractions. The feedback was positive, highlighting the engaging and enjoyable nature of the learning process. Here are some of the students' responses:

Student A: "Nindot man ang puzzle Mam. Lingaw dayon makatabang pod para mas makasabot mi" "I liked the puzzles. They made learning fun and helped me understand better."

Student B: "maka excite. happy kay kami ang nakadaog man" "I want the excitement. I am happy because we won in the game."

Student C: "Sayon kaayo mam. Nagtinabangay lang mi tanan para macomplete and puzzle" "It was an easy game. We help each other to complete the puzzle."

Student D: "Lingaw unya sayon ra pod." "fun and easy topic in fraction"

Student A appreciated the use of puzzles in the learning activities. The interactive nature of the puzzles not only made the learning process enjoyable but also facilitated a

better understanding of fractions. Student B highlighted the excitement and motivation that came from participating in and winning the game. This competitive aspect added an extra layer of engagement, encouraging students to put more effort into understanding the material in order to succeed in the game. Student C emphasized the collaborative aspect of the puzzle activities. Working together to complete the puzzle fostered a sense of teamwork and mutual support among the students. This collaboration not only made the task seem easier but also reinforced learning through peer interaction. Student D found the topic of fractions to be fun and easy. This response suggests that the intervention successfully demystified the concept of fractions, making it more approachable and less intimidating for students.

The feedback from the first focus group discussion indicates that the use of interactive and engaging activities, such as puzzles and games, had a positive impact on the students' initial experiences with learning fractions. Additionally, Kiili (2005) highlights that game-based learning environments can foster motivation and deep learning by providing meaningful contexts and immediate feedback. Collaborative learning, as described by Johnson and Johnson (1999), also emphasizes the benefits of teamwork and peer interaction in enhancing comprehension and retention of material.

Second Focus Group Discussion (July 18, 2024)

This discussion aimed to gather students' reflections on their overall learning experiences and the impact of the intervention on their understanding of fractions. Here are some responses from the participants, along with discussions on their implications:

Student E: "Ang pagkuha sa LCD kay libog og lisod. Peru kabalo naman ko sa process nga divide and times. Dili pa ko anad. Kinahangalan mag practice of solve gyud." The hardest part was finding the lcd, but now I know the process. I need to divide then multiply. I still need more practice, but I'm getting there."

Student F: "Lingaw", "magtinabangay mi og sabot para makuha ang answer." Fun, we helped each other to understand and get the answer

Student G: "abi namug lisod peru dili diay. Basta timan-an ang rules sa addition of fractions" I thought it was difficult, but it's not. As long as you remember the rules of adding fractions.

Student H: "O, nakabalo naman ko daan fraction peru dli ko ganahan niya kay lisod. dula man enjoy lang." Yes, I already know fractions, but I don't like them because they are difficult but it's a game, I enjoyed it.

Student I: "bisan fraction ang gi solve, peru kinahanglan lang kabalo ka sa plus, minus, times, divide. mahimo na nga sayon."Even though we solved fractions, you just need to know addition, subtraction, multiplication, division. Then it becomes easy.

Student J: "daghan man kog nasolve sa posttest. Kabalo nako kay gibalik-gibalik man namu og solve ang LCD." I was able to answer the posttest because we practiced finding the LCD many times.

Student F acknowledged the challenge of finding the least common denominator. Student J highlighted that with regular practice and reinforcement students can fully master challenging concepts, such as finding the lcd. Student I understand that solving fractions requires a solid foundation in basic arithmetic operations. Emphasizing these foundational skills within the context of fraction problems helps students see the connections between different mathematical concepts, facilitating easier comprehension and application.

The feedback from the second focus group discussion underscores the positive impact of the collaborative activity with the use of trigram puzzles on students' understanding of

fractions. The use of puzzles, games, and collaborative learning not only made the learning process enjoyable but also effectively addressed misconceptions and built confidence. These findings suggest such strategies should be incorporated more broadly to enhance learning outcomes and student attitudes towards challenging subjects.

Is there a significant difference between the pre-test and post-test scores of learners after exposure to collaborative learning with the use of trigram puzzles?

The study compared the pre-test and post-test scores of 7th graders in the intervention camp during the NLC 2024 (Figure 2). The pretest scores showed the students' level of fractional knowledge and operation skills before the intervention. Based on the scores, only 2 students had average fractional knowledge, 7 of them had low, 1 had very low and 2 students have absolutely no mastery. (see Table 3) This clearly indicates that the group consisted mostly of high-need students concerning their understanding of fractions.
The implementation of the cooperative learning model with trigram puzzles for 7th graders over a 2-week period appears to have been successful in enhancing their understanding and skills in fractions. The posttest scores show an improvement compared to the pre-test scores: 5 students had average fractional knowledge, 3 were moving towards mastery, 1 was closely approximating mastery and 3 mastered the fraction topics discussed. (see Table 3) This indicates a notable shift from the initial assessment, where most students were identified as having low fractional knowledge. The intervention helped all the students make substantial progress, with several achieving mastery in the topic fraction.

To verify the implications, a Wilcoxon signed-ranks test results on whether there is a significant difference between the pre-test and post-test scores of learners after exposure to collaborative learning with the use of trigram puzzles are given in Table 4.

The Wilcoxon signed-ranks test indicated that the median post-test ranks, Mdn = 12, were statistically significantly different than the median pre-test ranks, Mdn = 6.5, z = -3.083, p = 0.002. The increase was large, i.e., r = 0.8.

Table 3: Mastery Level on Fractions of the 7th Graders in the Intervention Camp

Mastery Level	Pretest	Posttest
Mastered		3
Closely Approximating Mastery		1
Moving Towards Mastery		3
Average	2	5
Low	7	
Very Low	1	
Absolutely No mastery	2	
Mean	**4.17**	**14.75**

Table 4: Wilcoxon signed rank test results regarding the pretest and posttest scores

Posttest - Pretest		Rank Average	Rank Sum	Z	p
Negative Rank	0	0	0	-3.083	.002
Positive Rank	12	6.5	78		
Ties	0				

Based on negative ranks

When the rank totals of the difference scores are considered, it is seen that the observed difference is in favor of positive ranks and post-test scores. According to these results, it was observed that the use of trigram puzzle as a collaborative learning activity applied in

teaching fractions had a significant effect on enhancing fractional knowledge and operational skills of the Grade 7 students in the intervention camp.

Students' engagement in the collaborative activity with the use of trigram puzzle

The level of engagement among the 7th graders in the trigram puzzle collaborative activity was summarized in Table 5 which revealed a positive response (Mean=4.20, SD=0.635).

Table 5: Descriptive Statistics for 7th Graders Level of Engagement

Respondents	Dimension	Mean	SD	Implication
(N = 12)	Affective	3.98	0.645	Positive
	Behavioral	4.208	0.735	Highly Positive
	Cognitive	4.417	0.525	Highly Positive
	Total	**4.20**	**0.635**	**Highly Positive**

Legend: 1.00-1.79 *Highly Negative* 1.80-2.59 *Negative* 2.60-3.39 *Fairly Positive* 3.40-4.19 *Positive* 4.20-5.00 *Highly Positive*

This means that in the affective dimension, the students developed a strong interest in learning fractions (Mean=3.98, SD=0.645). The collaborative nature of this approach has made the learning experience enjoyable and engaging. This approach has not only fostered a positive and supportive learning environment but also enhanced comprehension and retention of fractional knowledge. Behavioral engagement refers to the intervention's effort, persistence, and participation (Birch and Ladd, 1997). Then, the current study discovered that students were highly positive in behavioral engagement (Mean=4.208, SD=0.735), implying that the students are actively participating and fully engaged in the learning process. They are motivated to participate because they genuinely believe that it is beneficial to them. Moreover, cognitive engagement refers to the cognitive strategies that students adopt and employ during the learning process (Walker et al., 2006). Based on the result, students were highly positive (Mean=4.417, SD=0.525). This is analogous to the argument presented in the study of Lam et al. (2014) that students who have cognitive engagement participate more in deep cognitive processing and have a better understanding and retention of meaningful material.

Additionally, the student responses during the second focus group discussion provide valuable qualitative feedback on their engagement on the activity. Below are some notable comments from the students during the focus group discussion.

Student C: "Sige ra mig katawa kay dili mi kabalo unsa ang naporma. Review napod asasayop." We kept laughing because we didn't know what we were forming. We reviewed to find where the mistakes were.

Student F: "kinahangalan jud mag abtik og hunahuna para makadaog or makuha ang sakto nga arrangement" You really need to think quickly to win or get the correct arrangement.

Student I: "kadugayan paspas na kaayo mag add og fractions, samot kong similar, katong parehas og ubos nga number. Kato ang pinakasayon."

Eventually, I got really fast at adding fractions, especially when they were similar, with the same denominators. That was the easiest part.

Student C experienced that the use of trigram puzzles in the activities created a learning environment where students felt comfortable and engaged. Humor and the opportunity to review and correct mistakes together helped foster a supportive and enjoyable learning atmosphere, which is crucial for effective learning. Student F thinks that trigram puzzles are activities that require quick thinking and problem-solving. Thus, it enhanced students' critical thinking and decision-making skills. Student I realized trigram puzzles

collaborative activities makes them solved repeatedly and regular practice in adding and subtracting fractions improved students' speed and accuracy in performing basic fraction operations.

The positive experiences reported by the students support the positive level of engagements and the significant improvements observed in their post-test scores. It highlights the effectiveness of the activity using trigram puzzles.

4. Conclusion and Recommendation

This study investigated the effects of collaborative activity using trigram puzzles on high-need 7th graders' understanding of fractions. The results demonstrated significant improvements in students' fractional knowledge as evidenced by the marked increase in post-test scores compared to pre-test scores. Notably, the intervention helped all students achieve substantial progress, with several reaching mastery in their fractional knowledge. The Wilcoxon signed-ranks test further confirmed the statistical significance of these improvements, underscoring the effectiveness of the intervention.

The study also explored students' engagement through both quantitative measures and qualitative feedback. The overall positive engagement scores, particularly in the cognitive domain, suggest that the collaborative and interactive nature of the trigram puzzles enhanced students' interest, participation, and deep cognitive processing. Student feedback from focus group discussions highlighted the enjoyable and supportive learning environment fostered by the trigram puzzles activities, which facilitated better understanding and retention of fractional concepts.

In summary, the implementation of trigram puzzle game proved to be a successful strategy in improving students' fractional knowledge, addressing misconceptions, and fostering a positive learning experience. The findings suggest that incorporating interactive and collaborative activities can significantly enhance learning outcomes and student attitudes toward challenging subjects. Future research could explore the long-term effects of such interventions and their applicability to other mathematical concepts and educational contexts.

5. References

Becky, L., S. & Susie, S.L. (2010). *Puzzles—Toys...or teaching tools?*. Super Duper Publications. Retrieved from https://www.superduperinc.com/handouts/pdf/245_Puzzles.pdf

Birch, S. H., & Ladd, G. W. (1997). The teacher–child relationship and children's early school adjustment. *Journal of School Psychology,* 35(1), 61–79. https://doi.org/10.1016/S0022-4405(96)00029-5

Brown, G., & Quinn, R. J. (2006). Algebra students' difficulty with fractions: An error analysis. *Australian Mathematics Teacher, The, 62(4),* 28-40.

Booth, J. L., & Newton, K. J. (2012). Fractions: Could they really be the gatekeeper's doorman? *Contemporary Educational Psychology, 37*, 247–253.

Booth, J. L., Newton, K. J., & Twiss-Garrity, L. K. (2014). The impact of fraction magnitude knowledge on algebra performance and learning. *Journal of Experimental Child Psychology, 118*, 110–118.

Burns, A. (2009). *Doing action research in English language teaching: A guide for practitioners*. Routledge.

Christine A. Tadios, Utilization of Tarsia Puzzle in Improving Learning on Integers, Rationales, Patterns, and Algebra (IRPA) among Senior High School Students in a Public School , *Journal of Student and Education Volume 1 Issue 1*, Year 2023ISSN: 2837-4398. https://doi.org/10.54536/jse.v1i1.1417https://journals.e-palli.com/home/index.php/jse

Cantoria, Jr., A. L. (2016). The predominance of procedural knowledge and between-operation interference as deduced from fraction errors of preservice teachers. *Asia Pacific Journal of Multidisciplinary Research, 75-79*.

Debrenti, E. (2024, March). Game-Based Learning experiences in primary mathematics education. In *Frontiers in* Education (Vol. 9, p. 1331312). Frontiers Media SA.

DepEd K-12 Curriculum Guide for Mathematics (2013). Retrieved July 2024, from DepEd.

Dillenbourg P. (1999). What do you mean by collaborative learning? In P. Dillenbourg (Ed), Collaborative-learning: Cognitive and computational approaches. Oxford: Elsevier, pp. 1-19.

Farlex, (2009). The Online Free Dictionary. Retrieved 12 July 2024 from http://www.thefreedictionary.com

Ghavifekr, S. (2020). Collaborative learning: a key to enhance students' social interaction skills. *MOJES: Malaysian Online Journal of Educational Sciences*, *8*(4), 9-21.

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education, 8(1),* 13-24.

Klymchuk, Sergiy. (2017)"Puzzle-based learning in engineering mathematics: students' attitudes." *International Journal of Mathematical Education in Science and Technology 48, no. 7*. 1106-1119.

Laidin, D. R., & Tengah, K. A. (2021). Applying butterfly method in the learning of addition and subtraction of fractions. *Jurnal Pendidikan Matematika, 15(2),* 161-174. https://doi.org/10.22342/jpm.15.2.13934.161-174

Lam, S.-f., Jimerson, S., Wong, B. P. H., Kikas, E., Shin, H., Veiga, F. H., Hatzichristou, C., Polychroni, F., Cefai, C., Negovan, V., Stanculescu, E., Yang, H., Liu, Y., Basnett, J., Duck, R., Farrell, P., Nelson, B., & Zollneritsch, J. (2014). Understanding and measuring student engagement in school: The results of an international study from 12 countries. *School Psychology Quarterly, 29*(2), 213–232. https://doi.org/10.1037/spq0000057

Nakata, Y., Nitta, R., & Tsuda, A. (2020). Understanding motivation and classroom modes of regulation in collaborative learning: an exploratory study. *Innovation in Language Learning and Teaching*, *16*(1), 14–28. https://doi.org/10.1080/17501229.2020.1846040

Nunes, T., & Bryant, P. (2008). Rational numbers and intensive quantities: Challenges and insights to pupils' implicit knowledge. *Anales de Psicología, 24*, 262–270.

Omar, W S and Said, NEM. (2019). The effect of Tarsia puzzle on vocabulary learning in a primary school setting. *International Journal of New Technology and Research, Volume 5,* Issue 7, pages 86-91

Qomaria, N. (2021). Teachers' Perception Towards the Use of Tarsia Puzzle to Create Joyful Learning of Mathematics. *Vygotsky: Jurnal Pendidikan Matematika dan Matematika*, *3*(1), 13-24.

Stafylidou, S., & Vosniadou, S. (2004). The development of students' understanding of the numerical value of fractions. Learning and Instruction, 14, 503–518.

Stoten, D. W. (2017). Tarsia: An Interactive and Engaging Activity That Promotes Consolidation of Knowledge. *Management Teaching Review, 2(3),* 225-234.

Villagonzalo E (2014) Process Oriented Guided Inquiry Learning: An Effective Approach in Enhancing Students' Academic Performance, *DLSU Research Congress*

Walker, B. H., C. S. Holling, S. R. Carpenter, and A. P. Kinzig. 2004. Resilience, adaptability, and transformability. *Ecology and Society 9(2)*: 5. [online] URL: http://www.ecologyandsociety.org/vol9/iss2/art5/.

Ziliwu, S., & Anas, N. (2024). The Development of Puzzle Board Card Media to Enhance Students' Critical Thinking Skills in Science Learning. *Jurnal Elementaria Edukasia, 7(2*), 2772–2785. https://doi.org/10.31949/jee.v7i2.9612