Jigsaw strategy: strengthening achievement and interest in mathematics among elementary pre-service teachers

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ABSTRACT

Mathematics is considered one of the most challenging courses for many elementary pre-service teachers (EPTs). In hopes for improvement, teacher educators have been incorporating a jigsaw strategy to equip future teachers with the necessary competencies. Hence, the study aimed to determine the effectiveness of the jigsaw strategy with EPTs' level of mathematics achievement and interest in an online cooperative learning environment. The research utilized a pre-experimental design with 40 participants. The researchers used pretest and posttest questions covering fraction operations and a mathematics interest questionnaire before and after the intervention. With the implementation of the jigsaw strategy, results showed that the EPTs' mathematics achievement improved while their interest in mathematics improved to some extent. Likewise, a significant difference between the pre-and post-intervention concerning the EPTs' mathematics achievement and interest in mathematics was found. Furthermore, correlation analysis revealed that study time is negatively related to mathematics achievement, as is the overall level of interest in mathematics. These findings imply that a jigsaw strategy is a useful tool in teaching mathematics online. However, several modifications may be considered to recognize that the EPTs' interest in mathematics varies from one person to another. Teacher education institutions are encouraged to apply this strategy not only for EPTs to increase their mathematical know-hows but also to serve as an example for them to employ in their future teaching careers.

Keywords: cooperative learning, fractions, mathematics education, prospective teachers, teacher education institution

INTRODUCTION

Filipino elementary pre-service teachers (EPTs) find mathematics as a challenging endeavor (Domingo et al. 2021; Pentang et al. 2021), which is attributed to the EPTs' dislike for mathematics (Ibañez and Pentang 2021). Dislike for mathematics contribute to loss of interest and underperformance in the subject (Areelu and Ladele 2018), where low interest in mathematics has a direct impact on motivation to complete activities. These factors challenged mathematics educators on how they could help EPTs appreciate and perform better in the subject. Some researchers used cooperative learning strategies to address this problem (Mbacho and Changeiywo 2013; Timayi et al. 2015; Johnson and Johnson 2018; Yemi et al. 2018; Ibañez and Pentang 2021).

Cooperative learning begins in a small group who is equally accountable and share the rewards and even failures; has a positive effect on the learner's motivation to complete a task while developing a greater sense of belongingness and accomplishment; and derives its strength from positive interdependence, interaction, and accountability (Garcia et al. 2017; Johnson and Johnson 2018). Among the various cooperative learning strategies, the jigsaw is an effective strategy. Jigsaw strategy was first introduced in the classroom in 1971 (Aronson 2000). This strategy was designed for small groups of learners that gives them a chance to become an 'expert' in a specific lesson.

The utilization of the jigsaw teaching strategy resulted in enhanced performance in mathematics (Aronson 2000; Mbacho and Changeiywo 2013; Russo 2014; Okeke 2015; Garcia et al. 2017; Areelu and Ladele 2018; Casing 2018; Yemi et al. 2018; Abed et al. 2020; Okafor and Nwosu 2021; Ummah and Hamna 2021). For learners, the jigsaw strategy provided them opportunities to express themselves and process information, which can improve both their abilities and learning outcomes (Timayi et al. 2015; Areelu and Ladele 2018; Yozza et al. 2018; Abed et al. 2020). However, research on the effectiveness of jigsaw strategy in an online environment to enhance mathematics achievement and interest in the

Philippines is limited, especially in the context of the EPTs.

The EPTs' mathematics achievement was relatively poor as it can be influenced by a lot of factors (Domingo et al. 2021; Ibañez and Pentang 2021; Pentang et al. 2021). Interest in mathematics is one of the contributing factors in the EPTs' performance towards the subject. With the implementation of online learning, EPTs are facing an additional burden in learning mathematics as technical difficulties could contribute to their frustration towards the subject. Teachers are also limited in utilizing cooperative learning techniques during online classes since overseeing them requires more effort. As future teachers, the mathematics achievement and interest of the EPTs can provide insights on how they perform in the subject with the help of jigsaw strategy in an online setting. With this, the study ascertained the effectiveness of the jigsaw strategy in enhancing mathematics achievement and interest in an online environment among EPTs. Specifically, this determined and compared their level of mathematics achievement and interest before and after the intervention; and determined the relationships between their mathematics achievement and interest after the intervention.

Jigsaw strategy fosters a positive learning environment in which EPTs develop a strong sense of responsibility in their learning, strengthen camaraderie among themselves, and become experts on a specific topic. As a result, this study would benefit EPTs not only in appreciating mathematics but also in embracing the essence of collaborative learning and its impact on academic achievement. In addition, curriculum developers and teacher educators can use the findings of this study to consider incorporating the jigsaw strategy into the revision of the mathematics curriculum. The jigsaw strategy can further the promotion of mathematics by making it more appealing to EPTs who typically dislike the subject.

METHODS

Research Design

A pre-experimental design was employed to determine the effect of using jigsaw strategy in enhancing the EPTs' mathematics achievement and interest in mathematics. Pre-experimental design involves observing a group after an intervention has been administered to determine whether the intervention has the potential to cause change (Frey 2018). The researchers and an external expert served as observers and validators of the jigsaw strategy intervention. The current study is the first of three phases of a continuing intervention. The first phase is limited to a two-week implementation. The second and third phases will be four and six weeks, respectively. In the end, these three will be evaluated.

Participants and Sampling Procedure

Employing total population sampling, 40 EPTs of Central Luzon State University enrolled in Teaching Mathematics in Intermediate Grades served as the participants of the study, given a small population. Approved consent was secured from the authorities and participants before gathering pertinent data for the study. The participants volunteered to take part in the study, and their participation had nothing to do with their grades.

Data Gathering Procedure

For the pre-intervention stage, a 30-item pretest was modified from Ibañez and Pentang (2021) and the 27-item Student's Mathematics Interest Questionnaire (SMIQ) from Stevens and Olivarez (2005) were employed to determine the EPTs' mathematics achievement and interest before the jigsaw intervention. The pretest included (a) basics of fractions, (b) adding/subtracting similar fractions, dissimilar fractions, and mixed numbers, and (c) multiplication and division of fractions and mixed numbers. The SMIQ was divided into three groups – positive valence, negative valence, and time. The use of these instruments was permitted by the developers. Excellent test-retest reliability coefficients (> 0.9) were obtained, and the instruments were validated by mathematics education experts.

The intervention stage comes next. This stage was the deployment of the jigsaw strategy on the teaching-learning process for two meetings. The first meeting covered the topics of basics of fractions, adding/subtracting similar fractions, dissimilar fractions, and mixed numbers. the second meeting was composed of multiplication and division of fractions and mixed numbers. Both meetings have an hour and a half to execute the jigsaw strategy.

Each meeting was conducted in a synchronous delivery through Google Meet. The assembly group was the first meeting to designate their respective home groups, the participants then join a meeting according to their homegroup. After designating specific topics for each member in the homegroup, the participants then join a meeting based on their specific topic, that is, their expert group. After they master their topic, they returned to their original homegroup to discuss the lesson with their classmates. Then, when everyone is done, they all return to the assembly group to wrap things up.

Finally, the post-intervention stage. A posttest was administered to assess the effectiveness of the intervention on enhancing mathematics achievement, together with the SMIQ to determine

significant differences in the interest in mathematics after the implementation of the jigsaw strategy.

Data Analysis

Data gathered were analyzed using arithmetic means and standard deviation in describing the mathematical achievement and interest of the participants before and after the intervention, respectively. A paired-sample t-test was used to ascertain the significant differences concerning the mathematics achievement and interest of the participants before and after the intervention while Pearson product-moment correlation was employed to establish significant relationships between their mathematics achievement and interest after the intervention.

RESULTS

Elementary Pre-service Teachers' Level of Mathematics Achievement

The EPTs achieved satisfactory pretest, while they obtained an outstanding posttest score. Specifically, the EPTs performed poorly to satisfactory during the pre-test, and very satisfactorily to outstanding after the implementation of the jigsaw strategy, correspondingly (Table 1). The posttest score was significantly higher than the pretest score after employing the jigsaw intervention ($P < 0.001$).

Elementary Pre-service Teachers' Level of Interest in Mathematics

The EPTs' overall interest in mathematics before the intervention was moderate but increased after the intervention. The positive valence before the intervention was moderate, while the positive valence after the intervention was high. In terms of negative valence and time, the pre-and post-intervention interests of the EPTs were moderate (Table 2).

The EPTs' overall interest in mathematics during the post-intervention was significantly higher than the pre-intervention, $t_{(8)} = -4.419$, $P < 0.001$ (Table 3). Besides, the positive attraction towards mathematics was reported to have a significant difference as well, $t_{(8)} = -3.441$, $P < 0.01$. The post-intervention of the positive valence was more likely to have a higher positive attraction in mathematics compared to their pre-intervention positive attraction. However, negative valence and study time showed no significant difference before and after the intervention.

Relationship between the Elementary Pre-service Teachers' Interest and Mathematics Achievement

Study time was negatively related to mathematics achievement of the EPTs ($r = -0.338$, $P < 0.05$). Similarly, overall interest in mathematics was negatively related to mathematics achievement ($r = -0.177$, $P < 0.05$). On the other hand, positive and negative valence were not significantly related to mathematics achievement (Table 4).

Table 1. Elementary pre-service teachers' level of mathematics achievement. Note: 24.01-30.00 = outstanding, 18.01-24.00 = very satisfactory, 12.01-18.00 = satisfactory, 6.01-12.00 = unsatisfactory, 0.00-6.00 = poor.

Topic	Pretest		Posttest	
	Mean	SD	Mean	SD
Adding/Subtracting Similar Fractions	18.00	9.90	26.50	2.12
Adding/Subtracting Dissimilar Fractions	18.67	11.68	29.01	1.41
Adding/Subtracting Mixed Numbers	15.25	8.61	24.82	6.03
Multiplication and Division of Fractions	10.08	6.20	21.50	6.36
Multiplication and Division of Mixed Numbers	5.25	6.13	18.25	4.72
Overall Achievement	13.45	8.08	24.02	6.59

Table 2. Elementary pre-service teachers' level of interest in mathematics. Note: 6.15-7.00=very true of me, 5.29-6.14=true of me, 4.43-5.28=somewhat true of me, 3.58-4.42=not sure, 2.72-3.57=somewhat not true of me, 1.86-2.71=not true of me, 1.00-1.85=not at all true of me. 4.67-7.00=high interest, 2.34-4.66=moderate interest, 1.00-2.33=low interest

PARAMETERS	Pre-intervention			Post-intervention		
	Mean	SD	Description	Mean	SD	Description
Positive Valence	4.58	0.76	Moderate Interest	4.94	0.96	High Interest
1. I like to answer questions in mathematics class.	3.88	1.34	Not sure	3.98	1.37	Not sure
2. I like mathematics.	4.18	1.36	Not sure	4.13	1.45	Not sure
3. I am interested in mathematics.	4.53	1.38	Somewhat true of me	4.68	1.35	Somewhat true of me

PARAMETERS	Pre-intervention			Post-intervention		
	Mean	**SD**	**Description**	**Mean**	**SD**	**Description**
4. Knowing a lot about mathematics is helpful.	5.70	1.45	True of me	6.23	1.00	Very true of me
5. I feel good when it comes to working on mathematics.	4.13	1.26	Not sure	4.20	1.36	Not sure
6. I want to know all about how to do mathematics problems.	5.35	1.51	True of me	5.80	1.24	True of me
7. I feel excited when a new mathematics topic is announced.	3.88	1.24	Not sure	4.05	1.47	Not sure
8. I want to learn more about mathematics.	5.60	1.50	True of me	6.18	1.20	Very true of me
9. I choose to work on mathematics.	4.03	1.35	Not sure	4.28	1.43	Not sure
10. I want to know all about mathematics.	5.38	1.53	True of me	5.90	1.17	True of me
Negative Valence	3.95	0.60	Moderate interest	4.27	0.82	Moderate interest
1. I am wasting my time on mathematics.	3.05	1.75	Somewhat not true of me	2.68	1.67	Somewhat not true of me
2. I am bored when working on mathematics.	3.63	1.41	Not sure	3.83	1.52	Not sure
3. I would rather be working on something else besides mathematics.	4.25	1.41	Not sure	4.35	1.82	Not sure
4. I give up easily when working on mathematics.	4.03	1.80	Not sure	3.93	1.80	Not sure
5. When working on mathematics, I want to stop and start working on something else.	4.13	1.64	Not sure	4.28	1.75	Not sure
6. I am always thinking of other things when working on mathematics.	4.03	1.56	Not sure	4.10	1.66	Not sure
7. I get mad easily when working on mathematics.	3.70	1.64	Not sure	4.23	1.44	Not sure
8. I have difficulty paying attention when working on mathematics.	4.63	1.33	Somewhat true of me	5.20	1.52	Somewhat true of me
9. I spend as little time as possible working on mathematics.	4.13	1.42	Not sure	4.35	1.73	Not sure
10. I struggle with mathematics.	5.30	1.60	Somewhat true of me	5.80	1.16	True of me
Time	4.35	0.54	Moderate interest	4.50	0.68	Moderate interest
1. I work more on mathematics problems than I have to.	3.80	1.20	Not sure	3.80	1.52	Not sure
2. I spend many hours working on mathematics.	4.93	1.29	Somewhat true of me	5.33	1.56	True of me
3. I work on mathematics in my spare time.	4.03	1.42	Not sure	3.88	1.40	Not sure
4. I want to talk about mathematics with my friends.	4.20	1.42	Not sure	4.53	1.73	Somewhat true of me
5. I spend more time than most of my classmates working on mathematics.	4.38	1.21	Not sure	4.83	1.60	Somewhat true of me
6. I prefer easy mathematics over mathematics that is hard.	5.23	1.75	Somewhat true of me	5.33	1.42	True of me
7. I am too involved in mathematics.	3.88	1.47	Not sure	3.85	1.72	Not sure
OVERALL MEAN	4.37	0.67	Moderate interest	4.58	0.86	Moderate interest

Table 3. Difference between the elementary pre-service teachers' interest in mathematics.

Mathematics Interest	Mean	SD	df	t	*P*
Positive Valence					
Pre-Intervention	4.58	0.76	8	-3.441	0.009
Post-Intervention	4.83	0.95			
Negative Valence					
Pre-Intervention	3.95	0.45	8	-1.577	0.153
Post-Intervention	4.10	0.66			
Time					
Pre-Intervention	4.35	0.54	6	-1.777	0.126
Post-Intervention	4.50	0.68			
Overall Interest					
Pre-Intervention	4.37	0.67	26	-4.419	0.000
Post-Intervention	4.58	0.86			

Table 4. Relationship between the elementary pre-service teachers' interest and mathematics achievement. *Correlation is significant at the 0.05 level (2-tailed).

Pearson Correlation	Positive Valence		Negative Valence		Time		Over-all Interest	
	r	*P*	r	*P*	r	*P*	r	*P*
Posttest	-0.242	0.133	0.021	0.899	-0.338*	0.033	-0.177*	0.027

DISCUSSION

Elementary Pre-service Teachers' Level of Mathematics Achievement

The EPTs' mathematics achievement before the intervention is weak which implies that the future teachers were not able to answer the pretest covering operations on fractions. However, it was evident that there is an increase in the number who got an average mark after the intervention. Meanwhile, it is interesting to point out that the EPTs' were able to get an excellent and above-average mark after the intervention. The jigsaw strategy indeed strengthened the mathematics achievement of the EPTs. It coincides with the findings of Casing (2018) where more EPTs' got higher marks after the implementation of the jigsaw strategy and conforms to Ibañez and Pentang (2021) which resulted that cooperative learning strategy can improve EPTs' achievement in fractions. Russo (2014) and Okeke (2015) also reported that students' performance was improved when mathematics was taught using the jigsaw strategy. This result shows that EPTs can utilize jigsaw strategy in the teaching-learning process even with fractions. Thus, by exchanging ideas, EPTs will have a better sense of responsibility for their learning and their peers.

Jigsaw strategy allows the EPTs to become an expert in a specific topic. After they became experts on a specific topic, they were able to share their knowledge with their peers. Hence, from a single knowledge, they were able to gain additional learnings from among themselves. Instead of memorizing just one step in addition or subtraction of fractions, the EPTs have now learned new and simpler methods of solving problems. Also, the jigsaw strategy promotes cooperation among them. Some lessons are difficult, and they were terrified to ask their teachers for clarifications. This results in unclear or lack of mastery towards the lesson. In the jigsaw strategy, EPTs can easily ask their peers for clarifications as they see them as their equal, where it was evident the differences between before and after the intervention were found significant. Though fraction operations are confusing for many, it was easier for students who work together compared to individual learning through modules or video tutorials (Abed et al. 2020), which is predominant in today's online class setup.

This result was comparable with Anaduaka et al. (2018) when the experimental group displayed a significant increase in their academic achievement in mathematics which means that the utilization of the jigsaw strategy is highly effective for instruction. This shows that the utilization of the jigsaw strategy in mathematics class, even though online class, benefitted the EPTs in strengthening their achievement. It can also be construed that the use of the jigsaw strategy is effective even in an online learning environment where internet connectivity can be a problem. Abed et al. (2020) reported a similar result after they investigated the predicting effects of

jigsaw strategy in proficiency in mathematics where the test scores of those in the jigsaw group increased significantly than those in the teacher-centered group. Additionally, Mbacho and Changeiywo (2013) and Yemi et al. (2018) revealed that students who were subjected to the jigsaw strategy scored better in the posttest as compared to their pretest score. Considerably, pedagogical interventions can enhance mathematics achievement (Pentang 2021) and a jigsaw strategy can help in strengthening the knowledge and skills in mathematics. Thus, training should be designed for mathematics teachers on the appropriate usage of the strategy rather than focusing on the traditional method of teaching. EPTs will be having more hands-on experience in understanding a specific topic in mathematics that will then be converted into better outputs and achievement.

Elementary Pre-service Teachers' Level of Interest in Mathematics

The EPTs developed a more positive attraction towards mathematics after the intervention since they expressed their feelings on how helpful their knowledge in mathematics can be and that they were willing to learn more about the subject. This is parallel with Oduro et al. (2014) where most participants showed a strong affinity for mathematics. In physics, students improved their interest as they developed critical thinking and they became more responsible for the success of their group (Kade et al. 2019). However, this finding showed setbacks in terms of excitement in learning new topics and answering questions about mathematics after the jigsaw strategy intervention. These setbacks may be influenced by the EPTs' unfamiliarity with jigsaw strategy or the observation that they have poor mathematical interest.

The jigsaw strategy failed to decrease the negative attitude of the EPTs. It also shows that EPTs developed a negative attraction towards the subject. Negative attraction towards the subject could stem from the frustration brought by slow internet connectivity and online learning adds up to the stress in learning mathematics. This finding is comparable with Wong and Wong (2019) where some participants agreed that they are wasting time on mathematics, while others perceived that they get mad easily when working on mathematics.

Generally, the findings implied that the jigsaw strategy slightly increased the EPTs' interest in mathematics. It means that the participants develop a higher level of interest in mathematics after they were subjected to the intervention. This result can be attributed to the fact that the jigsaw strategy helped in the development of cooperation among EPTs. Similarly, Okeke (2015) and Areelu and Ladele (2018) noted that those who were subjected to the jigsaw strategy had increased their level of interest in mathematics.

The EPTs' interest in mathematics was enhanced when the jigsaw strategy was used in teaching fraction operations. The EPTs were able to motivate each other during the jigsaw strategy intervention since they can discuss the topic with their peers in jigsaw strategy, as compared to traditional teaching where learners must listen attentively to the discussions of the teacher. Similarly, Oduro et al. (2014) reported that the majority of the participants do not like the traditional approach and methods employed by the teachers in teaching mathematics. Breaking the learners into smaller groups also helps in developing camaraderie. Learners become more interested in mathematics when they are divided into small groups. Timayi et al. (2015) reported a similar result when their study revealed a significant difference in the interest level of the EPTs when exposed to the jigsaw strategy. Moreover, Areelu and Ladele (2018) found out that the jigsaw strategy was an effective method of teaching to improve the mathematics interest among learners. This implies that the jigsaw strategy can help the EPTs develop an appreciation of mathematics since they will be handling the same to their future students. Furthermore, the jigsaw strategy is effective in increasing student involvement and understanding towards the subject thus creating more fun and positive environment for learning mathematics (Yozza et al. 2018).

The jigsaw strategy promotes positive valence towards mathematics as it creates a positive climate in learning the subject. It implies that the EPTs were able to develop a positive attraction towards the subject as they were able to learn fractions with their peers rather than passively learning from their teacher's lectures. Abed et al. (2020) discovered a similar result where they concluded that learners developed a positive attitude towards the mathematics lessons. As a result, EPTs were more likely to have a strong interest in learning mathematics. The EPTs need to have a high positive attraction towards the subject as they will be the ones paving the way for their students to have more interest in mathematics.

Moreover, the negative attraction and time commitment of the EPTs after the intervention were not statistically different from the pre-intervention. This can be attributed to the stress brought by the new, online setup of education. Though jigsaw strategy proved its efficacy towards the enhancement of mathematics achievement, poor internet connectivity challenges online learning. Thus, affecting the participation of the EPTs in the utilization of the strategy.

Relationship between the Elementary Pre-service Teachers' Interest and Mathematics Achievement

The EPTs who have dedicated more time to solve mathematical problems tend to have low

achievement in fractions. This implies that allocating more time to understand the concept of fractions is tiresome, resulting in poor mathematics achievement. This result opposes Spitzer (2021) who found that increasing study time is contributory to success in mathematics.

The result also showed that EPTs who have a higher interest in mathematics tend to have low mathematics achievement. This shows that even though a high level of interest was shown, internal factors such as unpreparedness before taking the test and other personal factors could affect mathematics achievement. The result agrees with Wong and Wong (2019) who showed that those who are inclined to mathematics did not quite see the benefits of learning the subject and vice versa. In contrast, Asbury et al. (2016) and Chen et al. (2018) had proven that a positive outlook towards mathematics has a greater impact in predicting students' achievement in the subject.

The finding indicates that high interest in mathematics does not necessarily guarantee a higher mathematics achievement, which agrees with Pentang et al. (2021) who found that EPTs who are into mathematics did not perform excellently in mathematical problem-solving. This result can help EPTs understand the concept between achievement and interest in mathematics. Hence, they aren't ought to focus on developing the interest of the students towards the subject.

In general, the jigsaw instructional strategy strengthened the mathematics achievement and interest of the EPTs, allowing them to become experts in and develop an interest in fraction operations. Since innovative pedagogies and learning materials enhance the effective transfer of learning (Pentang 2021; Ummah and Hamna 2021), it is suggested that mathematics educators be well-versed in the background and implementation of the jigsaw strategy, particularly in an online setting. Jigsaw strategy is effective despite its application in online classes where the EPTs can have a more meaningful learning experience. Other strategies may be explored to facilitate the training and preparation of the EPTs and to advance their interest and capabilities as future mathematics teachers.

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