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The Effect of Using Blended Jigsaw-4 Problem-Solving Instruction on Preservice Physics Teachers' Problem Solving Skill

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The main purpose of the study was to investigate the effect of Jigsaw-4 problem-solving instruction on preservice physics teachers' (PSPT) problem-solving skills in the college of teacher education in the Southern nation nationality region of Ethiopia. The study involves 136 first-year PSPTs who are attending their preservice teacher education program in four colleges of teacher education. A quasi-experimental research method with a pretest-posttest design was used in the study. The instrument that was used to collect data for this research was a problem-solving skill test. The reliability of the test was checked using KR-20 and found to be 0.72. In treatment groups, one, two, and three, the TECMRER (Thinking, Exploring, Choosing, Manipulating, Discussing, Reflecting, Evaluating, and Re-teaching) model was used in Jigsaw-4 problem-solving strategies (J-4PSS), Jigsaw-4 (J-4), and Problem-Solving Strategies (PSS), respectively were employed, while the customary method was employed for the comparison group. The data were analyzed using descriptive and inferential statistics. The results revealed that despite treatment groups outperforming the comparison group, Blended Jigsaw-4 problem-solving instruction was the most effective approach for improving preservice physics teachers' problem-solving skills due to increments of interactive engagement among the individual within the group.

Keywords: blended jigsaw-4 problem solving instruction, jigsaw-4, mechanics, physics, problem solving strategies

INTRODUCTION

Education is the most important factor in a country's prosperity; welfare, and security (James & Singer, 2016). Notably, science education in general, and physics education in particular, are important drivers of economic growth and serve as the foundation for technological advancement (Shairose, 2015). Physics is a field of natural science that uses natural laws and principles to help people understand both nature and the phenomena they encounter (Papachristou & Academy, 2020). Understanding physics in this regard enables us to develop a wide range of inventions that either directly or indirectly improves our way of life. It enables using technology to do everyday jobs, deriving conceptual understanding from natural phenomena, and developing mental models to convey information (Poljak & Jakić, 2017). Thus, it is vital to promote science literacy in general and physics in particular, as well as to nurture the next generation of scientists (Shairose 2015). To that end, maintaining quality science education, particularly physics education is critical (Puchongprawet 2022).

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However, students' poor performance at both the global and national levels hampered efforts to promote quality physics education (Education, 2020). According to Gbollie and Keamu (2017), despite students' poor performance being noticed at all levels of education, the problem is more pronounced in teacher education colleges. Fariyani et al (2020) also claim that pre-service teachers' performance is declining at an alarming rate. Such unsatisfactory performance of students is also evidenced by other studies such as (Alemu et al., 2019; National & Pillars, 2018; Tadese et al., 2022). One of the witnesses in this regard is the assessment of the educational bureau of the Southern Nation Nationalities People Region State (hereafter called SNNPRS). The SNNPRS educational bureau administered the Certificate of Competence (COC) examination to pre-service teachers from 2015 to 2018. According to this official report document, in 2014, 2015, 2016, and 2017, 63%, 83%, 58%, and 58% of pre-service teachers respectively scored less than 50% in physics (Southern Nation Nationalities People Regional Education Bureau, 2019).

Among other things, when learners lack sufficient conceptual understanding and problem-solving skills in prerequisite subjects or concepts, it has a trickledown effect to gain necessary problem-solving skills in subsequent subjects, or concepts (Yavaş, 2016). This suggests that efforts invested in prerequisite subjects have indispensable roles to comprehend subsequent subjects or concepts. In this connection, mechanics is used as a prerequisite for other topics in physics such as work, energy, momentum, gravitation, electrostatics, electromagnetism, rotation, and oscillation (Alrasheed, 2019; Papachristou & Academy, 2020). Thus, understanding basic mechanics concepts and possessing the necessary skills to solve mechanics problems are thought to lead to understanding other subsequent concepts or subjects that likely lead to good physics achievement in general. However, studies revealed that pre-service physics teachers failed to master mechanics concepts (Alemu et al., 2019; Bahcivan & Kapucu, 2014; Koponen & Nousiainen, 2012; Prachopchok et al., 2020). According to Baring et al (2022), college students complete their Newton's Law of Motion course with insufficient comprehension and lack problem-solving skills, resulting in low achievement in mechanics and subsequent physics subjects (Ning, 2016; Wancham, 2023). It is well known that mechanics in particular and physics in general highly demands problem-solving skills. Thus, the purpose of this study is to address the weakness of students' problem-solving skills in mechanics with a particular focus on Newton's law of motion also thought to serve as a solid foundation for succeeding physics concepts and subjects.

Why the researcher used Jigsaw-4 techniques of teaching?

Jigsaw 4 is built around cooperative learning practices, with each group member interacting with the session's contents three times in a single lesson. Furthermore, it fosters a sense of mutual advantage among group members by increasing their reliance, which reduces racial conflicts among college students. Jigsaw-4 was advanced by Özdemir & Arslan (2016) and includes three important new features: an introduction, quizzes, and re-teaching after individual assessment. Thus, the Jigsaw-4 method is useful for assisting students to take an active role in their education, learning a large amount of material quickly, sharing their knowledge with other groups, listening less, and taking ownership of their learning. These features make the Jigsaw-4 better than the other Jigsaw types (1, 2, 3, Reversed Jigsaw, and Subject Jigsaw)

Why this study is important

The study's primary contribution was to guide college instructors on how to improve PSPTs' problem-solving abilities when learning physics (mechanics) using various approaches, such as the blended Jigsaw-4 Problem-Solving Instruction for teaching and learning physics in general and mechanics in particular. The other significance of this study was for textbook writers and policymakers to think about and suggest to college teachers about such types of active learning methods that are used to enhance students' problem-solving abilities toward the learning of mechanics. This study was important for researchers to use as a source, and to guide them when undertaking similar research in physics or other fields.

Contribution of This Study to the Literature

Globally, in every nation, there is a need to create citizens who can solve challenges to address person al, societal, and global issues. To improve students' achievement and problem-solving abilities as well as to teach them difficult science subjects (like physics) and help them solve real-life or practical problems, it is necessary to use student-centered teaching techniques like Jigsaw-4 techniques of teaching, problem-solving instruction and blended Jigsaw-4 problem-solving instruction. It is necessary to evaluate several approaches for enhancing students' interest in and the ability for enhancing students' interest in and ability to address various problems, as well as their problem-solving skills in physics that in turn enhance student's 21st-century skills. Thus, this study will contribute to meeting these needs. Additionally, researchers could incorporate the study's findings into others.

Statement of the problem

In a body of literature, some of the identified factors for insufficient concept understanding and a lack of problem-solving skills were the absence of an effective teaching method, low motivation to learn physics, a lack of teachers' physics content knowledge, a lack of prior knowledge, and rote memorization (Ambreen & Ahmad, 2017; Eguabor & Adeleke, 2017; Erfan & Ratu, 2018; Silitonga et al., 2020; Supriyati, 2020). Thus, the use of ineffective teaching techniques was one of the major reasons why students' understanding of physics concepts and problem-solving skills was hampered, resulting in poor academic achievement. According to numerous studies, the traditional approach is the most popular teaching method employed in physics classrooms at all levels in general and the college level in particular, which does not help students to comprehend concepts and develop problem-solving skills (Negassa, 2014; Noel et al., 2015). To address students' lack of conceptual understanding and problem-solving skills, educational scholars around the world have attempted to intervene through various active learning strategies. Problem-solving strategies and jigsaw-4 teaching techniques are often utilized as intervention strategies by educational scholars in response to a lack of students' comprehension of physics concepts and a lack of solving physics problems that require problem-solving skills (Jamilu; Iliyasu; Shehu, 2022; Montalbano & Benedetti, 2013).

Many scholars across the world have researched the effectiveness of Jigsaw-4 teaching techniques (Dincer et al., 2013; Yimer & Feza, 2019) They claimed that Jigsaw-4 teaching strategies were successful in enhancing students' conceptual understanding as they provided opportunities for social engagement. The interaction creates positive interdependence. However, despite its relative advantage in boosting students' conceptual comprehension, it fails to foster individual competition and inhibits individuals' abilities to solve issues on their own (Aydin & Biyikli, 2017; Huang et al., 2014)

On the other hand, scholars who studied the effect of problem-solving strategies demonstrated that problem-solving strategies enhance learners' problem-solving skills (Esan, 2015; Selçuk et al., 2008). However, this strategy disregards social interaction and a common aim in favor of an individualized approach and individual competition that ignores learning from one another, leading to poor conceptual understanding (Dhillon, 1998; Jennifer L: Docktor et al., 2015; Ince, 2018; Mann & Tan, 2021; Gita:& Taasoobshirazi & Farley, 2013). Conversely, without an understanding of the concepts, solving physics problems is unlikely. This implied that teaching physics, which largely relies on solving physics problems, requires a teaching approach/strategy that simultaneously gives learners the chance to understand concepts and enhances their problem-solving skills.

Recognizing the drawback of Jigsaw-4 techniques of teaching and TECMRER problem-solving strategy, the two approaches were blended in teaching Newton's law of motion to see if the hypothesized approach has significant effects in boosting students' problem-solving skills. Therefore, the main objective of this study is to examine the effects of J4PSS on the problem-solving skills (PSK) of pre-service physics teachers. Particularly, the mean differences in PSK among the four groups in learning Newton's laws of motion were investigated based on the following specific research question:

RQ1: Is there a significant post-test mean difference in PSK among the four groups in learning Newton's laws of motion?

METHOD

Research Design

This study used a pre-test–post-test non-equivalent group quasi-experimental design to compare the treatment groups with the comparison group and details are shown in Table 1 below using symbolic representation. The use of a quasi-experimental design was necessitated by the difficulty of randomly assigning subjects to the comparison and treatment groups and a lack of control over the threats of validity that is inherent in the college setting. The design was summarized in Table-1.

Table 1
Symbolic representation of the multiple treatments quasi-experimental design used in the study

Group	Pre-test	Treatment	Post-test
Treatment group I	O1	E_1	O2
Treatment group I	O1	E_2	O2
Treatment group II	O1	E_3	O2
Comparison group	O1	X	O2

Where: O_1 *= represent pre-test;*

O_2 *= represent post-test;*

E_1 *= represents Jigsaw-4 Problem Solving instruction*

E_2 *= represents Jigsaw-4 problem-solving instruction*

E_3 *= represents the Problem-solving strategy*

X = represents the traditional instruction

Sample and Sampling Techniques

The population of the study was obtained from Bonga, Hossana, Arbamich, and Dilla Colleges of teacher education (CTE) in the South Nation Nationalities People's regional state of Ethiopia. Four CTEs found in this region were randomly selected via simple random sampling techniques. The target populations of this study were first-year physics pre-service teachers. The preservice physics teachers in these four government CTEs come from families with almost similar socioeconomic status, and their demographic distribution is also urban-rural. An available sampling technique was used and took one intact class for each of the four colleges. The sample size of the study was one hundred thirty-six (N=136) physics upper primary pre-service teachers.

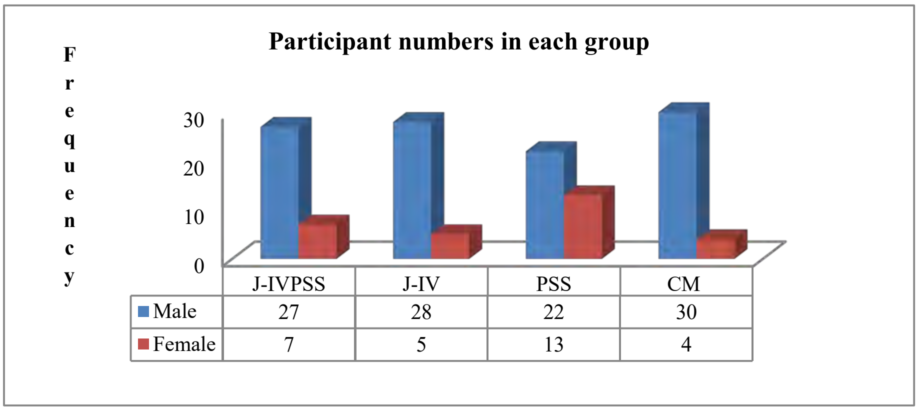

Figure 1
Participants of the study in each group

To account for instructor variability, four teachers (one from each college) were chosen from among the available teachers who are comparable in terms of experience, qualification, and willingness to participate in the study. CTEs were assigned at random to J4PSS, J4, PSS, and CM, followed by a random selection of one intact class from each of the four colleges, and then a pre-test was administered to all groups to determine the baseline. Accordingly, Bonga, Hossana, Arbamich, and Dilla College of Teacher Education were randomly assigned to J4PSS, J4, PSS, and CM, respectively.

Data Collection Instrument

The problem-solving skills test was used to collect data. The test consists of three open-ended problems on Newton's laws of motion that were adapted from the Force Concept Inventory Test (FCIT) and aligned with the objectives stated given in the Mechanics I module (PHY-101) for pre-service physics teachers (Keh, L. K., Ismail, Z., & Yusof, 2016).To ensure content and phase validity, the draft test was given to experts and practitioner teachers. After necessary modifications were made based on feedback from experts and teachers, the test was pilot tested on another college that was not involved in the actual study to see the reliability of the instrument. To test the reliability of the test KR20 was calculated and the resulting value was 0.72, revealing that the item's internal consistency was within the recommended range. See Appendix 1

To evaluate the workout problem, the five categories of Minnesota assessments of Problem-solving rubric (MAPS) were adapted for this study. The dimension of an adapted rubric includes distinguishing and graphically describing a problem, selecting appropriate physics laws and principles, adapting physics laws to the specifics problem, pursuing appropriate mathematical procedures, and having a structured, goal-oriented logical progression that directs the problem-solving process (Jennifer L. Docktor et al., 2016; Jennifer Lynn Docktor, 2009; Mckagan & Madsen, 2022). An overall rubric score for each problem solution was calculated by assigning a score ranging from 0 to 4 for each of the five categories of the rubric to a written solution and then adding all the scores together. This summed score (with a maximum of 20) was then divided into several categories (5) to re-grade/reweight the resulting score out of 4). The reweighed results of each of the three items were added together and divided by the number of items (3) to generate aggregated results of the three items, which were then divided by the maximum category score (4) and multiplied by 100 to obtain a percentage. Then, the resulting percentages were interpreted using a performance quality level of problem-solving skills that range from very poor performance to very good performance as shown in

Table 2 below. Besides, grand mean scores of the three workout problems were used to compare mean differences across the groups.

Table 2
Level of performance quality on problem-solving skills tests adapted from the MAPS Rubric

Dimensions (indicator)	Likert scale to assess participants' Problem-solving skills (Rubric)					Level of performance
	4	3	2	1	0	In percentage & PQ
Identify a problem & graphically describe	Identify the problem & fully describe the problem	Identify the problem but the description contains minor error	Identifying but the majority of the descriptions contain an error	Identify the problem but & fails to describe the problem	NA	[0-20) = Very Poor [20-40)= Poor [40-60)= Acceptable [60-80)= Good >= 80 = Very Good
Choosing appropriate physics laws & principles	Fully choose appropriate law & principle	Choosing the majority of the appropriate law & principles	Choose some of the appropriate laws & principles	Choose while failing to choose appropriate laws & principles	NA	[0-20) = Very Poor [20-40)= Poor [40-60)= Acceptable [60-80)= Good >= 80 = Very Good
Adapting physics laws to the specifics problem	Fully adapt the law to the specific problem	Adapt laws to the specific problem with few mistakes	Adapt some laws to the specific problem	Adapting law while failing to the specific problem	NA	(0-20) = Very Poor [20-40)= Poor [40-60)= Acceptable [60-80)= Good >= 80 = Very Good
Pursuing appropriate mathematical procedures,	Pursue appropriate mathematical procedures consistently	Pursue appropriate mathematical procedures with a minor error	Pursue appropriate mathematical procedures in part	Pursue suitable mathematical procedures in part with major error	NA	(0-20) = Very Poor [20-40)= Poor [40-60)= Acceptable [60-80)= Good >= 80 = Very Good
Goal-oriented logical progression	Progress is fully observed	Progress is being observed but not at the expected level	Progress is observed in part	Progress observed is far below than expected	NA	(0-20) = Very Poor [20-40)= Poor [40-60)= Acceptable [60-80)= Good >= 80 = Very Good

Note: NA refers to "not accepted", PQ refers to 'performance quality

Procedure

Based on expert feedback and the result of the pilot test, the necessary amendment was made. Pre-service physics teachers in the four groups were given a pre-test used for drawing a baseline that later helps to judge the change that might be observed is due to intervention or not. In the process, treatment group-I was exposed to Jigsaw-4 techniques of learning blended with the TECMRER model of Minnesota problem-solving strategy possessing seven processes including thinking, exploration, choosing strategies-planning and manipulating, discussions, and reflection; the process of evaluation; and the process of re-teaching. This blended technique is referred to as Jigsaw4-problem solving strategies (J4PSS) and the process of implementing it is depicted in Figure 2 below. Accordingly, a teacher who taught treatment group-I using J4PSS received training on Jigsaw IV, the TECMRER model of Minnesota problem-solving strategy, and how to blend and implement in the classroom to teach the mechanics law of motion.

Figure 2
The cycle of the TECMRER model with 7 processes used for the implementation of J4PSS Lesson instruction in jigsaw 4-problem solving strategies

The teacher, who taught treatment group II received training on how to implement the Jigsaw IV technique of teaching. The teacher who taught treatment group III also received training on how to implement the TECMRER model of Minnesota problem-solving strategy, while, the teacher who taught the comparison group used the conventional method. During the process, the researcher assisted the physics teachers who taught the three treatment groups in the preparation and delivery of the lesson as anticipated. Then, after the session, each of the three treatment groups and one comparison group was given a written post-test with open-ended questions.

Data Analysis

To analyze the data SPSS version 24 software was utilized. Descriptive statistics like frequency, percentage, and mean as well as inferential statistics like ANOVA were used as part of the data analysis technique. Frequency and percentage were used to label the level of pre-service problem-solving skills (to label pre-service level performance quality on problem-solving skills).

FINDINGS

To check for the equivalence of the groups before the treatment, the mean difference in problem-solving (PSK) scores across the four groups in learning Newton's laws of motion was compared, and the results are presented in the part that follows.

Table 3
The mean score of the pre-test of PSK in physics

Group	N	Mean	Std. Deviation	Skewness	Kurtosis
J4PSS	34	1.8647	.40218	.120	.889
J4	33	1.8000	.24495	.326	.115
PSS	35	1.7429	.27255	.332	.052
CG	34	1.6706	.31864	.190	.161
Total	136	1.7691		. 300	.130

Table 3 indicated that the mean, standard deviation, Skewness, and kurtosis of the pre-test results on the problem-solving skills of all four groups in learning physics, particularly Newton's law of motion. The data revealed that the average of the problem-solving skills for Jigsaw-4 Problem-solving strategies, Jigsaw-4method of teaching, Problem-solving teaching strategies, and conventional method of teaching was (M=1.86, SD= .57), (M=1.80, SD= .22), (M=1.74 SD= .283), and (M=1.7, SD= .525) respectively.

Regarding skewness and kurtosis, all treatment and comparison groups have values of skewness between -1 and +1 and values of kurtosis between, -2 to +2 (-1.96 to +1.96). This showed that all the obtained values of skewness and kurtosis were found at an acceptable level (ORCAN, 2020). The values obtained for problem-solving skills among the four groups are a little skewed and kurtosis. This showed that the data did not differ significantly from normality. Thus, these data were approximately normally distributed from normality in terms of skewness and kurtosis.

The average mean of the problem-solving skills of preservice teachers for groups was rated by using five scaled Likert scales out of 5 marks. The result revealed that the percentage of the problem-solving skills of preservice teachers in learning mechanics courses (particularly Newton's law of motion) for J4-PSSS, J4, PSS, and CG were 37,2 %, 36 %, 34.8%, and 34 % respectively. This implied that, before the intervention, the level of problem-solving skills of preservice teachers in learning Newton's law of motion is at a poor level for all groups. Since basic assumptions to use ANOVA were satisfied, ANOVA was carried out to compare the pre-test scores of the groups. The pre-test score of the groups was compared to see the baseline, which helps determine if any differences that might be seen after intervention are attributable to intervention after all variables supposed to confound the outcome are controlled. The analysis was performed at a 95% confidence interval, and a p-value of less than 0.05 showed that the difference, if any, is statistically significant.

Table 4
ANOVA results before treatment

Test categories	Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Pre-test	Between Groups	.696	3	.232	2.333	.077
	Within Groups	13.134	132	.099		
	Total	13.830	135			

a. R Squared = .704 (Adjusted R Squared = .697)

Table 4 shows the pre-test mean scores comparison among the groups. The result indicated that F (3,132) =2.333, p=0.077 for the pre-test. The significance value (0.077) indicated that there was no statistically significant difference between the groups before treatment. To check for the effect of J4PSS on pre-service physics teachers' problem-solving skills, ANOVA was conducted on the post-test mean scores among the groups after checking for the assumptions. The result is indicated in Table 5.

Table 5
Levene's test after treatments

Test of Homogeneity of Variances			
problem solving skill			
Levene Statistic	df1	df2	Sig.
3.670	3	132	.014

Table 6
ANOVA results after treatment

Test categories	Source of variation	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Post-test	Between Groups	10.098	3	3.366	46.509	.000	.704
	Within Groups	9.553	132	.072			.990
	Total	19.651	135				.704

a. R Squared = .704 (Adjusted R Squared = .697)

The result indicated that F (3,132) =46.509, p=0.000. The significance value (.000) value after treatment revealed that there was a statistically significant difference between the groups after treatment. Given the statistically significant difference between the groups after treatments, Post Hoc ANOVA was employed to identify between which groups a statistical significance difference exists. During the analysis, Games-Howell Post Hoc ANOVA was preferred over Tukey HSD Post Hoc ANOVA because the test of variance homogeneity on Levene's statistics was significant, as shown in Table 5 below.

Table 7
Games-Howell Post Hoc ANOVA Test

(I) Groups	(J) Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
J4PSS	J4	.57344*	.07614	.000	.3714	.7755
	PSS	.62790*	.07518	.000	.4282	.8276
	CG	1.20147*	.08062	.000	.9883	1.4146
	J4	-.05446	.05209	.723	-.1918	.0829
	CG	.57357*	.05844	.000	.4193	.7278
	CG	.62803*	.05967	.000	.4706	.7855

As depicted in Table 7, a statistically significant mean difference was observed between J4PSS and J4 (I-J=.57344, P=.000), between J4PSS and PSS (I-J=.62790), between J4PS and CM (I-J = .6720, p=.000), between PSS and CM (I-J = .6280, p=.000), between J4 and CM (I-J = .5736, p=.000). However, even though there is no statistically significant difference between PSS and J4, the mean score of the group exposed to J4PSS outperform better than the two groups exposed to PSS and J4. This suggests that J4PSS is the best approach to improving students' problem-solving skills.

The normalization learning gains were used to determine the learning approach that helps groups gain a higher mean was calculated using a formula

$$\langle g \rangle = \frac{(\%\, post - \%\, pre)}{(100 - \%\, pre)}$$

Table 8 shows the mean, standard deviation, and means normalization learning gains of the problem-solving test results from the pre-and post-tests for the four groups exposed to different instructional strategies.

Table 8
Mean standard deviation and normalization learning gains of the pretest and post-test scores of problem-solving skills

Dependent variable	Groups	Strategy	Pre-test			Post-test		Mean-Normalization .learning Gains
			N	Mean	SD	Mean	SD	
Problem solving skills	Treatment groups	J4-PSS	34	1.86	.402	3.38	.385	.484
		J4	33	1.80	.245	2.80	.217	.312
		PSS	35	1.74	.273	2.75	.211	.310
	Control group	CG	34	1.67	.319	2.18	.269	.153

Based on the data indicated in Table 8, the mean normalized learning gain was 0.153 for the CG (i.e., for the group that is exposed to the conventional method) and 0.484 for the treatment group who was treated with Jigsaw-4 problem-solving strategies using the TECMRER model in their learning of the selected contents of mechanics. 0.312 and 0.31 for treatment groups who were treated by jigsaw-4 Techniques Teaching and problem-solving strategy respectively. The mean Normalized learning gains for CG were low, but the mean normalized learning gain of preservice physics teachers who were treated by J4PSS was higher than J-4 and PSS. From the mean normalized learning gain result analysis, it is possible to say that using Jigsaw-4 problem-solving strategies (J4PSS) helps to improve PSPT‘s problem-solving skill of Newton’s laws of motion more than, Jigsaw-IV Techniques of teaching(J4), Problem-Solving Strategy(PSS), and traditional teaching methods (CG).

On the other hand, Figure 3 shows the performance quality of students' problem solving skills. As it is indicated in Figure 3, 1 (2.94%), 2 (5.88%), 11 (32.35%), 10 (29.41), and 10 (29.41%) of pre-service physics teachers' performance quality in terms of problem-solving skills is at the level of "very poor", “poor”, “acceptable”, “good” and “very good” for the groups treated with J4PSS. In the group treated with the J4 teaching method, the performance quality of 11 (33.33%), 7 (21.21%), 6 (18.18%), 5 (15.15), and 4 (12.2%) of pre-service physics teachers in PSK was at the level of "very poor," "poor," "acceptable," "good," and "very good," respectively. Moreover, in the group taught with PSS, 7 (20%), 5 (14.29%), 10 (28.57%), 7 (20), and 4 (17.14%) of pre-service physics teachers' performance quality in terms of PSK was at the level of "very poor", “poor”, “acceptable”, “good” and “very good”, respectively. Further, in the group exposed to the conventional method the performance quality of 17 (50%), 8 (23.53%), 4 (11.76%), 3 (8.82%), and 2 (5.88%) of pre-service physics teachers in PSK was at the level of "very poor," "poor," "acceptable," "good," and "very good," respectively.

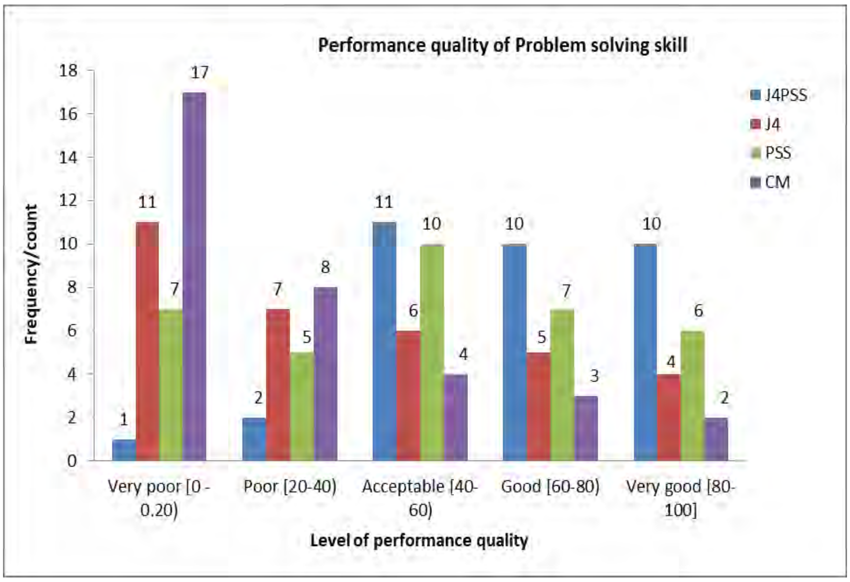

Figure 3
Performance qualities of pre-service physics teachers in problem-solving after treatment

It is clear from the result that 31 (91.18%) of students in the J4PSS group demonstrated problem-solving skills of a quality that ranged from acceptable to very good, while only 3 (8.82%) of them demonstrated poor to very poor problem-solving skills. In the group treated with J4, 15 students (45.45%) had problem-solving skills of a quality that ranged from acceptable to very good, while 18 (54.55%) of students were at the level of poor and very poor. In the group that received PSS, 60 students (60%) had problem-solving skills of a quality that ranged from acceptable to very good, whereas, 14 (40%) of them were at the level of poor to very poor. The results also showed that in the group thought with CM, 9 students (26.45%) had problem-solving skills of a quality that ranged from acceptable to very good, while 25 students (73.55%) were at the level of poor and very poor. The findings revealed that J4PSS is the most appropriate strategy for improving students' problem-solving skills, followed by PSS and J4, while CM of teaching is the least preferred approach when compared to J4PSS, PSS, and J4.

DISCUSSION

The findings of this study suggest that teaching using a combination of Jigsaw 4 and physics problem-solving strategies had improved problem-solving skills of Newton's laws of motion better than using Jigsaw-4 alone, problem-solving strategy, and the traditional way of instruction. The integrated approach was the best of all the techniques used, despite some discrepancies between problem-solving and Jigsaw -4 strategies in the elements of problem-solving skills. Similarly, problem solving strategy was more effective than the jigsaw-4 techniques of teaching and lecture method in improving problem solving skills in learning physics.

According to the study by Habtamu et al. (2022), 9th-grade secondary school students' problem-solving abilities were enhanced by the application of a cooperative problem-solving technique. The research conducted by researchers (Akintolre, 2020) on the relative effectiveness of Jigsaw and problem-solving techniques also showed that students' achievement and computation when learning physics improved (Knopik & Oszwa, 2021). The research's findings are consistent with the findings of the current investigation. The present study's findings match up with earlier studies. Jigsaw 4 and problem-solving techniques both have advantages and disadvantages, according to academics. It is necessary to combine these two teaching strategies to gain the advantages of both. There is social interaction and cooperation when using Jigsaw-4 whereas the problem-solving strategy promotes individual problem-solving skills and limited the interaction between the peer groups.

A study done by Karacop (2017) determined the effects of Jigsaw 4 on prospective physics teachers learning of different topics. The results showed that preservice physics teachers had higher levels of achievement in different topics of physics compared to the conventional methods of instruction. Also, other researchers like Özdemir and Arslan (2016) found out the effects of Jigsaw-4 on university students in learning English.

The results revealed that the student's academic achievement increased. Different authors researched problem-solving strategies and found that it increases the problem-solving skill of an individual learner (Abubakar & Dr. Danjuma, 2012; Argaw et al., 2017; J. : Docktor et al., 2016; Gita Taasoobshirazi et al., 2022). Similarly, the study done by High (2020) demonstrated that the was a significant difference between problem-solving ability and problem-solving strategy. However, it is criticized for its competitive and individualistic nature. This limitation of the problem-solving strategy could be improved using the Jigsaw-4 method of strategy because this approach improves social interaction and cooperation of learners with their teacher and peers. Therefore, the blended Jigsaw-4problem solving strategy improves the achievement of preservice physics teachers on Newton's laws of motion than using either of the methods solely.

The Jigsaw-4 teaching method is effective in the learning of theoretical courses in the development of critical thinking processes in their capacity for self-expression, and in their communication skills through some different types of research (Zdemir & Arslan, 2016; Yaayin et al. 2017). Mahidol (2020) discovered thatthe theJigsaw-4 method was less effective than an inventive approach, the linear model, although it was advised to be employed when instructional time is restricted. Despite the use of problem-solving strategies, studies have shown that academic achievement in science education is still low because these strategies promote greater individualism and minimize the importance of social interaction, collaboration, and interaction (Johnson& Johnson, 2015). By contrast, in the Jigsaw-*4* Problem Solving Strategies classroom, students form a mutual internal source of positive reinforcement for one another because of their relationship of positive interdependence (Yavaş, 2016).

CONCLUSION

It is evident from this study's finding that the blended Jigsaw 4-problem solving strategy improved preservice physics teacher problem-solving skills better than, Jigsaw 4 techniques of teaching, Problem-solving strategy, and convectional method in learning Newton's law of motion. Generally, a combination of Jigsaw-4 Problem Solving improved pre-service physics teachers' problem-solving skills better than another approach. Similarly, the research's results showed that there is no significant difference between Jigsaw-4 teaching methods and problem-solving techniques but so far there are significant -differences between the conventional learning method and problem-solving strategies, as well as between Jigsaw-4 teaching techniques and this approach.

RECOMMENDATIONS

The authors recommend practitioners, researchers, policymakers, and textbook writers use such types of active learning methods to improve students' problem-solving skills toward learning mechanics. The college of teacher education and other associated bodies should give training on learner-centered practices and ways to improve preservice physics teachers' problem-solving skills in teaching and learning Newton's laws of motion. To make students perform better in problem-solving skills PSPT in

Newton's laws of motion, instructors should apply blended Jigsaw-4 Problem-solving strategies in their classroom instruction.

Furthermore, others are recommended to investigate such methods in other areas of physics, such as geometrical optics, electrostatics, temperature, and heat.

LIMITATIONS

While the research was being put into practice, many limitations were encountered. Four instructors led this investigation, which was carried out at four teacher training institutions. Although the researcher trained to choose comparable colleges and instructors from a different perspective and provided training on the instructional approach and way of implementation, the interventions might be affected due to individual differences because it is impossible to control all instructor- and college-related variables. Covid-19 might also create a problem for students learning in groups.

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Appendix –1

Problem-solving skill test-items

Instructions: read each open-ended question carefully to follow your strategies and attempt to answer in the space provided. The problem-solving skill test contains 3 open-ended questions. Find the solution to the problem using the traditional method or Minnesota problem-solving strategies. The time allowed was 90 minutes to complete the test.

1) Two boxes of the same shape are placed on a frictionless leveled surface as depicted in Fig 4 below where. But mass 'B' = 40kg and mass 'A'=25kg. A force of 500N is applied to move them with constant velocity

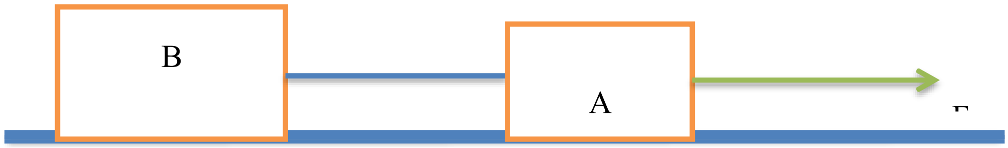

Figure 4
Two boxes are moving with constant velocity

Depending on the fig1 answer the following question respectively.

a. Is there any force acting on the block "A" and "B"? --------------------------------

b. If your answer is "a" is yes, Calculate the force exerted on each block, the direction, and the magnitude of acceleration.

2) Two metal blocks of A and B are placed gently one upon the other as shown in fig-2 below. If the mass of the bocks are 40kg and 30kg respectively, then

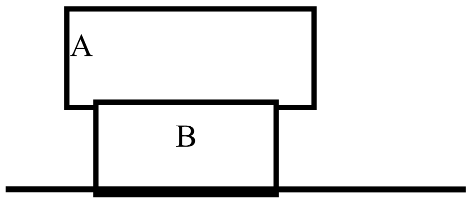

Figure 5
Two metal boxes A and B

Depending on Fig 5 answer the following question.

a) Calculate the force exerted on the surface

b) Find the force exerted on each mass.

3) The system of two blocks of masses of M1=4kg and M2= 2kg are connected by an ideal massless string on a massless pulley as shown in Figure 6. If the coefficient of friction between the table and mass one (M1) IS 0.6. Find the tension and acceleration of the system.

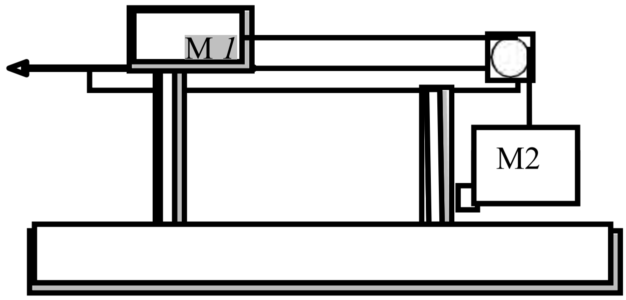

Figure 6
Two blocks are connected by an ideal massless string on the table