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# Enhancing College Students' Procedural Knowledge of Physics Using Blended Jigsaw-IV Problem-Solving Instruction

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## Abstract

Jigsaw-IV Problem-solving method is innovative active learning instruction used to improve college student's learning. The main purpose of the study was to investigate the effect of Jigsaw-IV problem-solving instruction on preservice physics teachers' (PSPT) procedural knowledge in 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. To achieve the goal of the study, a quasi-experimental research method with the pretest-posttest design was used. Procedural knowledge test was used for Data collection. The reliability of the test was checked using KR-20 and found to be 0.83. In treatment groups one, two, and three, the TECDRER (Thinking, Exploring, Choosing, and Manipulating), Discussing, Reflecting, Evaluating, and Re-teaching) model used in Jigsaw-IV problem-solving strategies (J-IVPSS), Jigsaw-IV (J-IV), and Problem Solving Strategies (PSS) were employed, while the customary method was employed for the comparison group. After checking all necessary assumptions, the data was analyzed using descriptive statistics and inferential statistics such as ANOVA and ANCOVA. The results showed that treatment groups performed significantly better than the comparison group. It was suggested that the J-IVPSS is a good approach to enhance PSPT's Procedural knowledge.

## Introduction

Education is a life-long process in which all human experiences, knowledge, and wisdom are acquired at various stages, which can be formal, informal, or incidental (Gupta, Banerjee, Uppal, Gautam Ganguly, & Srivastava, 2014) . In this rapidly changing world, scientific knowledge and applications are expanding and becoming increasingly important in daily life. Science is a major component that contributes to a nation's level of prosperity, welfare, and security; it is the foundation of technology and a key factor in economic growth (Tanak, 2016). As a result, studies on students' understanding of science concepts have been a topic of discussion for the last four decades, eventually becoming one of the major fields of research in science education (Soeharto, 2019).

Science is the foundation for progress in our contemporary society, and it has an ever-expanding role in daily life. It is self-evident that science-based education is the most important factor in a country's prosperity, welfare, and security (James & Singer, 2016). Furthermore, science education is thought to be a key factor in economic growth and serves as the foundation for technological development. As a result, promoting science literacy and nurturing the future of scientists is critical (Kaindume et al., 2018).Governments from all over the world work very hard to improve their educational systems in general and physics education in particular so that their curricula reflect the real world of a scientifically evolved society. Despite efforts to improve educational quality, the system revealed a significant barrier to student achievement and performance in science subjects, particularly physics (Amadalo & Musasia, 2016; Ogunleye, 2019; Pavešić, 2019) .All of the studies revealed the importance of paying close attention to students' physics knowledge at every level of the educational pyramid. Numerous studies from throughout the world suggested that students' physics performance had declined (Saks et al., 2021) and that they did not enjoy learning the subject (Taştan, 2018).

Ethiopia, like other developing countries, needs significant improvements in science education and looks to be e quipped to address concerns about science and technology development through its education and training polici es Ababa (2018) however science education implementation has limitation at all levels, and this is not an exception for colleges of teacher education. From this perspective Eshetu and Assefa (2019) argued that the low performance of students in science education is alarming.. Such unsatisfactory performance of students is also evidenced by other studies such as (Cashata et al. 2022; Molla 2019; National and Pillars 2018; Ses, Polonia, and Ravi 2020).

Physics is a fundamental science because it studies the natural phenomena of the world around us (Poljak & Jakić, 2017).Evidence indicates that physics education is in a state of crisis, even in developed countries (Apple, 2009). The reports of national learning assessments reveal that students' academic achievement is alarmingly declining at both lower and higher levels of education (Poljak & Jakić, 2017; Saks et al., 2021; Ses et al., 2020). Similar trends were observed when Regional Education Bureaus (REBs) conducted similar assessments regionally (REB, 2019). The Southern Nation Nationalities People Region (SNNPR) educational bureau administered the certificate of competence (COC) examination to pre-service physics teachers (PSPT) from 2015 to 2018, and the results of the examination were disseminated at the college level. The results of all college-level subjects are included in this official report document. The result shows that the number of PSPTS who took the COC exam in 2015 and 2016 was 63% and 83% respectively, failing the exam. Furthermore, the number of pre-service teachers who took and failed the exam in 2017 and 2018 was 83% and 58%, respectively. This study discovered that the physics achievement of college students from 2015 to 2018 was unsatisfactory.

According to the National Assessment and Examination Agency (2014) report from 2000 to 2013, grade 8, 10, and 12 composite mean scores in for Physics, 34%, 31.2%, and 36.6%, respectively, were below the standards of the Ethiopian Ministry of Education. Moreover, the recent National Learning Assessment conducted in 2017 revealed that the achievement of students in content-specific topics of physics is below 50% for both grades 10 and 12.students average score in ,Mechanics, 28.99% and 32.24%. Their mean physics achievement of students in content-specific topics of physics in grades 10 and 12 was 31%, which is lower than pass mark of the MoE. The total result shows that 92.6 percent of grade 12 students scored below 50%, while 95.4 percent scored below 50% in grade 10. Furthermore, the assessment of NLA found out that students mean score achievement in physics across cognitive domains demonstrated by such as factual knowledge, 30.67 and 38.98 and procedural knowledge 29.94% and 31.45%). According to this report, students achievement in physics is low, particularly in the area of mechanics due to lack of procedural knowledge (Cashata & Seyoum, 2022).

Through test performance, where the test questions require their abilities to analyze, synthesize, coordinate and use many physics formulas to arrive at the final correct answers, test achievement can be used to demonstrate procedural knowledge by PSPTs in their physics learning. Utilizing the relevant physics formula to answer physics problems when they are presented in a different way is another way to demonstrate procedural knowledge (Saks et al., 2021; Ses et al., 2020). It's crucial for students to comprehend physics formulas in order to solve physics problems using mathematical equations but also procedural knowledge used as one of the building block of problem solving skill (Chandrasekaran 1986; Surif, Ibrahim, and Mokhtar 2012).According to certain studies, students may occasionally retain physics formulas but fail to use them after some time to solve problems that were given using a different approach as examples in the classroom ((Bautista, 2012)).They claimed that high school students who entered to college with low ability to combine different physics formulas to work out procedural knowledge of physics tasks specially in mechanics course (Alemu et al., 2019; Programme et al., 2000; Cashata & Seyoum, 2022).

Mechanics is used as a prerequisite for other topics in physics such as work, energy, momentum, gravitation, electrostatics, electromagnetism, rotation, and oscillation (Lindner & Strauch, 2018; Mahajan, 2020). To gain an understanding of college mechanics, college students need to conceptually understand and in using procedural knowledge actively in solving problem of Newton's laws of motion, This is because, Newton's low of motion is regarded as the corner stone of mechanics (Saglam-Arslan & Devecioglu, 2010).

Research shows that the majority of college students complete their Newton's Law of Motion course without sufficient understanding including misunderstanding of concepts, and knowledge (Liu & Fang, 2016) resulting in low achievement. Despite numerous studies on physics achievement, a number of issues related to students' poor performance persist (Eguabor & Adeleke, 2017; Liu & Fang, 2016) .Some of the factors influencing the academic achievement of pre-service physics teachers in Newton's laws of motion are lack of concept master (Salim Nahdi & Gilar Jatisunda, 2020; Saprudin et al., 2017), lack of procedural knowledge of dimensions of the problem such as determining and understanding the problem, writing important physics laws and principles, correctness of the solution( (Alemu et al., 2019; Cashata &Seyoum, 2022). since the procedural knowledge acts as the building block of problem solving skill ,since the lack of procedural knowledge results in deficiency in problem-solving skills (Morphew et al., 2020).

During performing, the test questions require their abilities to synchronize and use many physics formulas to arrive at the final correct answers, test achievement can be used to demonstrate procedural knowledge by students in their physics learning. Utilizing the relevant physics formula to answer physics problems when they are presented in a different way is another way to demonstrate procedural knowledge (Ses et al., 2020). It's fundamental for pre-service physics teachers to understand physics formulas in order to solve physics problems using mathematical equations. According to certain studies, students may occasionally retain physics formulas but fail to use them after some time to solve problems that were given using a different approach as examples in the classroom (Bautista, 2012). They claimed that high school kids couldn't combine different physics formulas to work out procedural knowledge of physics tasks. These studies showed that physics lecturers' teaching strategies did not improve their students' procedural knowledge since they were boring from the start to the end of the class (Aragaw, 2022; NLA, 2017).

According to Ses et al (2020) the main issue with physics classroom instruction is that the instructors did not employ a manner that enabled pupils to understand the objectives and content being provided as anticipated but also students' physics instruction and learning at any grade level will be successful and meaningful if the teaching process is supported by available resources, active learning methods, the learner's prior knowledge, and their own experiences (Konopka et al., 2015). Tandem instructional approach of Jigsaw-IV Techniques of teaching and problem solving strategies was proposed by the researcher, from other active learning methods (Assistant et al., 2012; Karamustafaoglu, 2009; Maera, 2016). The significance of the Jigsaw-IV teaching and learning methodology is as follows. Jigsaw VI 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 (Holliday, 2002; Thompson, 2013; Wyk, 2015) popularized the Jigsaw-IV method, which assists students in taking 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 own learning.

**Statement of the Problem**

According to empirical evidence, developing country physics learning outcomes are poor (A JOINT UNESCO, UNICEF, 2021; Lewin, 1992).Furthermore, physics education is in crisis in both developing and developed countries (A JOINT UNESCO, UNICEF, 2021; Apple, 2009). The Ethiopian Ministry of Education and the Research and Evaluation Board have agreed that the quality of education in general, and physics instruction in particular is a major concern at all level. According to NLA data, the average physics grade 10 and 12 score was 31%, with a large proportion of students scoring less than 50% (Little & Rolleston, 2014; NLA, 2017) . The lecture method is the most common teaching method at the college level, and it causes PSPT to have poor procedural knowledge and achieve low grades (Dejene & Chen, 2019; Kaur, 2011; Walter & A.Rangaswamy, 2014) and the major contributor for such poor achievement in physics . In this technologically advanced world (Noel et al., 2015) discovered that the convectional method of teaching is not an effective instructional approach. As a result, innovative active learning methods are required to solve the law achievement of college students. As such this study contributed by employing two active learning methods such as problem solving strategies (PSS) and the Jigsaw-IV method of teaching (J-IV).But both of them has the following drawbacks such as the Jigsaw-IV method of teaching emphasized interaction between the groups but ignore competitive spirit between learners (Aydin & Biyikli, 2017; Jainal & Shahrill, 2021; Mohammad & Hamadneh, 2017; Shakerian et al., 2020).But the problem solving strategies intensified the competition between the individuals. This is also a significant gap in the literature (Albay, 2019; Junsay, 2016; Rohma, 2018; Surif et al., 2020).

Preservice physics teachers also face challenges in physics throughout the cognitive domains, particularly in procedural knowledge and problem solving skills. It also demonstrated that the mean achievement in cognitive domains, specifically in procedural knowledge is below 50% (Binder et al., 2019; Z. A. Cashata, D. G. Seyoum, 2022). This was accomplished by closing the gap between the two by using tandem instruction between problem solving strategies and Jigsaw –IV method of teaching. This method allowed students to interact critically with the content both individually and in groups. The sociocultural theory of learning and motivational theory are the connecting theories. As a result, the active learning method's mechanism becomes more interactive. The current study examines the effect of Jigsaw-IV problem-solving strategies on pre-service physics teachers' procedural knowledge on the dimensions of the problem such as determining and understanding the problem, writing important physics laws and principles, correctness of the solution . The main objective of this study is to examine the effects of J-IV PSS on the procedural knowledge (PK) of pre-service physics teachers. Particularly, the mean difference in PK between the four groups in learning Newton's laws of motion where investigated based on specific research questions were:

RQ1: Is there a significant pretest mean difference in P K among the four groups in learning Newton's laws of motion?

RQ2: Is there a significant post-test mean difference in PK among the four groups in learning Newton's laws of motion?

## Method

This study used a pre-test–post-test non-equivalent group quasi–experimental design to compare the three treatment groups with the comparison group. 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 of the treats of validity that is inherent in a school setting. Table 1 shows the symbolic representation of the multiple treatments quasi-experimental design used in the study.

Table 1. Design of the Research

| | | | | |
|---|---|---|---|---|
| Treatment group I | N | O1 | X1 | O2 |
| Treatment group I | N | O1 | X2 | O2 |
| Treatment group II | N | O1 | X3 | O2 |
| Comparison group | N | O1 | | O2 |

*Note.* N = represents the non-randomization of subjects to groups; O1 = represents the pre-test; O2 = represents the post-test; X1= represents Jigsaw-IV Problem Solving Strategies. X2 = represents Jigsaw-IV teaching method, X3 = represents the problem solving strategies.

### Sampling

The study was conducted in Bonga, Hossana, Arbamich, and Dilla Colleges of teacher education in the South Nation Nationalities People's regional state of Ethiopia. The preservice physics teachers in these four government colleges of teacher education come from families with almost similar socioeconomic status, and their demographic distribution is also urban-rural. So as to control for teacher variability, four teachers (one from each college) that are approximately equivalent to each other in terms of their experience, qualification, and willingness to participate in the study were selected from the available teachers. After that, among the sections taught by the selected teachers, eight sections (two from each of the colleges due to COVID-19 Regulation) that are approximately equivalent to each other based on their first year GPA results were purposely selected from second year, second semester preservice physics teachers. Prior to administering the instrument as a pre-test, the sampled sections from Bonga, Hossana, Arbamich, and Dilla College of Teacher Education were randomly assigned to J-IV PSS, J-IV, PSS, and CM, respectively, using a lottery method. Table 2 presents the data related to the participants in each group.

Table 2. Participants Number in Each Group

| **Group** | | | | | | |
|---|---|---|---|---|---|---|
| | | J-IV PSS | JIV | PSS | CM | Total |
| Gender | Male | **27** | **28** | **22** | **30** | **107** |
| | Female | **7** | **5** | **13** | **4** | **29** |
| | Total | **34** | **33** | **35** | **34** | **136** |

**Data Collection Instrument**

The procedural Knowledge test was used to collect data with the aim of finding answers to the research question. This test consists of three workout problems related to Newton's laws of motion that were adapted from the Force Concept Inventory Test (FCIT) by the researchers based on the objectives stated in Module of Mechanics I (phy-101) for preservice physics teachers. Several discussions among the researchers were conducted to assure the content and face validity of the items. Further validation was also achieved by giving the draft test to experts and practitioner teachers. Following appropriate modifications based on feedback from experts and teachers, the test was pilot tested on another college that was not involved in the actual study. After the pilot study, the calculated value for the internal consistency reliability of the test was 0.83. Thus, according to Tavakol & Dennick (2011) and others, the test used in this research was found to be in a high reliability range as it is between 0.70 and 1.0. Hence, the test was administered to the actual sources of information**.**

Procedural knowledge of college students' in Newton's Law of Motion was assessed using three indicators adopted from Minnesota Assessment of problem solving Rubric (MAPSR). It entails breaking down information about the problem into the following dimension such as determining and understanding the problem, writing important physics laws and principles, correctness of the solution (Docktor & Mestre, 2009). Pre-service teachers' average mean procedural knowledge were measured using five scaled Likert scales with a minimum score of 1 and a maximum score of 5.The average mean a of procedural knowledge for groups of pre-service teachers were graded. Take the average of all the points or values for each written response to the five rubric categories. The total score was then divided by the number of dimensions with a numerical value in the rubric. In this manner, the findings for the mean average was five, for analysis's sake (Erhardt, 2016). The total score was then divided by the number of rubric categories that had a numerical value. In this manner, the findings for each of the three components' mean averages score of the test were acquired and converted to five solely for analytical purposes, as shown in Table 3. Table 4 and Table 5.

Table 3. PSPT level or Quality of Performance in Procedural Knowledge Diagnostic Test Adapted from The MAPS Rubric for Each Dimension

| | |
|---|---|
| Determining and understanding of the problem | 5. They are fully determined and understand the problem.<br>4. Recognizing and comprehending some of the problems<br>3. Identifying but not comprehending the issue<br>2. The determination and understanding of the problem are not correct<br>1. not accepted |

Table 4. Showed the Criteria for Evaluating Performance Level of Each Dimension Open Ended Problem of Newton's Laws of Motion Using Percentage and Likert Scale was Adapted from (Malik et al., 2020)

| Level of performance in percentage | Quality of performance | The Likert scale rate level |
|---|---|---|
| $80\% \leq X \leq 100$ | Very good | 5 |
| $60\% \leq X < 80\%$ | Good | 4 |
| $40\% \leq X < 60\%$ | Acceptable | 3 |
| $20\% \leq X < 40\%$ | Poor | 2 |
| $0 \leq X < 20\%$ , | Very poor | 1 |

Table 5. The Dimensions of Procedural Knowledge Used for Criteria of Evaluation for Quality Performance of PSPT on Procedural Knowledge (PK)

| Dimensions (indicators ) | Criteria of evaluation for quality performance of PSPT on procedural knowledge test adapted from MAPS Rubric | | | | |
|---|---|---|---|---|---|
| determining and understanding the problem, | 1 | 2 | 3 | 4 | 5 |
| writing important physics laws and principles, | 1 | 2 | 3 | 4 | 5 |
| correctness of the solution | 1 | 2 | 3 | 4 | 5 |

**Procedure**

Items that needed modification were altered after assessing the expert feedback and the results of a pilot study. The three physics instructors who taught the treatment groups received instruction on how to use the intervention in the classroom prior to the intervention. Preservice physics teachers in the four groups were given a pre-test used for drawing a baseline for the implementation.

During the intervention period, treatment group I preservice physics teachers (PSPT)were instructed to use the TECDRER Model, which was modified from (Holliday, 2002) Techniques of Learning Jigsaw-4, Minnesota problem-solving strategies by Jennifer L Docktor et al (2016) and Krulik and Rudnik's Heuristic Strategy Istiandaru (2017) for the Instruction of Newton's Laws of Motion.

It has seven processes, including the following: thinking, exploration, choosing strategies-planning and manipulating, discussions, and reflection; the process of evaluation; and the process of re-teaching. As illustrated in the cycle of TECDRER Model implementation, the tandem instructional approach was adopted. The first physics teacher who participated in the teaching of experimental group-I received training regarding the instructional material for implementing the TECDRER MODEL for three days 45 min for each day. The second PSPT received training on Jigsaw 4-Techniques of Learning for experimental group II, and the third instructor received training on problem-solving techniques for experimental group III. The intervention lasted for seven weeks. The researcher assisted the physics teacher in the preparation and delivery of the physics lesson for three instructors in the three treatment groups. Then, following the end of the intervention, three experimental groups and one control group each received a written post-test with open-ended questions.

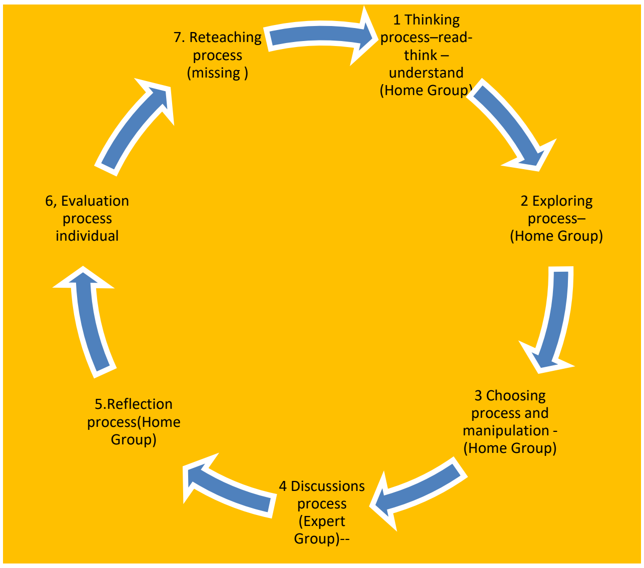


Figure 1. The Cycle of TECDRER Model with 7 Process Used for Implementation of J4PSS

Assumptions of test statistics were checked to determine whether there was a statistically significant mean difference in the pre-test and post-test scores between the two groups after the procedural knowledge data from the PSPT pre-test and post-test were both collected, coded, and entered into SPSS version 24. An independent sample t-test was performed to assess the mean difference between the two groups after we confirmed that the assumptions of normality and homogeneity of the data were not significantly violated.

**Techniques for Data Analysis**

After the assumptions of normality were tested, the data was assessed using descriptive statistics as well as parametric statistical tools such as ANOVA and ANCOVA. An ANOVA was carried out to determine whether the pre-test scores of the groups were comparable. In order to statistically control the pre-test exposure, which influences the outcome of the post-test, the post-test scores were examined using ANCOVA. In the ANCOVA analysis, the pre-test results are employed as covariates. SPSS version 24 was used to compute all statistical tests. A p-value of less than 0.05 was used to indicate statistical significance.

## Results

In the present study, the effects of Jigsaw-IV problem-solving strategies on pre-service physics teachers' procedural knowledge in Newton's laws of motion were investigated based on specific research questions were:

RQ1: Is there a significant pretest mean difference in PK among the four groups in learning Newton's laws of motion?

RQ2: Is there a significant post-test mean difference in PK among the four groups in learning Newton's laws of motion?

In order to address the effect of the intervention, procedure knowledge was measured before and after the intervention using a quasi-experimental pretest-posttest non-equivalent comparison group design. The pretest data were analyzed to determine the participants' prior study experience and the statistical method to be used for the posttest data. Pretest score analysis and assumption checking are critical in research. In order to investigate the effects of different instructional strategies on PSPTs' learning of physics regarding procedural knowledge in Newton's laws of motion, the researcher employed the appropriate statistical instrument for the research investigation by recognizing the statistical assumption. He took into account the significance of the ANOVA test as well as the normality of skewness and kurtosis, as indicated in Table 6.

Table 6. Descriptive Statistics Procedural Knowledge for Pretest Result

| DV | Group | N | M | SD | SS | SE | ZS | KS | KE | ZK |
|---|---|---|---|---|---|---|---|---|---|---|
| Procedural knowledge | J4-PSS | 34 | 4.43 | .978 | ..348 | .403 | .864 | -.845 | .788 | -1.07 |
| | J4 | 33 | 4.36 | .886 | .442 | .409 | 1.081 | -.391 | .398 | -.982 |
| | PSS | 35 | 4.46 | .950 | .239 | .398 | .601 | -.722 | .778 | -.928 |
| | CG | 34 | 4.49 | .925 | .168 | .403 | .417 | -.774 | .788 | .982 |

Table 6 indicated that the mean, standard deviation, Skewness, kurtosis and the z-scores of the pre-test results on the procedural knowledge for all the four groups which consisted of three experimental groups and one comparison group. The data revealed that the average of the procedural knowledge for blended Jigsaw-IV-Problem solving skills, Jigsaw-IV, Problem solving strategies and Comparison group were (M=4.43, SD= .978), (M=4.36, SD= .886), (M=4.46, SD= .950), and (M=4.49, SD= .925) respectively. The average mean of the procedural knowledge for all groups were measured out of 15 marks. The result revealed that the percentage of the procedural knowledge in learning mechanics course (particularly Newton's law of motion) for J4-PSSS, J4, PSS and CG were 29.5%, 29.1%, 29.7%, and 29.9%, respectively. This implied that the level of procedural knowledge of pre-service teacher in learning Newton's law of motion at college of South Nation and Nationalities were failed under a poor level of motivation for all groups in the pre-test results.

Regarding the Skewness, kurtosis and its respective z-values all treatment and comparison groups have the values of Skewness in between -1 to +1 and the values of kurtosis between, -2 to +2 and the respective z-values of both Skewness and kurtosis in the range of acceptable values (-1.96 to +1.96). This depicted that all the obtained values of Skewness and kurtosis found in the acceptable level and ranges. The values obtained for procedural knowledge among the four groups are 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.

Table 7. ANOVA Analysis of Procedural Knowledge of Pretest Scores

| Dependent variables | | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| Procedural knowledge | Between Groups | .274 | 3 | .091 | .104 | .958 |
| | Within Groups | 115.631 | 132 | .876 | | |
| | Total | 115.904 | 135 | | | |

The one way ANOVA-test was run to determine any significant difference between the four groups for their, procedural knowledge of pre-service teachers. The pre-test scores of pre-service teachers were F (2,132) = .104, p = .958 for procedural knowledge. The ANOVA F-test result for students' procedural knowledge between the control group and treatment group was no significance in learning Newton's law of motion at college of education at the region. This showed that all of the groups have the same backgrounds in learning physics courses at college of teachers' education.

Table 8. The Result of Tamhane's T2 Post-hoc Tests Indicated that the Problem-solving Skill Pre-test Mean Scores of the Students'

| Groups | Mean | Std. Deviation |
|---|---|---|
| J4PSS | 4.43 | .978 |
| J4 | 4.36 | .886 |
| PSS | 4.46 | .950 |
| CG | 4.49 | .925 |
| Total | 17. 7 4 | 3.739 |

Table 8 indicate the results of the pre-test mean score results of the three treatment groups (J4PSS, Ma = 4.43; J-4, Ma = 4.36, and PSS, Ma = 4.46 for the first, second, and third treatment groups, respectively) was larger than the comparison group CM, Ma = 1.6706). The results of Tamhane's T2 post-hoc tests in table -8 revealed that the procedural knowledge pre-test mean scores of the students in the three treatment groups were significantly higher than the mean scores of the comparison group. Hence the main goal of performing post hoc test in an experimental study was to determine the precise location of the difference between independent variable (treatment) that were shown to have a significant interaction impact on the dependent variable (achievement).Hence, so as to create statistically equivalent groups, ANCOVA was used to fit off the initial differences in pre-test mean scores so that the post-test scores were analyzed against equivalent pre-test scores.

Table 9. ANCOVA Output for Posttest Scores of Procedural Knowledge Test

| Source | SS | df | MS | F | $\rho$ | $\eta^2$ |
|---|---|---|---|---|---|---|
| Corrected Model | 397.91 | 4 | 99.48 | 2532.18 | .000 | .987 |
| Intercept | 137.92 | 1 | 137.92 | 3510.76 | .000 | .964 |
| PrePRO | 127.60 | 1 | 127.60 | 3248.07 | .000 | .961 |
| Groups | 281.96 | 3 | 93.99 | 2392.43 | .000 | .982 |
| Error | 5.15 | 131 | .039 | | | |

The effects of the instructional strategies were statistically significant, as shown in Table 9 above, F (3,131) =2392.43, p=.000, effect size =.982. That is, the implemented instructional strategies have a statistically significant effect on preservice physics teachers' procedural knowledge of using Newton's laws of motion. When the effect of pretest scores was removed, the effect of intervention strategies became more significant, with the partial eta squared value increasing from .961 to .982.

Table 10. Mean and Standard Deviation of the Pretest and Post-test Scores of the Both Groups

| Dependent variable | Groups | Strategy | Pre-test | | | Post-test | |
|---|---|---|---|---|---|---|---|
| | | | N | Mean | SD | Mean | SD |
| Procedural knowledge | Treatment groups | J4-PSS | 34 | 4.43 | .978 | 12.43 | .978 |
| | | J4 | 33 | 4.36 | .886 | 10.36 | .886 |
| | | PSS | 35 | 4.46 | .950 | 10.46 | .950 |
| | Control group | CG | 34 | 4.49 | .925 | 7.16 | 1.17 |
| | | Total | 136 | 4.43 | .927 | 9.60 | 1.73 |

As can be shown in Table 10 prior to and after the planned topics, mean and standard deviations of both groups' procedural knowledge scores were seen. Mean points could be considered to be equal prior to teaching. Mean and standard deviation scores of the experimental group were *M* = 4.43, *M* = 4.36, M=4.46 and SD = .978, SD =.886, SD=.950 before teaching for Jigsaw Iv-problem solving strategies, Jigsaw IV, problem solving strategies respectively. Mean and standard deviation score of the control group was M = 4.49, SD= .925 before teaching.

Mean and standard deviation scores of the experimental group were M = 12.43, M = 10.36, 10.46 and SD = .978, SD =.886, SD=.950 for Jigsaw Iv-problem solving, Jigsaw IV, problem solving strategies after teaching respectively. Mean and standard deviation score of the control group was M = 7.16, SD= 1.17 after teaching. This revealed that the pre-service physics teachers in learning Newton's law of motion have no as such difference in their procedural knowledge in pre-test results in both experimental and control groups. Whereas, the data shown in table 10 indicated that there was a difference between control group and experimental groups in procedural knowledge in the post test scores. Furthermore, the overall scores of the procedural knowledge of physics pre-service teachers level of performance 9.6 out of 15(64%) was in the average level in the post test which showed improvement from pre-test scores.

## Discussion and Conclusion

Under this section, discussions are presented by relating the results of the study with previous researches. It is possible to deduce from the results that teaching procedural knowledge of Newton's laws of motion using blended Jigsaw IV-problem solving strategies in physics was found to be effective than Jigsaw IV lonely, problem solving strategies and the conventional method of teaching. For teaching of procedural knowledge the blended approach was the best of all the methods implemented.

The results of the current study are in consistent with prior researches. Scholars argued that problem solving strategies and Jigsaw IV have their pros and cons. In order to benefit from the pros of both methods, there is a need to blend these two methods of teaching. There is social interaction and cooperation when using Jigsaw IV whereas problem solving strategy promotes individual problem solving skill and limited the interaction between the peer groups. A study by Karacop (2017) determined the effects of Jigsaw IV on prospective physics teachers learning of different topics. The results showed that pre-service physics teachers had higher level of achievement in different topics of physics compare to conventional method of instruction. Different authors conducted a research on problem solving strategies and found that it increases the procedural knowledge of an individual leaner (Abubakar S. M. & Dr. Danjuma I. M., 2012; Docktor et al., 2016; Taasoobshirazi & Farley, 2013) .However, it is criticized for its competitive and individualistic nature. This limitation of problem solving strategy could be improved using Jigsaw IV method of teaching and learning strategies because this approach improves social interaction and cooperation of learners with their teacher and peers. Therefore, blended Jigsaw IV-problem solving strategy improves the achievement pre-service physics teachers on Newton's laws of motion than using either of the methods solely.

Several research has revealed that the Jigsaw IV-technique of teaching is effective in the learning process of theoretical courses, in the development of the critical thinking process of the students, in their ability to express themselves and in their communication skills(Kilic, 2008). In a study to examine approaches for implementing STEM activities Mahidol ( 2020) found that the Jigsaw IV method was less effective than an innovative approach, linear model, but it was recommended to be used when instructional time is limited. Researches showed that academic achievement in science education remain low even after problem solving strategies as problem solving strategies promote more individualistic and ignore the importance of social interaction, collaborations and interactions(Docktor et al., 2016). By contrast, in the Jigsaw-IV Problem Solving Strategies (J4PSS) classroom, students form a mutual internal source of positive reinforcement for one another because of their relationship of positive interdependence(A. Hananingsih, 2020; Hancock, 2004; Ning, H., & Hornby, 2014).

Preservice physics teacher‘s procedural knowledge was influenced by the combination of Jigsaw-4 problem solving strategies ,Jigsaw-4 techniques of teaching and problem solving strategies in general. Furthermore, the Jigsaw-IV problem solving strategies had a better influence on preservice physics teacher's procedural knowledge in newton's laws of motion than other ways.

The college of teacher education and other associated bodies should give training on learner-centered practices and ways to improve preservice physics teacher‘s procedural knowledge in teaching and learning of newton's laws of motion. College instructors should use blended Jigsaw -IV problem solving strategies, Jigsaw-IV techniques of teaching and problem solving strategies', among other learner –centered approaches ,to increase procedural knowledge generally in physics particularly in newton's laws of motion. To perform better in understanding of Newton's laws of motion .instructors should applied blended Jigsaw-IV Problem solving strategies in their classroom instruction using the following TECDRER-Model. Finally, investigations in other areas of physics, such as geometrical optics, Electrostatics, temperature, and heat, can be done to improve PK.

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