A Blended Approach of Jigsaw-4 and Problem-Solving Strategies in Preservice Physics Teachers' Understanding of Newton Laws of Motion Concepts and Their Affective Factors

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This is to certify that the dissertation prepared by Zerihun Anibo, entitled “**A Blended Approach of Jigsaw-4 and Problem-Solving Strategies in Preservice Physics Teachers’ Understanding of Newton Laws of Motion Concepts and Their Affective Factors** “to be conducted in partial fulfillment of the doctor of philosophy in physics education, complies with the department’s research agenda and all standards of AAU as to the originality and expected level of rigor. This dissertation has been submitted for examination with our approval as the thesis supervisor.

Signed by the supervisors

Supervisors	Signature	Date
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Declaration

I declare that this work has not previously been formed on the basis for the award of any Degree or diploma of any University, Other higher Institution, or publication.

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Abstract

A Blended Approach of Jigsaw-4 and Problem-Solving Strategies in Preservice Physics Teachers' Understanding of Newton Laws of Motion Concepts and Their Affective Factors.

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Education in the twenty-first century needs new, creative instructional approaches to teach, like the active learning method, to help students understand physics concepts better. The purpose of this study was to investigate the effects of Blended Approach of Jigsaw-4 problem-solving strategies on factual, conceptual understanding, procedural knowledge, problem-solving skills, motivation, and perception in a mechanics course, particularly on laws of motion, compared to the conventional method in the college of teacher education in the Southern Nation Nationality Peoples Regional State. In this study, 136 preservice physics teachers were chosen non-randomly from four colleges of teacher education. A quasi-experimental, non-random pretest-posttest research design with a mixed research method was used. Factual knowledge diagnostic tests, conceptual understanding tests, procedural knowledge tests, problem-solving skills tests, and physics motivational questionnaires were administered to all groups as pretests and posttests. After the treatment, 24 preservice physics teachers, six from each group, were interviewed semi-structurally to collect data. In terms of data analysis, descriptive statistics, paired sample t-tests, and inferential statistics such as Analysis of Variance (ANOVA), post hoc tests were used for the analysis of the quantitative data, whereas deductive coding of verbal description was used for qualitative analysis. The findings of the quantitative analysis revealed statistically significant differences in preservice physics teachers' conceptual understanding, procedural knowledge, and problem-solving skills in learning laws of motion, which were found to be better after learning through Jigsaw-4 problem-solving strategies. Concerning motivation, it was found that the blended Jigsaw-4 problem-solving strategy had a significantly superior effect over other problem-solving strategies and conventional instruction. The interview analysis was drawn out using five major themes of pre-service physics teachers' views: conceptualizing concepts of force view, the advantage of frictional force view, laws of inertia view, third law of motion view, and nature of frictional force view. It was found that preservice physics teachers' views improved more through Jigsaw-4 problem-solving strategies. In conclusion, the blended Jigsaw-4 problem-solving strategy using the TECMRER (Thinking, Exploring, Choosing Strategies, Manipulation, Reflection, Evaluation, and Reteaching) model improved learning of physics more than the Jigsaw-4 Techniques of Teaching, Problem-Solving Strategies, and conventional method. Finally, the researcher suggested that physics teacher educators have to use the Jigsaw-4 problem-solving strategy using the TECMRER model to develop the conceptual understanding, procedural knowledge, and problem-solving skills of preservice physics teachers in laws of motion concepts.

Keywords: factual knowledge, procedural knowledge, conceptual understanding, problem-solving skill, Jigsaw-4-problem-solving strategy

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Acronym	Meaning
SNNPRS	South Nation Nationalities People Regional State
J4PSS	Jigsaw-4 Problem-solving Strategies
J-4	Jigsaw-4 Techniques of Teaching
PSS	Problem-solving Strategies
CM	Conventional Method
REB	Regional Education Bureau
TECDRER	Thinking, Exploring, Choosing, Discussion, Reflection-Evaluation, Re-teaching
NLA	National Learning Assessment
MFKT	Mechanics Factual Knowledge Test
MCUT	Mechanics Conceptual Understanding Test
PSKT	Problem-solving Skill Test
OPQ.	Observation Protocol Questionnaires
MoE	Ministry Of Education
SMQ	Science Motivation Questionnaire
UNESCO	United Nations Educational, Scientific and Cultural organization
UNICEF	United Nations International Children’s Emergency Fund
NEAEA	National Educational Assessment and Examinations Agency

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Chapter One

1. Introduction

In this study, the impact of Blended Approach of Jigsaw-4 problem-solving techniques (J4PSS) on motivating physics educators' understanding of the laws of motion was examined. This chapter starts by providing background data that helps define the problem. The problem statement, study objectives, and research questions account for this; the study's relevance, boundaries, and limitations are then described. Additionally, the terminologies utilized in the thesis are finally defined.

1.1. Background of the study

In the modern world, science is a cornerstone for growth and has an ever-growing role in daily life. According to James (2015) a country's educational system has a significant impact on its level of wealth, welfare, and security. Science education is thought to be the cornerstone of technical advancement and a major driver of economic expansion. Therefore, it is essential to increase the understanding of science and foster the next generation of scientists (Kaindume et al., 2018) . Despite the above efforts, there are still some challenges facing Ethiopian science education.

Ethiopia, like other developing nations, needs to quickly improve science education. However, because of its focus on education and training, according to the Minister of Education [MoE] (MoE, 2009, 2020). Ethiopia appears prepared for the issues caused by the development of technological and scientific knowledge. However, the implementation of science education at all levels in Ethiopia is not an exception. From this point of view, there are a lot of pieces of evidence that indicate the poor performance of students in science education in the contemporary world of science (Alturki, 2016; Banerjee, 2016).In the last two decades, educational efforts in Ethiopia have had both national and international goals of expanding primary education access for all children in a way that ensures learning. Accordingly, during the last two decades, schooling opportunities expanded more than ever in South Nation Nationalities People Regional State (SNNPRS), as is valid throughout the nation. Millions of youngsters are registered in elementary schools, with an increased student population at all levels (primary, secondary, and tertiary) (MoE, 2020).

The global community recognized Ethiopia‘s exemplary success in bringing children to school and heading towards establishing educational institutions at all levels (United Nations Educational, 2008). However, empirical evidence indicates that the quality of education is in a state of crisis. The condition of physics education in Ethiopia and other developing nations is a topic of discussion in this regard (Castillo et al., 2019; WAEC, 2011).For instance, according to the results of the national learning assessment, academic achievement among students is drastically falling at both lower and higher levels of school. The case is even more severe for subjects such as physics and mathematics(MoE, 2009, 2010, 2020).Particularly, studies on a series of national learning assessments revealed that the mean achievement scores in grades 4, 8, 10, and 12 are low (MoE, 2009; NLAE, 2017).

Other studies carried out in Ethiopia also indicated the failure of physics in secondary and tertiary education (Asfaw, 2015; Cashata et al., 2022; Jibril, 2021; Mekbib et al., 2019). Moreover, the Federal Ethiopia Teacher’s and Educational Leaders' Professional Licensing Directorate from 2013–2018 designed physics content and pedagogical license exams for preservice primary school teachers (grades 5-8). Each year, the exam consists of a total of 75 multiple-choice items, of which 60 questions are multiple-choice items from physics courses and 15 items from pedagogy. According to the official report document, the Regional Educational Bureau (REB) failed the physics Certificate of Competency (COC) exam in the years 2015, 2016, 2017, and 2018 (REB, 2019). This implies that the academic achievement of college students in physics is below the standard of pass mark (50%) of MoE in the aforementioned years, though there are irregularities. In terms of disaggregation, the proportion of students that failed the physics COC exam in the years 2018 and 2017 in Arba Minch was (48%, 77.1%); in Bonga was (50%, 100%); in Dilla was (57.6%, 93.8%); in Hawasa was (71.2%, 81.1%); and in Hosaina was (41.1%, 76.5%).

Accordingly, the summary of the COC exam results for physics from five colleges of teachers' education indicated that the college COC exam of physics content accommodates over 70% of the mechanics course material has been covered.This implies that physics students in the college took more physics content than the item from pedagogy, and their exams showed a decline (ANLAS, 2010; REB, 2019). These results are below the standard set by the Ethiopian Ministry of Education [MoE]. As a result, the education office of SNNPRS recommended that an extensive investigation be conducted to enhance the achievement of students in education (REB, 2019) .

To ensure that each national exam follows the materials and content of the new curriculum, the National Educational Assessment and Examinations Agency and the Ministry of Education should examine each exam (MoE, 2020).According to Yibrah (2017) , 92.6 percent of pupils in grades 12 and 10 received physics test scores below 50, while 95.4 percent of grade 10 did so with the same results. The national literacy evaluation result of the professional test in physics is below the Ethiopian Ministry of Education's norm, and academic progress among pupils is low, the study claims (MoE, 2017). In this context, the state of physics instruction in Ethiopia as well as other emerging countries are becoming a contentious issue and is deteriorating quickly. Castillo, et al (2018) also showed that Students' results in the content-specific area of physics were below 50 in both grades 10 and 12 (electricity and magnetism, 31.16 and 29.49, mechanics, 28.99 and 32.24, and temperature and heat, 25.82 and 29.49), according to the National Learning Assessment (NLAE, 2017). The average physics achievement of students in grades 10 and 12 in the content-specific area of physics was 31, which is lower than the Minster of Education threshold of (50%), in physics achievement,92.6 percent of grade 12 students scored below 50, compared to 95.4 percent in grade 10. Yibrah (2017) report confirmed that student achievement in physics is very low.

Additionally, according to the Ethiopian Ministry of Education's 2017 report, their expectations were not met by the physics national learning evaluation findings from the professional test. Students' academic performance on physics exams and in the classroom shows that they have bad attitudes and problem-solving skills (Zwolak & Hazari, 2018). According to research by Cashata et al.(2022, 2023) and Reddy and Panacharoensawad (2017) several variables are to blame for students' poor performance in physics, including their lack of problem-solving abilities, conceptual understanding, and procedural knowledge. These include ineffective teaching, a lack of mathematical background, teachers' demotivating behaviors, and students' apathy toward the subject. Likewise, a deficiency in drive, the low self-esteem of primary school teachers, a dearth of creative teaching methods, a shortage of teaching materials, a bad school climate, a lack of incentives and motivation, low pay, and unattractive working conditions are other problems that many researchers have identified (Cook & Artino, 2016; James & Adewale, 2012).

All these factors lead to student misconceptions (Murti et al., 2019; Sopandi & Sukardi, 2020; Syaharudin et al., 2015; Uwizeyimana et al., 2018) . Studies in the literature show that students have many different misconceptions, ranging from the lower level to the higher level of education (Ning, 2016; Syaharudin et al., 2015) . Preservice teachers in college mechanics often encounter challenges when it comes to understanding key concepts such as velocity and position, acceleration and velocity, and force and motion (Bayraktar, 2007) .Similarly, according to Hart's research in (2002), students frequently confuse concepts such as force, balancing force, gravity, and frictional force. The study done by Sapuro (2016) revealed that the highest misconceptions of college students on the topics of kinematics focused on centripetal and average acceleration (86.67% and

85.87%), respectively. This implies that there is a strong area of misconception among college students (Murti et al., 2019; Sopandi & Sukardi, 2020; Suprapto et al., 2016).

This study intends to enhance the learning atmosphere in a physics preservice teacher's class to promote better learning of factual knowledge, conceptual understanding, procedural knowledge, problem-solving abilities, motivation, and perception of the content of mechanics. To this effect, instructional strategies that engage preservice physics teachers in the Jigsaw-4 problem-solving strategy were employed in their motivation, engagement, perception, conceptual comprehension, procedural knowledge, and factual knowledge, as well as their problem-solving abilities. This approach is compatible with policy and curriculum reforms that promote student-centered learning (MoE, 2010, 2020).

Individuals acquire all of the experiences, information, and wisdom they need during their lives of existence (Valerio, 2012).Effective teaching methods are also necessary to improve the understanding of learners in the 21st century (Seidman, 2019). One of the biggest limitations is the use of conventional teaching methods, which may not be as effective or practicable today. Research shows that the predominant teaching method at the college level is conventional (Mekbib et al., 2019; Silva et al., 2021; Zulherman et al., 2021).It has its drawbacks in helping students' effectiveness in science learning, specifically in physics (Hossain & Tarmizi, 2013). Even if there is debate regarding the most effective instructional strategy based on modern technological innovation and developments, researchers have been looking at appropriate and suitable instructional methods in the teaching and learning process (Bybee, 2009).Numerous instructional strategies that enhance learning have been created (developing the best instructional approach, which is dependent on recent technological innovation and developments), and research has shown how effective they are at enhancing education, particularly science learning.

The aforementioned empirical examples from science education research are also supportive of this research, in addition to the theoretical and practical justifications. For instance Shishigu et al (2018) indicated in their research the use of problem-solving methodologies for acquiring science education for a better grasp of the subject matter. Contrarily, actual data shows that even after using problem-solving techniques, students' conceptual understanding and academic achievement in science education remain low (Cashata et al., 2022; Cavagnetto et al., 2010) . The methods used to solve problems tend to be more individualistic and minimize the importance of interactions, partnerships, and social connections. Researchers propose combining cooperative learning techniques with problem-solving strategy education to improve students' conceptual understanding, knowledge of procedures, and capacity to solve problems. For instance, the research by Eshetu and Assefa (2019) advised integrating active learning techniques and problem-solving strategies to improve students' problem-solving abilities.

The Jigsaw-4 technique is a group learning strategy that involves dividing students into small groups, assigning each group a specific topic to research and present to the class, and then reorganizing the groups to share information and develop a more comprehensive understanding of the material. According to studies by Akkus and Doymus (2022) and Kallio et al. (2016) students have been proven to increase student achievement, motivation, and engagement. The effectiveness of Jigsaw-4 teaching methods has been studied by a large number of academics worldwide (Yimer & Feza, 2019).They asserted that Jigsaw-4 teaching techniques improved students' intellectual knowledge while offering chances for social interaction. Positive dependency is produced by the contact. Although it has a relative advantage in improving students' motivation and conceptual understanding, it fails to create individual competition and limits people's capacity for problem-solving on their own (Aydin & Biyikli, 2017; Huang et al., 2014).

In contrast, a problem-solving strategy comprises issue identification, action plan design, plan execution, and result assessment. This method encourages pupils to think critically, creatively, and independently to solve challenges. Research has shown that the use of problem-solving techniques may improve students' academic achievement across several disciplines, such as science, math, and language arts (Knopik & Oszwa, 2021; Loria Jr., 2014).Researchers who have examined the benefits of problem-solving techniques have shown that they enhance learners' problem-solving abilities (Esan, 2015; Sezgin et al., 2008) . But this method disregards learning from one another, which leads to good conceptual understanding, and instead favors individual competition and individualized approaches that disregard social interaction and a shared goal (Aydin & Biyikli, 2017; Huang et al., 2014; Ince, 2018; Mann & Tan, 2021; Mohammad & Hamadneh, 2017; Shakerian et al., 2020) .

In order to enhance physics education, the research finds gaps that need to be bridged between the Jigsaw-4 approach and the problem-solving strategy from the literature review. Among these gaps are...Individual thinking: Jigsaw 4 often emphasizes collaborative learning above the importance of individual thinking when solving problems. This may impede pupils' capacity to acquire conceptual knowledge and problem-solving skills of individual thinking when solving problems. This may hinder pupils' capacity to acquire conceptual knowledge and problem-solving skills. Sequential problem-solving: Jigsaw-4 emphasizes the need for segmenting complex issues in to digestible pieces for group discussions; sequential problem-solving techniques may make this difficult.Conceptual understanding: Jigsaw-4 promotes information sharing but does not provide enough attention to the development of conceptual understanding. Students may find it more difficult to apply their knowledge in different contexts as Time management: Jigsaw4 often requires a significant amount of time for material sharing and group discussions, which makes it more difficult for students to practice problem-solving on their own. Analysis of errors:Because Jigsaw-4 is a collaborative tool, pupils do not have enough chances to assess their mistakes critically and develop their problem-solving skills. Scaffolding: Jigsaw-4's collaborative approach could not provide learners with enough scaffold if they needed more help solving problems. Jigsaw 4 places a strong emphasis on group work and cooperative learning. It may not, however, provide a true assessment of a person's capacity for problem-solving.

The research demonstrates the relationship between problem-solving strategies and the Jigsaw4 teaching method in physics education. Knowing these variations may assist educators in selecting the best teaching methods for their pupils in light of their requirements and learning goals. The integration of Jigsaw4 instructional techniques with a problem-solving methodology has the potential to improve student learning objectives, cultivate collaboration and analytical abilities, advance conceptual comprehension, and provide a welcoming and inclusive learning environment. Students are encouraged to participate actively, to work together, and to become interdependent using the Jigsaw-4 approach. By letting students use what they've learned in practical settings, it also encourages improved conceptual understanding. A student-centered approach, where each student's thoughts and efforts are recognized, is encouraged by the problem-solving method. Combining these two elements may create a friendly, inclusive classroom that promotes positive social connections and gives students a feeling of pride in their education. The integration of problem-solving strategies with Jigsaw 4 teaching methods in physics education offers several advantages. These include promoting collaborative learning, developing critical thinking abilities, encouraging a deeper understanding of the subject matter, and establishing an inclusive and supportive learning environment. This combination of Jigsaw and problem-solving strategies closes a research gap in the field.

1.2. Statement of the Problem

According to concrete evidence, scientific learning outcomes are unsatisfactory in underdeveloped nations (UNESCO, 2021). Additionally, physics education is in crisis in both wealthy and developing nations (Michael, 2010; Unctad/TIR, 2021; Walter & Rangaswamy, 2014).Little and Rolleston (2014) state that teacher education is still a problem. The Ethiopian government has chosen to admit people into teacher education using low entrance profile considerations, despite failing tests at both levels and convincing proof of a lack of dedication to the teaching profession. This decision appears to work against the change's effectiveness in achieving the anticipated learning results (Mekbib. et al., 2019; MoE, 2020).Preservice physics teachers have weak problem-solving abilities, low conceptual understanding, and poor procedural knowledge, resulting in low achievement, which can be associated with how physics content is presented to the student (Argaw et al., 2017; Dejene & Chen, 2019; Marmah, 2014; Mekbib. et al., 2019; NLAE, 2017; REB, 2019).

The quality of education in Ethiopia, particularly the quality of physics instruction, has been identified by both the Ministry of Education and the Research and Evaluation Board as a key cause of concern at all levels (MoE, 2010, 2017, 2020).The primary cause of such unsatisfactory performance was the instructional strategy (Noel et al., 2015). Future physics teachers performed poorly and lacked effective problem-solving techniques due to the lecture method's frequent use at the college level (Dejene & Chen, 2019) . According to Noel et al. (2015) the traditional mode of education is ineffective for teaching mechanics at the college level. It has been conducted on a significant number of college students (Mekbib. et al., 2019). The study's findings demonstrate that the degree to which students can use factual, conceptual, and problem-solving abilities to resolve laws of motion issues depends on which students learn and the instructional strategies that the teacher uses (Bransford et al., 2004).

Therefore, students need to obtain an adequate understanding of the conceptual ideas in mechanics to improve their academic performance. The present state of college students' learning of laws of motion is in agreement with the research done by Raikes et al (2017) and Ismai (2016), which demonstrated that the majority of students finish their mechanics course with inadequate problem-solving skills and a lack of grasp of the principles. According to the researchers, Alharthi and Alsufyani (2020) and Saud et al.(2013) the main problem faced by students is the learning of laws of motion through problem-solving strategies. It encourages the development of individualized problem-solving abilities that had previously been neglected in interactions and teamwork among colleagues (Bao, 2019; John, 2013; Safari & Meskini, 2016).

They are unable to comprehend the fundamental ideas of mechanics as a result. On the other hand, the Jigsaw-4 technique of teaching rejects individual competition and promotes social connection among learners (Azmin, 2016; Baring et al., 2022; Choi et al., 2011; Timayi et al., 2015; Tran et al., 2014). To address the shortcomings of Jigsaw-4 methodologies and problem-solving procedures, this study used a blended approach of instructional teaching approach to give a remedy for preservice physics teachers' understanding of the facts, concepts, problem-solving skills, motivation, and perception in mechanics.The present practice of learning and teaching processes in the College of Teacher Education is more of a teacher-centered method (Hagos, B., & Tefera, 2015; Little & Rolleston, 2014; Mekbib. et al., 2019) .It is based on lecture methods that consider instructors as a source of knowledge and dominant. In this method, the preservice physics teachers have low participation in the teaching-learning process, such as inactive participants who receive information, store it, write short notes or memos, and reprocess it for valuation or assessment purposes (Chowdhury & Chakraborty, 2017; Schiller, 2002) .

Furthermore, they focus on gaining information for retrieval rather than assisting with knowledge of procedures, understanding the concept, and additional abilities related to such a lecture-based method, and Ambreen and Ahmad (2017) was unsuccessful in stimulating motivation, engagement, and perceptions of learning mechanics among preservice physics teachers (Sharkey & Weimer, 2003) . Fostering the long-term preservation of specific conceptual understandings is crucial for science learning, yet it has failed or broken down (Umar, 2011) .Therefore, the lecture-dominated instructional method in the science classroom failed to enhance the ability to solve issues, skills, conceptual knowledge, and procedural knowledge of aspiring physics teachers.

These drawbacks of the traditional approach resulted in the need for the exploration of an effective method of teaching science in the 21st century. Scholars emphasized the importance of searching for approaches that promote meaningful learning, understanding of concepts and knowledge of procedures, and problem-solving skills for diverse students in science education that are focused on learners rather than instructors. This movement resulted in the emergence of an alternative approach, which is termed the learner-centered approach, a countermovement to the conventional method that is focused on teachers (Moate,& Cox, 2015; Rajapaksha & Hirsch, 2017). As a result, since the mid-1980s, there has been a significant change in scientific education all around the world based on research on how people learn and the creation of science teaching models (Jonassen, 2011; Lewin, 1992). As a result of constructivism learning theory, numerous instructional strategies have now been developed within the scope of learner-centered instruction.

To find a solution to the above science education problems, the researcher suggests different instructional strategies, especially for science education. In this regard, research literature places more emphasis on the use of problem-solving strategies for the learning of science education to gain a better understanding of the topic (Sattar & Labib, 2019; Shishigu. et al., 2018). On the other hand, despite the use of problem-solving techniques, student conceptual understanding and academic accomplishment in science education remain poor. Problem-solving techniques foster individualistic thinking, according to Greiff et al (2013) andMary et al (2012) lto improve students' conceptual comprehension, procedural understanding, and problem-solving skills. Researchers suggest merging cooperative learning techniques with problem-solving techniques. For instance, Eshetu & Assefa (2019) recommended integrating active learning tactics and problem-solving techniques to enhance students' problem-solving skills.

According to Montalbano and Benedetti (2013) and Slavin (2018) cooperative learning is a learning method that seeks to encourage students' intellectual and social growth. The Jigsaw-4 technique of teaching is successful in helping students acquire theoretical courses, according to numerous studies in the pupils' ability to articulate themselves, in their critical thinking abilities, and in their communication abilities (Özdemir & Arslan, 2016; Timayi et al., 2015). Therefore, the researcher designed the study to increase the preservice physics teachers' understanding of factual knowledge, conceptual understanding, procedural knowledge, problem-solving skills, motivation, and perception of mechanics using the blended approach of Jigsaw-4 and problem-solving strategies by applying the TECMRER model at the College of Southern Nations Nationality People Regional State (SNNPRS).

1.3. Objectives of the study

This study's main goal was to determine how the Blended Approach of Jigsaw-4 and Problem-Solving Strategies in Preservice Physics Teachers’ Understanding of Newton Laws of Motion Concepts and Affective Factors. Therefore, the specific goals were to:

1.1. Examine how J4PSS affected preservice physics instructors' conceptual and factual knowledge of Newtons Lows of Motion.

1.2. Examine how J4PSS has affected preservice physics instructors' procedural grasp of Newtons Lows of Motion.

1.3. Examine how J4PSS affects preservice physics teachers' ability to solve problems in Newtons Lows of Motion.

1.4. Consider J4PSS's impact on preservice physics instructors' motivation in Newtons Lows of Motion.

1.5. Explore the effect of J4PSS on preservice physics teachers' understanding of Newtons Lows of Motion.

1.4. Research Questions

The research issues addressed in this study were

1.1. Are there statistical differences between the intervention and comparisom groups of prospective physics teachers in terms of factual knowledge and conceptual comprehension of Newtons Lows of Motion.?

1.2. Are there statistically significant differences between the intervention and the comparisom groups in terms of knowledge of procedures in Newtons Lows of Motion.?

1.3. Do the preservice physics teachers' abilities to handle problems with Newtons Lows of Motion.differ statistically between the intervention and comparisom groups?

1.4. Do the intervention and comparisom groups' levels of preservice physics instructors' motivation to teach Newtons Lows of Motion.statistically differ?

1.5. How do preservice physics teachers view the effect of J4PSS on their understanding of the concepts of Newtons Lows of Motion.?

1.5. Significance of the study

This study assisted preservice physics teachers by expanding their knowledge of facts, ideas, and procedures. The learner's problem-solving skills, motivation, and perception in Newton's Laws of Motion course, as well as their methods of understanding these facts, concepts, and procedural knowledge, increased their acceptability by society and the scientific community if they were adequately trained in knowing. The study conducted jigsaw-4 problem-solving strategies in the physics classroom, within the domain of the mechanics course. In other words, this study transformed the knowledge base from the dominant traditional approach of treating mechanics courses to the emerging jigsaw-4 problem-solving strategies in preservice teachers' learning of the concepts of motion.As a result, the physics teaching and learning society benefited from a study of learners' grasp of facts, ideas, procedural knowledge, ability to solve issues, motivation, and perception in a challenging mechanics course brought about by jigsaw-4 problem-solving strategies, followed by instructors' responsibility to entertain this course accordingly. In addition, the study affected teaching and learning in upper primary-level physics teaching. This means the findings from this research changed student learning and problem-solving strategies not only in motion but also in other physics courses.

Physics curriculum experts and professionals can also benefit from designing and/or modifying the curriculum, emphasizing students' understanding of facts, conceptual understanding, procedural knowledge, problem-solving skills, motivation, and their perception approach to Newton's Laws of Motion. Also, other teacher education colleges across the country will use the results of this study to enhance students' understanding of facts, concepts, procedural knowledge, problem-solving skills, perception, and motivation in designing professional development schemes for in-service teachers. Mechanics educators at higher levels will benefit from this research effort. What is more, physics teachers teaching other courses will get the chance to promote problem-solving strategies and the jigsaw-4 method.

1.6. Delimitations of the Study

This research was carried out in four teacher education colleges in Ethiopia's Southern Nations, Nationalities, and Peoples Regional State (SNNPRS). This is to do a detailed investigation of the situation. The research focused on first-year preservice physics teachers taking mechanics-I. The problem identified focused only on mechanics content, specifically based on the laws of motion. Included in this study: the laws of inertia,the law of dynamics, and Newton’s third law studied in this investigation. The study period was only seven weeks long; nevertheless, a much a longer study period would have been preferable to determine the study's impact. But the reasons for the problem were time and money, among several variables. The study delimited prospective physics teachers' factual knowledge, conceptual understanding, procedural knowledge, problem-solving skills, perception, and motivation. In addition, to keep the study manageable, Jigsaw-4 Problem Solving Strategy (J4PSS), Jigsaw-4 Teaching Techniques (J-4), Problem Solving Strategy (PSS), and Conventional Method (CM) were used.

1.7. Limitations of the study

Several limitations were faced during the process of implementing the research. Four teacher education colleges and four teachers participated in this study. The instructors and the colleges of teacher education affected the intervention due to individual differences because it was impossible to control all instructor- and college-related variables, even though the researcher trained to select similar colleges and instructors from a different perspective and gave training on the instructional approach and way of implementation to make sure. He used research protocols that were followed according to a set of instructions. Other mechanisms of conducting observation and discussions with the instructors during implementation will overcome the problems of COVID-19 since the preservice physics teacher fears sitting near each other because it is transmitted through physical contact. The researcher followed an ethical norm about its protection and prevention.The other limitation of the study was that the lesson was conducted in a natural or real-world setting.of a college education, as the class was formed at the beginning of the semester.Since different colleges have different settings, this limits the finding's ability to be generalized to other learning institutions for teacher education. However, the researcher was unable to control the confounding factor caused by the college’s differences in locations, which was another issue of the natural setting of the quasi-experimental design (Vocht et al., 2021). The data’s internal validity was affected as a result. Moreover, there was no randomization in the quasi-experimental unless they had similar characters.

1.8. Organization of the study

The first chapter included background information, such as the rationale for the current investigation. It provided a robust foundation for conducting the current study by presenting practical and theoretical rationale, empirical evidence, and global and local practices in student-centered scientific education. Furthermore,the gap of the study, the goal of the study and the study's issues that will guide the investigation were outlined. Chapter two will situate the current study within a broader context by providing a review of the Jigsaw 4-technique of teaching and problem-solving strategies research in science education and its relation to factual, conceptual, procedural, problem-solving skills, and motivation, with a specific focus on the effect of Jigsaw 4-problem-solving strategies. Various models of frameworks for problem-solving strategies and Jigsaw-4 techniques of teaching will be examined concerning their relevance to science education. In addition, research on establishing teaching skills for Jigsaw-4 Problem-Solving Strategies and students' knowledge of concepts of laws of motion will be discussed in Chapter 2. Chapter 3 will provide a broad overview of the philosophical perspectives, the research designs developed, and the methods chosen to answer the research questions and, hence, address the study's objective. Chapter 4 will provide a detailed analysis of both quantitative and qualitative data to determine if Jigsaw-4 problem-solving strategies affected preservice teachers'.

A quantitative understanding of concepts of laws of motion will be achieved by statistical approaches used to determine overall changes in having accurate and verifiable information, grasping the underlying concepts, being driven by a sense of purpose or incentive, and actively participating and being interested in the subject matter. Qualitatively, the chapter will provide a detailed thematic analysis of pre- and post-intervention interview transcripts using a problem-solving assessment rubric to evaluate.problem-solving abilities and explore prospective physics instructors' views on physics.In Chapter 5, a full explanation of the outcomes of Chapter 4 will be offered, arranged around each theme of the research questions. Chapter 6 will discuss the study's findings and consquences for the country's education sector, as well as future research in the field of physics.

1.9. Operational Definitions of Terms

The following terms and phrases are defined in relation to this dissertation:

A blended instructional approach is defined as the instructional approach used to combine or integrate Jigsaw-4 techniques of teaching (J-4) with a problem-solving strategy (PSS).

Comparison Group: It is referred to as a teacher-centered, traditional, or business-as-usual instructional method that is implemented in an actual classroom.

Conceptual understanding reflects a student's ability to reason out their responses, which is assessed by scores on the mechanics conceptual understanding test.

Factual knowledge is the element of the knowledge domain that specifies information and facts about laws of motion.

Jigsaw 4-Problem-Solving Strategies (J4PSS): refers to an instructional approach organized using the blended instructional approach of Jigsaw-4-Technique of Teaching with TECMRER Problem-Solving Strategies. It creates an effective active learning method used to increase individual interaction and the sharing of skills with each other.

Jigsaw-4 is the technique of teaching method, referred to as the instructional method, in which the structured cooperative learning method is applied in the classroom. It supports learners with three additional activities, such as an introduction, a quiz, and re-teaching.

Problem-solving Skill refers to the ability of preservice physics teachers to solve physics problems using problem-solving strategies.

Problem-solving strategies are instructional approaches that apply TECMRER problem-solving strategies for students to enhance their problem-solving skills.

Procedural knowledge is defined as a series of steps or sets of instructions used in solving physics problems.

The TECDRER model is a learning cycle with seven stages that include thinking, exploration, choosing strategies, manipulation, reflection, evaluation, and re-teaching.

The affective factors are defined as variables such as motivation and perception that influence pre-service physics teachers' understanding of concepts in Newton's laws of motion.

Understanding concepts of Newton's Laws of Motion refers to the outcomes obtained from learning Newton’s Laws of Motion in terms of per-service physics teachers: factual information, conceptual comprehension, procedural expertise, and the ability to solve problems in mechanics.

Chapter Two –Review oF Related Literature

2. Introduction

Numerous studies have been conducted on educational science in general and the teaching of physics in particular to clarify how students learn physics and develop the abilities they possess as they do so (Erfan & Ratu, 2018; Suprapto et al., 2016; Uwizeyimana et al., 2018). In this research, the J4PSS method's impact on prospective teachers' use of the TECMRER Model to improve factual knowledge, conceptual understanding, procedural knowledge, problem-solving abilities, motivation, and perception was examined.

2.1 .Method of Teaching

According to the researcher, teaching is an art, and some people are just naturally gifted in this sector (Tsung-Jui & Ya-Chun, 2015) . However, there is room for improvement for the majority of educators through practice and the use of different science teaching methods. The purpose of the review is to get informed about relevant theories and practices of active learning methods. The goal of learning science in the contemporary world is to help students understand the concepts of the nature of science and construct their meaning-making with the respective topic of learning (Syaharudin et al., 2015). The success of this goal of learning science can foster interests, values, and attitudes toward science among students that underlie lifelong and meaningful learning. Hence, the study revealed by Ahammad et al (2022), Howell & Brossard (2021), and Lodge et al (2018) on students' understanding of science concepts has come to the forefront in the modern world and eventually become one of the major fields of research in science education (Syaharudin et al., 2015).

Physics is commonly known as the fundamental science (Raikes et al., 2017). It studies the natural phenomena of the world around us, and it plays a tremendous role in improving the lives of societies. Physics has become increasingly challenging, and it is not uncommon for students to encounter alternative conceptions and encounter difficulties when it comes to understanding the subject matter (Erfan & Ratu, 2018; Syaharudin et al., 2015) . As a result, students have a wide gap in their understanding of important topics such as motion, electricity, magnetism, thermodynamics, waves, and optics (Ning, 2016). Moreover, the findings of the studies revealed that alternative conceptions are highly resistant to change and strongly influence the teaching and learning of any topic, but physics in particular (Pfundt, 1994). Thus, it is the responsibility of a teacher to design the appropriate instructional strategies to overcome the problem of students' difficulty with physics content, particularly in the Laws of Motion.

Information from sources in the environment is re-interpreted in terms of existing knowledge and understanding (Yimer & Feza, 2019). From this point of view, the constructivist perspective on learning is now widely accepted. Although there may be variations in the emphasis placed on certain aspects, it is widely acknowledged that meaningful learning necessitates students' ability to comprehend new information by relating it to their pre-existing cognitive framework (Mystakidis, 2021). The modern education approach has led the teacher to face the responsibility of choosing the instructional method that will achieve learning at the maximum level (Acar, 2006).Learning is an active process that takes place in the mind of the learner, during which, therefore, teachers and teacher candidates who are responsible for education and instruction should innovate themselves continuously and thus try to utilize various methods and techniques. such as problem-solving strategies and the jigsaw method of teaching, specifically focusing on jigsaw-4 techniques of teaching.

2.1.1. Problem-Solving Strategy

The problem-solving strategy is explained as a complex process that requires many skills to be used together (Çalişkan et al., 2010; Morphew et al., 2020; Mualem & Eylon, 2007). The elements of this process are understanding the problem, choosing the necessary information among the given choices, converting the obtained information into mathematical symbols, and reaching the solution after performing the necessary operations. These elements do not follow a linear route (Saregar et al., 2019).The first step of problem-solving is understanding what is read, and when this step is not achieved, it is believed that utilizing the problem's randomly selected numbers will lead to meaningless outcomes for the person (Goos et al., 2000; Ulu, 2017) . When the literature is reviewed, two types of problems are observed: routine (or ordinary) problems and non-routine problems (Saygılı, 2017; Yazgan et al., 2021). Simple problems can be resolved using an equation, formula, or tried-and-true technique.These problems are the ones that help establish a connection between mathematical knowledge and life (Loria Jr., 2014; Zhang & Zhou, 2014). Many research findings indicated that the implementation of a problem-solving strategy improved problem-solving skills (Handriani, 2022; Purwaningsih et al., 2020).

The resolution of problems is defined by researchers Donald (1987) and as an operation that requires both the representational cognitive of prior experience and the components of the current problem situation to be rearranged. Problem-solving: therefore, when an objective is not immediately accessible, one can try to find an appropriate approach to achieve it, in this case, forming the right concept (Škėrienė & Jucevičienė, 2020) . Accordingly, the processes in problem-solving are to identify and frame problems, create efficient methods for solving issues, evaluate solutions, and continuously assess, reflect on, and redefine issues and solutions (Nisa et al., 2020).The capacity for problem-solving is dependent upon the extent to which a person undergoes a conceptual understanding, and this leads to concept formation, which is a prerequisite for solving problems.

Researchers Alharthi and Alsufyani (2020) and Saud et al (2013) claim that the biggest challenge students confront is understanding laws of motion through problem-solving strategies. It promotes individualistic problem-solving abilities that were previously overlooked in peer interaction and cooperation, resulting in experts with deep comprehension (John, 2013; Safari & Meskini, 2016; Vamvakoussi et al., 2019). According to Gurat (Farrell & Heller, 2010; 2018) the success or failure of a problem solver is frequently determined by unique variations in their approach. Minnesota's method of problem-solving by Docktor et al (2016), Farrell & Heller (2010) and Istiandaru, and Kusdinar (2017) heuristic techniques by Krulik and Rudnik, and Numerous scholars in the academic community have developed various methodologies for addressing and resolving problems.

The individual steps for each of these methods are listed as follows: According to Farrell & Heller (2010) the steps of the University of Minnesota's problem-solving strategy include focusing on the problem, which entails deciding the question, drawing a picture, and choosing a qualitative approach. Sketching a picture, identifying symbols, and outlining quantitative relationships are all part of the subsequent phase, "Describe the Physics." Plan a Solution requires selecting a relationship that contains the target amount, proceeding through a cycle of selecting further relationships to remove unknowns, and substituting to solve for the target. Simplifying an expression and entering numerical values for quantities as needed are part of the phase. Execute the plan. The final part of the process is to evaluate the solution, which includes examining it for consistency, accuracy, and clarity.

According to Farrell & Heller (2010) this procedure can be compared to a sequence of translations where each step changes the preceding stages significantly. Focus on the statements of problem words is transformed into a drawing for a visual description. Using a diagram and symbolic language, the drawing is converted into a physical representation of the problem in the describe physics stage. The physical description is converted into a mathematical form in Plan a Solution, utilizing equations and restrictions, and then those mathematical forms are converted into mathematical operations to produce an arithmetic solution in Execute the Plan. The steps of Krulik and Rudnik's heuristic strategy from Istiandaru and Kusdinar (2017) were similarly outlined in Table 2.1.

Table -2.1 Description of Krulik and Rudnik's heuristic strategies indicators used in problem-solving

No	Description	Indicator
1	Read and think	1.1 students write what is given in the problem 1.2 students write what asked in the problem 1.3 students explain the setting of the problem 1.4 students determine what is asked in the next action to solve the problem
2	Explore and plan	2.1students selected and organized information found in the problems 2.2students find the appropriate information required to solve the problem 2.3 students collect data that is not necessary to remedy the issue. 2.4 Students make illustration models or drawings. 2.5 Students create a chart and table.
3	Select Strategy	3.1students find a pattern within the problem 3.2students work the problem by working backward 3.3students use trial-and-error strategies 3.4students make simulations or experimentation 3.5students make simplification or expansion 3.6students suggest chronological steps to solve the problem 3.7 Students use deductive logical ways and distribution

4	Finding and answers	4.1students predict or estimate the solution 4.2students calculate without a tool to solve the problem 4.3 The problem was resolved by the pupils using their algebraic skills. 4.4To overcome the issue, learners used their geometrical skills. 4.5 When permitted, the students used calculators to solve the issue.
5	Reflect and extend	5.1After solving a problem, students evaluate their solution. 5.2. Students make an alternative solution or different from the previous one. 5.3.Students develops solution for other problems 5.4.Students make generalizations or conceptualizations 5.5.Students discuss the solution with their friends 5.6 . Students created a variety of problems derived from the previous problems

The research found that the advantages of learning together are well documented as being higher academic achievement, a higher level of reasoning, increased motivation to learn and succeed, enhanced focus, less disruptive behavior, and critical thinking abilities, as well as a deeper comprehension of and favorable attitudes regarding the subject matter behavior in class,higher self-esteem, and higher social skills (Ning, & Hornby, 2014; Priyana, 2020) .

2.1.2. Cooperative Problem-Solving

Cooperative problem-solving is a strategy of instruction whereby students work together in groups of varying composition to achieve common objectives (Habtamu et al., 2022; Matteo Tuveri2, 2019).To be successful in this strategy, students share ideas rather than working alone and assist one another to maximize mutual benefits (Esan, 2015).This is unlike the use of conventional teaching methods, where learners work individually or competitively. An analysis of different studies conducted on the effects of the CPS on learners' achievement in different subjects in the school curriculum indicated that 61 percent of them discovered considerably higher accomplishments than control groups that were trained conventionally. High, average, and poor achievers all saw positive results in all key subjects at all grade levels in urban-rural and residential schools (Esan, 2015; Serbessa, 2006).

There are several methods used in CPS categorized based on group composition, organization, and direction of study (Cheung & Slavin, 2011; Habtamu et al., 2022) . This study (CPS) and other selective problem-solving techniques include the students’ teams comprising five to six students working on a physics task given to each group. In this strategy, the teacher presented the mechanic's lesson first, and then the students’ teams used a variety of methods to master the material, such as quizzing each other, discussing, and using worksheets. In effect, the CPS strategy was able to promote face-to-face communication, positive interdependence, individual acceptability, interpersonal and collaborative skills, and positive attitudinal change, which are essential in improving the learning of physics, thereby leading to high academic performance and a positive attitude among learners (Esan, 2015). There are several cooperative learning techniques, among which the most popular ones are Student Teams-Achievement Division (STAD), Teams-Games-Tournaments (TGT), Learning Together Group Investigation, and Jigsaw (Yaayin et al., 2021).

2.1.2.1. The jigsaw method

The jigsaw method is a cooperative learning method; it is a way of doing activities that require a skill that was developed by Elliot Aronson and reported by Jainal and Shahrill (Jainal & Shahrill, 2021) .The jigsaw method was created with the goal of enhancing educational outcomes and fostering a sense of unity among students. It aims to reduce conflicts and highlight the importance of each student as a unique part of a larger group while also encouraging cooperation within a learning environment (Karacop, 2017; Pelobillo, 2018) .To create a more cooperative environment, Aronson and the teachers divided students into small groups that were diversified based on ability, ethnicity, and gender.

This structure required students to take responsibility for their class assignments and to work out any personal issues they had with one another. After eight weeks of using the jigsaw strategy, Aronson reported that there was a decrease in bias and unfavorable stereotyping among pupils, who displayed more self-confidence and showed more positive attitudes toward a school than did their peers in traditional classes. Academically, students who participated in the jigsaw learning technique showed greater academic improvement than their peers (M. N. Ali, 2019; Shakerian et al., 2020; Verma et al., 2019) .

Particularly in biology, chemistry, physics, mathematics, and the Earth sciences, the Jigsaw approach and its variations are said to be utilized in scientific classrooms more frequently than other collaborative learning techniques (Mahidol, 2020) . The jigsaw method is widely recognized as an effective approach to promoting cooperative learning, as it encourages active participation and knowledge sharing within a group (Karacop, 2017) .The jigsaw technique involves dividing a larger topic into smaller parts, assigning each part to a different group member, and then having those individuals become experts in their assigned area. Through collaboration and discussion, group members share their expertise with one another, ensuring that every member gains a comprehensive understanding of the entire topic. There are currently six types of Jigsaw cooperative learning strategies available for teachers to use in the classroom (Mohammad & Hamadneh, 2017) . They are: Jigsaw 1, Jigsaw 2, Jigsaw 3, Jigsaw 4, Reversed Jigsaw, and the Subject Jigsaw. The jigsaw method is implemented by using the following procedures:(Karacop, 2017; Turkmen & Buyukaltay, 2015; Yaayin et al., 2021) .

1 Rearrange the students into four jigsaw groups, each consisting of four individuals. It is important to ensure that the groups are characterized by a range of diversity factors such as gender, ethnicity, race, and ability.

2 Appoint one student from each group as the leader. Initially, this person should be the most mature student in the group.

3 Divide the day's lesson into four segments.

4 Give each pupil a piece to learn, making sure they only have direct access to it.

5 Give pupils enough time to read their section through at least twice so they can get a feel for it. They are not required to commit it to memory.

6 Organize pupils into makeshift "expert groups" by assigning a student from each jigsaw group to join other students in the same segment.

7 Allow students to practice the presentations they will make to their jigsaw group and to explore the key ideas of their segment in these expert groups.

8 Reassemble the pupils in their jigsaw groups. Every student concentrates on a specific task, and each student showcases their piece to the others.

9 Encourage group members to clarify their inquiries by posing questions to them.

10 Monitor the activities of different groups and observe how things progress. If any group encounters challenges, such as one member monopolizing the conversation or being disruptive,

appropriately intervene. Eventually, the group leader should handle this responsibility by quietly providing guidance on when and how to step in, until the leader becomes proficient enough to utilize this technique for training other leaders.

11 At the end of the session, administer a quiz to the children on the topic to help them recognize that these activities are not only enjoyable games but also valuable learning opportunities.

Jigsaw I is the original work of Aronson and associates (Verma et al., 2019). Here, students are members of two groups: the home group and the expert group. The students work in a home group ‘that is heterogeneous. After reading an expert sheet each, the members of the home group who have the same sheet move to a different expert group where they conduct in-depth discussions about their assigned topic. Once the discussion in the new group is complete, they return to their home group and teach all their home group members about the topic that they are now experts in. Once back in their home group, each student is accountable for teaching his or her assigned topic (Yoshida, 2018) . Abdullah developed Jigsaw II as a modified version of the original Jigsaw I, which was introduced by Yoshida (Yoshida, 2018). In Jigsaw II, the members of the home group receive identical content but concentrate on different sections of the material. Each member must become an "expert" on his or her assigned portion and teach the other members of the home group (Maden, 2011). This revised version of the method involves using computed team scores, such as the Student Teams-Achievement Division (STAD) method. Also, Jigsaw II has two substantial changes: all students in the team read all the lessons, and the scores of students are combined to contribute to an overall team score.This method has been used for subjects in the social sciences and in science, particularly when the learning goals focus on concepts rather than skills.

According to Özdemir & Arslan (2016) Jigsaw III was created by Holliday (1999). However, Mattingly & Vansickle (1991) modified Jigsaw II to increase the interaction between students (Tarhan et al., 2013). It has the addition of a cooperative test-review process. The home group will meet again, and the procedure will be examined as part of this cooperative test review. Hedeen (2003) designed the reversed jigsaw. During the instructional phase of the game, it is not the same as the original Jigsaw. Rather than going back to their home groups to teach the material, students in the expert groups teach the entire class using the reverse jigsaw technique (Hedeen, 2003) . Doymus (2010) developed Subject Jigsaw. It is also used in group-based learning, in which students need to cooperate with their peers to achieve personal goals. Each student is like a piece of a puzzle that needs to understand and learn the subject completely (Akbar et al., 2012).

2.1.2.2. Jigsaw-4-Method

Jigsaw-4, according to Turkmen and Buyukaltay (2015) was developed by Profile (2014) and has three significant new features: an introduction, quizzes, and reteaching following individual assessment. To attract students' attention, the teacher first introduces the lesson through lectures. In a plenary "class session," activities can include reading from literature, asking questions, and posing challenges. Then, pupils are put into a mixed-ability group called the "home group," and they are all given reading assignments. The expert sheet, which is based on a list of all issues, is now being discussed by each student. Again, as a group, the students who have the same information sheet discuss their subject. To check the accuracy and understanding of students in the expert group, they are assessed by employing a quiz based on the expert sheet. When they rejoin their initial unit, they instruct every member of that group and administer tests based on the original content. The teacher reviews and clarifies any concepts that it appears the students did not understand. A team score is produced by adding the results of the quizzes that each student completes individually. The teacher then reteaches any material that was not understood after the individual assessment process (Akudo & Olaoye, 2021).These features make the Jigsaw-4 better than the other Jigsaws (1, 2, and 3).

Finally, students are assessed on the material they have all learned through their cooperative learning. Research suggests that jigsaw is used across all grade levels, from K–16 to graduate and professional courses in various content areas. Since the invention of the jigsaw, various changes have been made to take into consideration the problems of teachers as well as learners who have utilized the classroom technique. In Jigsaw 2, students carry out research on specific topics as opposed to parts of one larger reading. As part of this adjustment to the original technique, students are required to complete expert sheets, which act as notes for bringing the subject back to the fundamental group, and are given individual assessments as opposed to group evaluations (Özdemir & Arslan, 2016) . Jigsaw 3 allows for a review process before assessment. Jigsaw-4 has several additional features: teacher introduction of material; group tests led by subject-matter experts; a review period before individual evaluations; and reteaching any subject that wasn't sufficiently examined in the cooperative group project (Turkmen & Buyukaltay, 2015) .

All Jigsaws, but especially Jigsaw-4, generally encourage good attitudes and interests, help students learn how to communicate with one another, and raise science learning achievement, especially in physics and chemistry (Boniface et al., 2021).It was concluded that the effect of Jigsaw-4 cooperative learning in comparison with individual learning methods on students' understanding of physics and other physical science concepts was that the jigsaw pupils performed better than the individual learning students. Parchment(2009) and Akbar et al (2012) because the Jigsaw-4 approach is profitable, this study attempted to investigate the academic performance of physics students in higher education in combination with other problem-solving strategies. The reason that the researcher selected Jigsaw-4 Techniques of Learning is that it incorporates both Jigsaw 2 and 2, quizzes during the process, accesses areas of the curriculum that have been well understood by students, and also requires additional teaching by the instructor (Turkmen & Buyukaltay, 2015).

On the other hand, Jigsaw-4 teaching techniques reject individual competition and promote social connection among learners (Azmin, 2016; Baring et al., 2022; Pelobillo, 2018) . They are unable to master the fundamental ideas of mechanics' content as a result. This research aimed to fill in the knowledge discrepancies that exist between problem-solving strategies and Jigsaw-4 methods by using a blended instructional teaching approach. To increase the understanding of the facts held by physics preservice instructors, concepts, problem-solving talent, motivation, and perception of laws of motion (Bao, 2019; John, 2013) .

Currently, this study focuses on the assessment of the Jigsaw-4 techniques blended with other problem-solving strategies in physics learning and enhances factual knowledge, conceptual understanding, problem-solving skills, motivation, and engagement. Similarly, Azmin (2016) explained that Jigsaw-4 is a highly structured cooperative learning method, as the content of the lesson is subdivided into different parts and then given to groups who would explain to each other their results as a whole after grouping the students into a specific topic. The Jigsaw-4 technique is preferable to lectures in that it enhances the learning process and piques students' interest in physics, making it a better teaching tool. Jafariyan et al (2017) recommended cooperative learning in teaching physics. Moreover, the blended Jigsaw-4-problem-solving strategies expected from this study can play the greatest role in increasing the academic performance of physics major students, and the Jigsaw-4 approach is a successful collaborative learning strategy for enhancing a college student's physics ability to solve problems (Limjuco & Gravino, 2012).

When playing jigsaw, the learners in the expert group developed higher-order cognitive abilities and acquired personal qualities such as motivation and a positive outlook, in particular when addressing problems. Additionally, students with good views toward physics will be inspired to participate in class (Ryan & Guido, 2013). In line with a study by (Ramani, 2012) shared activities with peers allow students the possibility to develop their communicative, active, and cooperative skills in real life. and social skills. In addition, whenever pupils engage in learning through collaboration, it leads to the development of higher-level thinking skills, positive attitudes toward learning, and greater motivation.

There hasn't been much study done on how the jigsaw technique affects the students' five dimensions of problem-solving skills. This study intends to look at the implications of the Jigsaw-4 Problem Solving Technique test findings and their capacity to solve physics problems to address the issues raised by the study. In addition, this study aids in understanding the factors affecting problem-solving skills. To assist instructors, learners, parents, and college administrators, it is necessary to comprehend, evaluate, and explain the ability to solve problems and test results between two groups. To help educators and curriculum writers realize the significance of physics teaching and learning, researchers can use this information as well.

In addition, only a few of the investigations included here were conducted in Africa, with the majority of the studies reported here being carried out in Indonesia and Turkey. The efficiency of students in college connected to J4PSS methods may not yet be evident from the stand point of physics instruction in our nation since the researcher was unable to locate a study related to J-4PSS that was conducted in Ethiopia and other nations. The researcher discovered that to ascertain the effects of J4PSS on PSPT's physics learning, further experiments with better designs were required. As a result, a study was conducted on physics topics, specifically laws of motion. This study compares the relative effectiveness of J-4PSS, the J-4, and the TECMRER approach of PSS to the traditional technique on PSPT's learning outcomes of laws of motion. The study's variables were addressed one by one in the sections that follow.

2.2 Factual Knowledge

Knowledge of fact refers to information that is objective, verifiable, and based on evidence or data. It is the kind of information that can easily be taught and assessed through memorization or recall, and it is often the foundation for higher-level thinking and problem-solving (Yimer & Feza, 2019). It can be separated into various fields, such as history, science, mathematics, literature, and the arts. For example, science includes knowledge about the natural world, such as the properties of matter and the laws of physics. It is also critical for success in education and career, as it forms the basis for higher-level thinking and problem-solving. Knowledge of the facts is often assessed through tests, exams, and quizzes, and it is considered a crucial component of academic achievement (OECD, 2022).

However, factual knowledge is not the only important body of knowledge for success in life. Knowledge of different kinds, such as conceptual knowledge and procedural knowledge, is also essential (Salim & Gilar, 2020). Knowledge of procedure refers to knowing how to take action, such as a skill or task, while conceptual knowledge refers to understanding the underlying principles or ideas behind a concept. Moreover, knowledge of facts is not fixed and unchanging. It is constantly evolving and being updated as new information and discoveries emerge. Therefore, it is important to be receptive to emerging knowledge and to continually update one's knowledge of facts. To improve their understanding of concepts and ability to solve a problem in physics, teachers should assist learners in building concepts using factual knowledge (Chandio et al., 2016) . Correspondingly, to determine the student's performance and understanding of the concepts of laws of motion, the researcher asked those questions about them. The students then compared their answers to how they would normally understand the words from the material they were studying.

Similarly, Bigozzi et al (2018) looked into the relationship between factual information and a conceptual understanding of laws of motion. The study's findings revealed that learners who had a solid grasp of factual knowledge were more adept at comprehending the underlying ideas of the laws of motion. In their study Nilüfer (2014) looked at the impact of factual knowledge instruction on students' conceptual knowledge of laws of motion. In contrast to pupils who did not get this teaching, those who got factual knowledge education had greater conceptual comprehension of the laws of motion, according to the study. However, the Bianchi et al (2021) study also showed the benefits of a computer-aided course of study on students' factual understanding of the laws of motion.The teaching program was successful in increasing students' factual understanding of the laws of motion. To determine the effects of a virtual laboratory on students' factual understanding of laws of motion, Saregar et al (2019) conducted a study. According to the study, pupils' understanding of the mechanics was improved via the use of the virtual laboratory.

In conclusion, factual knowledge is one of the key elements of education. It provides the foundation for higher-level ability to solve issues and reason, and it is critical for success in many areas of subjects. However, it is important to recognize that factual knowledge is just one type of knowledge; overall, these studies suggest that factual knowledge plays an important role in students' understanding of physics' laws of motion. Teachers should focus on building strong building blocks of factual information by providing instruction on key concepts, definitions, and formulas related to the laws of motion. The use of instructional programs and virtual laboratories can also be effective in improving students' factual knowledge of the laws of motion.

2.3 Conceptual Knowledge

Knowledge of concepts refers to the factual and theoretical knowledge that individuals acquire about a domain (Chandio et al., 2016; Puchongprawet, 2022). It includes knowledge of key concepts, principles, and theories, as well as the ability to recognize and apply this knowledge in a variety of contexts. Conceptual knowledge of the laws of motion refers to the factual and theoretical knowledge that students acquire about the principles of motion. It comprises an understanding of the three laws of motion in addition to the mathematical formulas that define the connection between acceleration, mass, and force. Research on conceptual knowledge of laws of motion suggests that students often struggle to acquire and retain this knowledge due to a lack of prior knowledge or misconceptions, difficulties with abstract reasoning and mathematical concepts, and other factors.

To promote conceptual knowledge of laws of motion, teachers can use a variety of strategies and approaches, including hands-on activities, simulations, analogies and metaphors, the integration of technology, and other resources. Teachers can use a range of tactics to assist students in gaining and remembering the theoretical and factual knowledge required to understand the principles of motion and their applications in the real universe. Many students misunderstand the laws of motion, such as the notion that an object must be held in motion by force. These misconceptions can persist even after instruction and require targeted interventions to address them (Mason & Zaccoletti, 2021).

Analogies can be effective in promoting conceptual knowledge of the laws of motion. For example, comparing the movement of things to the behavior of a ball rolling down a hill can help students understand concepts such as acceleration and friction (Jonane, 2015; Robert & Brown, 2004). Technology-based resources, such as computer simulations and virtual reality, can be effective in promoting conceptual knowledge of the laws of motion. These resources allow students to visualize and explore the concepts and principles involved in ways that are not possible with traditional classroom materials (Bao,2019). Similarly, inquiry-based approaches, where students are encouraged to explore and discover the laws of motion through hands-on activities, can be effective in promoting conceptual knowledge. These approaches help students develop a deeper understanding of the underlying principles of the laws of motion and how they apply in different contexts (Hand et al., 2021).The development of a strong conceptual knowledge of the laws of motion is important for academic success in fields such as physics and engineering, as well as for everyday life. Understanding how forces and motion work can help individuals make informed decisions about their safety and the safety of others in a variety of contexts (Poonyawatpornkul & Luksameevanish, 2018) .

In general, developing conceptual knowledge of laws of motion is an important foundation for academic success in fields such as physics and engineering, as well as for making informed decisions about safety in everyday life. Overall, the literature suggests that promoting conceptual knowledge of the laws of motion requires a variety of approaches and strategies, including active learning methods such as problem-solving strategies. Jigsaw techniques of teaching include hands-on activities, analogies, and the integration of technology. By using a range of techniques and resources, teachers can help students acquire and retain the factual and theoretical knowledge needed to comprehend motion's fundamentals and how they are used in practical situations.

2.4 Understanding of the Concept

Understanding concepts refers to a deep and meaningful understanding of the underlying concepts and principles in a particular domain (Tian et al., 2020). It involves the ability to connect and integrate different pieces of information, recognize patterns and relationships, and apply knowledge in novel and unfamiliar contexts. For students to succeed academically, a solid conceptual grasp is crucial, as it allows individuals to think critically and solve complex problems. It also enables individuals to make wise decisions and apply knowledge in real-world situations. Effective strategies for promoting conceptual understanding include the use of active learning, such as hands-on activities and problem-based learning, as well as the utilization of models to help connect new concepts to prior knowledge (Hand et al., 2021). It is also important to address common preconceptions that could prevent the development of a strong conceptual understanding (Brophy, 2004). Hence, conceptual understanding played an important role in the realization of problem-solving skills.

The behavior of moving things and their interactions with other objects are described by the laws of motion. The concept of net force plays a central role in Newton's laws of motion, as it is directly related to the acceleration of an object. Here are the main importances of net force in Newton's laws (Mochrie & De Grandi, 2023). Sir Isaac Newton first introduced them in the late 17th century, and they are still regarded as a core idea in physics today. The first law of the equation of motion is that an item at rest will remain at rest, and it will continue to travel at a constant speed if nothing else interferes with it. According to the 2nd law of motion, an object's acceleration is inversely related to its mass and directly proportionate to any external forces acting on it. $F = ma$, where F is the applied force which is called the net force or resultant force, m is the object's mass, and a is its acceleration, which is the mathematical formula for this (Papachristou & Academy, 2020). This shows that when the net force is applied to one thing by another, the other thing responds by exerting a force that is opposite and equal. These laws are fundamental to understanding many facets of physics, from the motion of planets to the behavior of particles at the atomic level.

In general, they describe how students frequently have misconceptions or naive ideas about physics, chemistry, astronomy, engineering, and other scientific phenomena that conflict with what they learn in school, which has led to extensive research on science instruction in the knowledge of concepts (Frederick;, 2008). Due to the numerous fallacies that students pick up from their everyday experiences, intuitive thinking, media such as movies and television, and superficial science instruction, conceptual understanding is very important in science education (Berrocoso et al., 2020; Garrison & Bentley, 1990) . Additionally, conceptual comprehension is the process through which a person alters his or her concepts by including new concepts, rearranging old concepts, or exchanging old concepts for new ones. Conceptual understanding, according to Yaayin et al (2022) is t,herefore, the act of getting past one's misunderstandings and implementing the right ideas.

In sociocultural theory, social interdependence theory, cognitive developmental theory, and motivational theory of learning perspectives, knowledge is dynamic; rather than merely being a passive illustration of the fundamental principle of the Laws of Motion, concepts can be used to make meaning of reality (Lantolf & Poehner, 2012) . Since most physics concepts are abstract and difficult to grasp conceptually, the researcher can be helped in this study by modeling and visual imagery to help them form mental images of the motion concepts (Hurrell, 2021; Sorden, 2012) .

Teaching conceptual knowledge is the main goal in any classroom, especially in science courses like physics, arithmetic, and chemistry (Eryilmaz, 2010; Matorevhu, 2020; Panprueksa, 2012; Sopandi & Sukardi, 2020). Because ideas are so important in science classes, for the learning process to be successful, students have to comprehend them. The width and depth of conceptual understanding may be explained by (Alao, S., & Guthrie, 1999; Mills, 2016).The primary component of a domain is represented by breadth, which relates to the extent to which it is disseminated. The term "depth," in contrast, refers to a person's understanding of scientific ideas and how they relate to one another. The main characteristics of conceptual knowledge are breadth and depth, which are intertwined (Tian et al., 2020).

According to Evans et al (2015) understanding is the most crucial aspect of learning. When students have a good knowledge of a subject, they can apply that understanding to learning new material and solving new issues. They should not utilize their skills to solve unknown problems, or if they are unclear about a subject, they should broaden their knowledge to cover new subjects. As a consequence, learners who lack a basic understanding of scientific concepts will find it difficult to participate in many open discussions about scientific findings (Mills, 2016). People are consequently unable to use their understanding of new subjects or their talents to address innovative problems. As a result, pupils should have the tangible experience to build conceptual knowledge moving to abstractions, and they also need chances to try and do, not just read about science. They should have tangible experience with topics before developing conceptual knowledge.

Learners are supposed to go through several steps to acquire new concepts or to change conflicting ones (Saba, 2020; Suprapto et al., 2016) . First and foremost, they must deliberately examine and comprehend the essence of the problem. Second, they must assimilate fresh data to fit it into the neural networks that already exist. Finally, people must accommodate new notions by critically analyzing and reorganizing their thoughts to evaluate their previous views. Finally, individuals must demonstrate proficiency in the newly acquired and comprehended topic so that it can serve as a foundation for future learning of more advanced and extended concepts. This demonstrates that a restructuring of the learner's view, the development of new cognitive arrangements, and the reorganization of previous ones take place in the learner's mind during the period of conceptual transformation.

As a result, to assist students in grasping the natural world, prior experience should be taken into account as the starting point for instruction. Teachers should focus their efforts on improving the learning environment so that pupils can learn more effectively (Riesen et al., 2018). On the other hand, although different instruments have been created for diagnoses and are utilized to categorize and measure learners’ grasp of ideas, the traditional multiple-choice achievement exams remain frequent assessment tools used in Ethiopian classrooms (Chandrasegaran et al., 2007; Park, 2020; Tsai & Chou, 2002).Despite the benefits of employing multiple-choice exams (such as the fact that they can be given to a large number of students at once and, in comparison to how long it takes to solve workout issues, the answers can be found much faster), there are issues with them in effectively testing the desired notion (Eryilmaz, 2010; Nilüfer, 2014) . As a result, researchers can only get a limited amount of information from multiple-choice test results since they can't be thoroughly examined (Kaindume et al., 2018). Students' misunderstandings may be the consequence of a lack of information, carelessness, or chance (Eryilmaz, 2010; Hasan et al., 1999). Since one cannot follow up with the answers supplied by the students, As a result, alterndiagnostic methods, such as two-tier examinations, have become widely used to classify learners' scientific misunderstandings (Franklin, 1992; Sulistri, 2017). Testing with two tiers is thought to b ative e a more complex tool than other tests, according to Didem & Saglam(2009) and Tsai & Chou (2002) since they incorporate learners' reasons and explanations for their replies to the first tier.

They also defined two-tier testing as a credible and dependable tool; it makes it easier for teachers to evaluate their students' conceptual understanding because it is straightforward to assess and apply. As a result, two-tier examinations were deliberately created to be a wonderful enrichment over previous ones since they take into account learners' rationale or explanation for their selected answer and also relate their replies to their comprehension of the ideas being assessed (Taslidere, 2016). As a product, when properly administered, these examinations may play a critical role in improving learners' scientific and conceptual comprehension. Numerous scientific education researchers have developed diagnostic exams with two tiers implemented since Treagust (2006) released his seminar article on how to prepare for two-tier exams (Djam’an et al., 2019).The criteria provided by Bayrak (2013) have been used to categorize learners' replies and make judgments on the degree of their comprehension when utilizing two-tiered examinations to measure their understanding. The following are the categories for identifying preservice physics teachers' understanding (Ayas et al., 2010; Çalik & Ayas, 2005; Tanahoung et al., 2010).

1. Full Understanding: Valid responses to each concept statement are provided, indicating that the topic is well understood.

2. Partial Understanding: The learner describes a partial understanding of the idea by stating at least one of the scientifically recognized concept's components or by associating one of them with a mistake.

3. Lack of comprehension: responses that contain illogical or wrong information, both of which are false or incorrect. These are responses that are described in at least one of the options listed below: repeating the question, providing irrelevant information or an unclear response, responding with "I don't know," or providing no response to the item.

But even students who perform well on exams in the classroom are not able to gain a strong conceptual understanding from lectures on physics that are traditionally presented (Uwizeyimana et al., 2018).The traditional classroom training, according to John (2013) leaves most students confused about basic physics topics. Despite the growing emphasis on scientific education in Ethiopian secondary schools, according to Mekbib et al.(2019) , these are the difficulties that have been seen in the mechanical learning process. Eshetu et al (2017) found that Ethiopian schools were ineffective in their efforts to improve the learning and teaching of physics as well as learners’ performance in physics. As a result, as compared to other science courses, many secondary school students show little interest in learning physics, which has resulted in poor performance on national exams (Melese & Tadege, 2019) .

Many researchers have attempted to define what it means to learn and teach with understanding. Numerous authors have acknowledged a range of effective teaching strategies for fostering scientific conceptual understanding(Bao, 2019; Hand et al., 2021) . These teaching techniques can be applied in numerous teaching situations and learning scenarios. However, context should be treated as the primary component of schooling for students, according to Finkelstein (2005) if one wishes to create an environment that promotes conceptual development in learners. This demonstrates that scientific principles are better remembered when students use them in real-life situations (Mahidol, 2020; Yager, 2001). Furthermore, the study of the influence of J4PSSs on students' conceptual understanding is limited because most studies focus on student accomplishment. As a result, the major concern of this research is to see how J4PSSs affect learners' knowledge of Laws of Motion ideas. The researcher adjusted the well-known approach of categorizing responses acquired from two-tier items. Numerous research studies have been utilized to find out students' conceptual accomplishment scores (Eshetu et al., 2017; Ozkan et al., 2015). Following this classification, the responses of the learners in the first-tier and second-tier conceptual test items are given the least 0 mark for the "no understanding" category, a mark of l points for the "partial understanding" category, and a score of 2 points for the "full understanding" category.

2.5 The differences and similarities between conceptual knowledge and conceptual understanding

Conceptual knowledge and conceptual understanding are related but distinct concepts regarding the laws of motion (Sands, 2014) . Students' facts, concepts, and beliefs about motion-based laws are referred to as conceptual knowledge. This includes knowledge of the three laws of motion as well as the mathematical equations that describe the relationship between force, mass, and acceleration. On the other hand, comprehension of concepts refers to the capacity to use this information in real-world situations and to understand the guiding principles. This involves comprehending how and why principles of motion relate to their actions and having the ability to foresee how objects will behave in various circumstances using this knowledge.

Alternatively, conceptual knowledge is the "what" of the rules of motion, whereas conceptual understanding is the "why" and "how” (Waldrip et al., 2013). Although conceptual knowledge and conceptual understanding have certain similarities, they are distinct concepts. One example of a student's conceptual knowledge would be their ability to recall the three fundamental principles of motion from memory (Barab et al., 2007). However, learners may not be able to apply these laws to a situation in the actual world due to a lack of conceptual comprehension. Similarly, a student may be able to use the laws of motion to make accurate predictions about the behavior of objects in different scenarios (demonstrating conceptual understanding), but may not be able to explain the underlying principles and relationships between the concepts (lacking some aspects of conceptual knowledge).

In summary, while conceptual knowledge and conceptual understanding are related, they are not interchangeable. Here’s a specific example that can further illustrate the similarities and differences between conceptual knowledge and conceptual understanding of the laws of motion: Conceptual knowledge of the laws of motion might involve memorizing the formula for the 2nd law of motion, which states that force (F) equals mass (m) times acceleration. On the other hand, a conceptual understanding of the laws of motion would involve being able to apply this formula in various contexts and understand the underlying principles behind it. For example, consider the following scenario: A 1-kilogram object is accelerating at a rate of 5 m/s2 due to a net force of 5 newtons. What is the object's acceleration if the overall force is doubled to 10 newtons?

Conceptual knowledge would involve applying the formula for Newton's second law to solve this problem, which would yield an answer of 10 m/s2. However, conceptual understanding would involve understanding the underlying principles behind the formula, such as the fact that an object's acceleration is oppositely correlated to its mass and directly proportional to the total force acting on it. It would also involve being able to apply this understanding to other scenarios, such as predicting the acceleration of an object given its mass and the net force acting on it. In summary, while conceptual knowledge involves memorizing the formula for Newton's second law, applying this formula in different situations and comprehending the fundamental ideas behind it are both parts of conceptual comprehension

2.6 Procedural knowledge

The capacity to carry out an action or find a solution by using a series of steps or algorithms is referred to as procedural knowledge. In the context of the laws of motion, procedural knowledge involves the ability to use the principles of the laws of motion to predict and analyze the behavior of physical systems. In the teaching-learning process of physics in the classroom, procedural knowledge refers to cognitive domain components that help us comprehend how to apply laws or rules in sequential order (Schiering et al., 2021). Different algorithms were developed as a tool to find more precise outcomes, and procedural knowledge covers them all. The ability of students to apply the proper algorithms, express the findings of the algorithms in the context of the problem, and connect an algorithmic process with a specific problem situation is a common indicator of procedural knowledge (Sudarmani et al.,2018). Science process skills are closely related to procedural knowledge, which helps students perform better in lab activities. Another essential objective of physics education is to turn physics concepts can be studied and understood with the use of abilities related to science processes.

These abilities are necessary for everyone in society, not just scientists, to be literate in science (physics) and to address problems that arise in daily life (Aktamiş & Yenice, 2010). College students are expected to become familiar with the laws of motion, waves, sound, and light as part of their coursework to be prepared for real-world physics challenges. The accuracy of the solution to an issue can gauge the fluency of procedural knowledge. The study assesses the preservice physics instructors' comprehension of several procedures and their perception by using effective criteria for gaining procedural knowledge using indicators of good performance of problem-solving in laws of motion. Conceptual knowledge leads to understand procedural knowledge (Hurrell, 2021; Vamvakoussi et al.,2019).

In a review of related literature Ting et al. (2019) describe how the development of procedural knowledge in the laws of motion can be facilitated through the use of instructional strategies such as active learning methods, problem-based learning, and interactive simulations. These strategies provide students with opportunities to apply the principles of the laws of motion to real-world problems and to receive immediate feedback on their performance. This allows students to develop a deeper understanding of the principles of the laws of motion and to gain the procedural knowledge necessary for solving more complex problems. Procedure knowledge includes what to do, how to do it, how to accomplish it, how to use abilities algorism, techniques, and sequences used in solving the problem. In this study, the researcher focused on preservice physics teachers’ procedural knowledge of laws of motion using open-ended problems which were adapted from the Force Concept Inventory Test (Luangrath et al., 2011).

Overall, the development of procedural knowledge in the laws of motion is an essential component of physics education. By providing students with opportunities to apply the principles of the laws of motion in a variety of contexts, educators can help students develop the problem-solving skills and procedural knowledge necessary for success in physics and many other fields. The written response of the preservice physics teacher for the open-ended problem of the motion of laws was measured using the following indicators, dimensions, or classifications as identifying and comprehending the issue, Composing significant rules and concepts of physics, The accuracy of a solution taken from the Minnesota Assessment of Problem-solving Rubric (MAPSR) is shown below in Table 2.2, Table 2.3, and Table 2.4.

Table 2.2. The elements of knowledge of procedures are utilized as standards for assessing the performance quality of PSPT in MPK diagnostic tests

Determining and knowing the problem	5	They are completely committed and have a thorough understanding of the problem..
	4	They acknowledge and understand certain issues.
	3	They recognize the problem but don't fully grasp it.
	2	The level of determination and understanding of the problem is incorrect.
	1	It is not acknowledged or accepted.
	0	No response is provided

Table 2.3 PSPT level of Test of knowledge of procedure performance, modified from the MAPS Rubric for each dimension

Metrics(measurements)	Evaluating procedural knowledge exam quality using criteria derived from MAPS Rubric					
identifying and comprehending the issue	0	1	2	3	4	5
Formulating significant rules and concepts	0	1	2	3	4	5
The solution's correctness	0	1	2	3	4	5

Table 2.4. Showed the relation among level and Quality performance, and furthermore, the Likert scale was modified from (Malik et al., 2020).

Percentage of performance attained	Performance caliber	Rate level on the Likert scale
$80\% \leq X \leq 100$	V.good	5
$60\% \leq X < 80\%$	Good	4
$40\% \leq X < 60\%$	Acceptable	3
$20\% \leq X < 40\%$	Poor	2
$0 \leq X < 20\%$,	V.poor	1

2.7 Problem-solving skill

Finding solutions to problems is known as problem-solving skills. It is one of the competencies of a present-day skill. To be competent, students should fill in the requirements, including teaching, problem identification, problem-solving skills, and problem-solving strategies, which are recommended topics in mechanics (Ince, 2018). One of the objectives of learning physics at a college is to solve problems they face. It comprises the capacity to recognize the issue, understand problems, plan to solve the problems, execute the problem, design mathematical models, solve models, and then explain the results you've found (Lestari et al., 2018) . Mathematical abilities to solve problems can be enhanced by applying the Polya concepts of learning while employing a model. Daulay & Ruhaimah (2019) argued that the Polya learning theory can raise problem-solving skills.

Applying their capacity for problem-solving in science, especially in motion based on scientific techniques, students may have the opportunity to employ their subject-matter knowledge in physics. According to Jawhara (2005) exercises that include addressing problems might give learners the chance to learn at their own pace. In their way, investigation, seeking the truth, developing ideas, and problem-solving are all encouraged in the classroom. Suh (2007) concluded that an increase in the levels of cognitive demand, scientific complexity, and abstraction balances students’ procedural fluency in problem-solving and is based on their ability to use intellectual knowledge and skills in interpreting the problem.

Problem-solving is defined as a method of investigation of learning that bridges the gap between a learner’s existing knowledge and Here, problem-solving will draw heavily on the previous or existing knowledge of the learner, which they must bring to bear on the situation at hand. Additionally, according to Mercer (2013) identifying and solving issues is a goal-directed cognitive learning process that makes use of previously learned information and methods that use cognition. Problem-solving is considered a process with numerous components that is useful for our everyday life experiences. It is also decisive to the Science, Technology, Engineering, and Mathematics (STEM) teaching and learning processes (Docktor & Adrian, 2022) . Mostly trying to succeed, teach, and evaluate college students in learning the contents of mechanics, teachers who teach physics are usually observed while exploiting problem-solving techniques. This asserts the value of problem-solving for physics teaching and learning processes (Gerace & Beatty, 2005) . Following McCormick (1997) their conceptual comprehension and procedures are used to solve technical problems. Process skills are referred to as the knowledge of procedures that are used in solving problems, while knowledge of the concept, in contrast, refers to the expertise, abilities, and resources that are essential for solving problems.

The process of problem-solving takes place when learners want to determine a situation for which they do not know a definite set of procedures to pursue to reach a solution (Foshay & Kirkley, 2003) . Yet, researchers and teachers require more information about the processes of solving problems to make their learners efficient problem solvers (Tok et al., 2014). Thus, efforts should be made to improve PSS through education, as it is a cognitive activity (Renkl, A., & Atkinson, 2016). Hailing the skills of solving problems enables us to give solutions to the problems that need to be faced in all parts of life in addition to those found in academic life . To prop up the enhancement of the ability to solve problems and demonstrate the difference between novice and expert problem-solvers in a classroom setting, it is essential to have the capacity to solve problems (Evan et al., 2016). According to F. Reif & Heller (1982) the major difference among them was in learners' usage and organization of knowledge in their efforts to solve problems.

According to Sezgin et al (2008) those who use the strategies of problem-solving properly and knowingly are expert problem solvers, while those who cannot explore them effectively are novice problem solvers. Thus, novices rush into finding the final answer to aid in understanding the idea of the problem, while experts make use of more qualitative reasoning and arguments in greater detail before using arithmetical formulas (Walsh et al., 2007). Physicists systematize their knowledge in an incredibly organized manner, and hence they can appeal to this know-how every time, even in the sequence that it is wanted. Conversely, novice physics learners fail to organize knowledge in such a manner. This is because their understanding consists of random information and equations having little meaning in concepts (Rosengrant et al., 2009).

There has been extensive research on the distinction between problem solvers who are specialists and those who are learners. This was done with a focus on categorizing the distinction between trainees and specialists in an attempt to find out how learners turn out to be more “experts’ in the procedures they follow while solving problems (Gerace & Beatty, 2005; Mcdernet, 2014; Reif & Heller, 1982; van Riesen et al., 2022) . Nevertheless, beginner physics learners seldom realize this ripper-level expertise in problem-solving. Lily only stands to construct a logical stricture of knowledge that they support them to access and use correctly when solving problems (Sabella, M., & Redish, 2007; Sabella, 1999). Unlike expert physicists, students do not have a coherent knowledge structure for solving problems in physics. Numerous academic works explore this distinction between professionals and beginners under the headings of information consumption and knowledge structuring (Morphew et al., 2020).

An academic review carried out by Mestre on problem-solving with an emphasis on the cognitive facets of learning demonstrated that skillful problem-solving is the product of a momentous, appropriately cross-referenced, and hierarchically structured knowledge base in addition to the qualitative reasoning rooted in conceptual knowledge. To underline the function of conceptual knowledge in problem-solving, learners need to be encouraged to incorporate a qualitative strategy during problem-solving (Gerace, 2016) . Along with other authors, Dufresne et al(2016) , Mestre et al (2009) , and Park (2020),. Morphew et al (2020) and Mualem & Eylon (2007) urge a reform that emphasizes solving problems in education and supports qualitative reasoning.

In the words of Cheng et al (2018) many different techniques range in complexity from low to high. For instance, in previous studies to solve problems, Carson (2007) emphasized the following five phases: These include the perceived level of problem complexity, the problem's location, its definition, suggestions for potential solutions, and the creation of a proposed solution based on observations and experimental test results. Rohma (2018) anticipated a simplified representation of coherent processes of problem-solving that incorporated the steps of constructing a problem representation, probing for solutions, and putting the solution into practice. Afterward, Javier (2019) explained the process of ill-structured problem-solving as illustrating the problem, developing possible solutions, providing explanations for generated or selected solutions, and controlling and evaluating.

A typical model for solving problems that was developed by Deek et al (1999) consists of the following six steps: problem formulation, planning, designing, interpreting, testing, and solution delivery. The predetermined steps of the issue-solving cycle were enumerated on the other side by Mukrimaa et al (2016), and they are as follows: defining the problem, recognizing the problem, developing a strategy, organizing the information, allocating the resources, monitoring, and assessing. The conceptual framework created by Shahat et al (2013) for the steps involved in identifying and solving issues in mechanics had eight phases. These phases are identification and the problem's formulation, triggering prior know-how associated with the problem, definition and representation of the problem, formulation of a predictable outcome, exploration of a probable means of tackling the problem, doing a preferred solution process, setting up data and scheming, looking back on the idea, and evaluating the obtained results (Czuk & Henderson, 2005; Saregar et al., 2019).

Conversely, after testing many dissimilar combinations of categories and marking many written solutions to a problem with different raters, Docktor et al (2016) identified the MA PS's five divisions as being the easiest and most reliable tool that can be implemented on a large scale.This rubric comprises a relevant definition, a physics approach, a particular application, mathematical procedures, and logical progression parts, and is hardened to evaluate learners' written solutions to a problem. The rubric ought to be utilized by instructors to guide their pedagogy (Jibril, 2021; Moore & Crouch, 2018).

In the rubric, according to Docktor et al (2016) useful description evaluates learners' process of information systematization (i.e., from a problem being identified to a suitable and valuable representation that encapsulates useful information through the use of symbols, diagrams, and writing). The physics approach evaluates a learner's process of choosing suitable concepts and principles of physics to be applied while solving the question. It is applied to reflect the expert-like process of picking important principles of physics that should be related to the situation under investigation before using them in the particular problem setting and proposing a solution.

The learners' progress is assessed by a specific application of physics, using the concepts and principles of physics to the exact circumstances of a problem. It frequently entails relating the objects, quantities, and constraints in a question via the definite relationships in physics. Specific application, thus, comprises a statement of description, qualitative relations among quantities, formulas, and given conditions, as well as a consideration of suppositions or constraints in the question. Mathematical procedure evaluates the learners' process of picking exact arithmetical procedures and pursuing rules of mathematics to find the required quantities.

In contrast, the learners' process of focusing on a target through signifying internal consistency is assessed under the category of logical progression. This category ensures whether the overall solution process goes forward consistently towards the goal that is intended to be achieved, where the backing for every step is obvious even if not necessarily stated clearly. The process may thus embrace modification, readdressing, or instinctive leaps (Docktor & Adrian, 2022). By considering this rubric as a method of teaching, Shishigu et al (2018) applied it to the treatment group learners after explaining it to them. As a result of the training, their study result showed a fruitful outcome on learners’ CU. Nonetheless, it is hard for learners to build up an understanding of the concepts of physics topics by only solving quantitative problems (Kim & Pak, 2002). So, it is hard to improve learners and the ensuing PSS by only using the problem-solving strategy rubrics as an intervention. Nevertheless, Argaw et al (2017) utilized the rubric by considering it a problem-based method of teaching. But, because the rubric is an instrument used for the assessment of PSS, it can be employed in learner-centered as well as teacher-centered classroom instructions, as it isn't a stand-alone teaching strategy.

In contrast, previous studies conducted by different researchers reported evidence of the improvement of learners’ PSS through the use of learner-centered methods (Argaw et al., 2017; Docktor & Adrian, 2022; Farrell & Heller, 2010). Among the learner-centered teaching methods that gained much prominence through different kinds of literature, the Jigsaw-4 method and problem-solving strategies are two of them. So far, the Jigsaw-4 technique's contribution to high school physics learners’ has been investigated by several research studies.

It is reported that the approaches are good at enhancing learners' achievement and conceptual understanding of physics (Isa, 2019; Özdemir & Arslan, 2016; Timayi et al., 2015) . Nevertheless, its effect on several other higher-order skills, like PSS, has not been investigated by many researchers (Eryilmaz, 2010; Panprueksa, 2012). As said by Eshetu and Assefa (2019) a lack of CU may weaken learners’ performance in procedural understanding tests. Moreover, according to many researchers (Crouch & Mazur, 2001; Kim & Pak, 2002; Mcdermott, 1980) . CU ought to be improved ahead of PSS. For that reason, understanding concepts as a consequence of J4PSS may bring about the formation of new procedures and PSS.Consequently, the impact of J4PSS on students' PSS in mechanics was investigated in the current study. To do this, the learners’ written solution to the workout PSS test had been marked through the use of the MAPS rubric. The five-category MAPS assessment rubric was used to evaluate the law of motion. Organizing the facts regarding the issue that needs to be separated Using the Minnesota problem-solving method, such as differentiating and illustrating a problem, choosing the appropriate physical laws and principles, adapting those laws to the specifics of a problem, using the appropriate math methods, and having a well-organized, goal-oriented logical progression that directs the process for solving issues are all necessary (Docktor, 2009a; Docktor & Adrian, 2022) .

Preservice teachers' average mean problem-solving skills were evaluated on five Likert scales, each having a maximum score of five and a minimum score of one. The prospective teachers' list's average mean problem-solving abilities were rated. Calculate the average of all the points or values for every written response to the five categories on the rubric. Next, the number of categories, divided by the rubric's numerical value, equaled the total score. For analytical purposes, the results for the mean average of the three items are thus multiplied by five (Erhardt, 2016).The ratio of the number of categories to the number of rubrics with a numerical value determined the final score. Thus, the results for the mean average scores of the test for each of the three components were obtained and converted to five only for analytical reasons, and they were shown in Tables 2-5, 2-6, and 2-7 (Vaamonde & Álvarez-Món, 2020).

Table 2 -5 the elements of problem-solving capability utilized for Evaluation criteria for preservice physics instructors' success on the PSKT (Problem-Solving Skill Test)

Distinguishing and describing the problem by graph	5 = They recognize the issue and are totally committed to solving it.
	4 = Understanding and identifying the problem
	3 = Not understanding the problem but recognizing it
	2 = The problem is not correctly determined or understood.
	1 = not recognized (N R)
	0 = No answer

Table 2.6. PSPT level or quality of performance on problem-solving skills tests adapted from the MAPS Rubric for each dimension

Dimensions (indicators) Evaluation guidelines for outstanding performance of PSPT on problem-solving skill test adapted from MAPS Rubric

Distinguishinga problem and graphically describing	0	1	2	3	4	5
Choosing appropriate physics laws and principles	0	1	2	3	4	5
Adapting physics laws to the specifics of a problem	0	1	2	3	4	5
Pursuing-appropriate-mathematical- procedures,	0	1	2	3	4	5
Goal-oriented-logical – progression	0	1	2	3	4	5

Table 2..7 showed the relation between the Level and Quality of performance, and the 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	V.good	5
60% $\leq$ X $<$ 80%	Good	4
40% $\leq$ X $<$60%	Acceptable	3
20% $\leq$ X $<$ 40%	Poor	2
0 $\leq$ X $<$ 20% ,	V.poor	1

2.8 Motivation in mechanics learning

Motivation is an important factor in success and growth in physics, as it encourages the prospective teacher to get interested in the subject. Several studies have assessed the variables that govern motivation in physics and have identified a range of factors that can impact student motivation, such as self-efficacy, interest, and relevance.The mechanics of instructional goals are an internal force, according to Sogunro (Sogunro, 2014) . Therefore, it is extremely important to raise the aspirations of per-service physics students. Any conceptual change model should unquestionably incorporate inspiration as a key factor when analyzing variables that influence the underlying conceptual change process. I argue that motivation is an expression of the autonomy of individuals in their determination to consider (or not consider) alternative explanations and form new conceptions.

There is a connection between incentives and conceptual change while learning science (Taasoobshirazi & Sinatra, 2011) . Those students who are highly driven can be quickly identified by the teacher since they produce work that demonstrates commitment and excitement. Similar to the uninspired learner, whose needs are not being met by life in the classroom. Even an uninspired student may participate actively in the learning process when activities in the classroom allow for the satisfaction of the student's requirements (Mubeen & Reid, 2014; White, 2016) .Motivational constructs are categorized as intrinsic motivation, extrinsic motivation, test anxiety, self-efficacy, self-determination, career motivation, and grade motivation. Based on the literature, intrinsic motivation fosters pupils' desire for new information, and understanding is a key component of teachers' educational strategies (Valerio, 2012). Examples of external motivators include recognition, which instructor awards, and the anticipation of receiving good grades (Mubeen & Reid, 2014) .

Indeed, Mubeen & Reid (2014) note that extrinsic motivation is often used not only in our educational institutions but also in our society in the form of prizes, awards, and honors. Nevertheless, extrinsic motivation and reinforcement can be criticized in that learners are not interested in the activity of learning for its own sake. Hung and Durcikova (2011) see intrinsic motivation as the inbuilt tendency to connect the interests of individuals to the development and use of their capacities. As a result, motivation will be intrinsic when learning is fulfilling and meaningful, when the learner believes what they have learned is valuable, when they have confidence and a purpose, and when there is all of this (Hung; & Durcikova:, 2011). In fact, intrinsic motivation could enable students to view their education as worthwhile and beneficial, regardless of how appealing the assignments are (Mubeen & Reid, 2014) .It is the responsibility of teachers to teach the material that the curriculum requires and to help their students pass the necessary exams. Due to the time-sensitive nature of an overloaded curriculum, teachers frequently have limited discretion over what they teach and even how they do so. However, Brophy (2004) and Mubeen & Reid (2014) emphasize the need to present the material in thoughtful and exciting ways to develop and stimulate motivation for learning. He acknowledges that the instructor will need to put in a lot of mental work and that the teacher's drive will ultimately determine this. Self-concept is related to how students regard their ability to move in a general manner (Abak, 2003) . Self-efficacy is defined as a person’s belief about his or her capabilities to produce designated levels of performance (Bandura, 1999; Özdemir & Arslan, 2016) .

Self-determination is one’s general assessment of his or her capability. In a general sense, student motivation is any intrinsic or extrinsic reward that influences performance (Abak, 2003).Anxiety is defined as a general uneasiness, a sense of foreboding, and a feeling of tension (Koballa, 2007). In this study, the researcher constructs a construct for motivating pupils to understand the concept of motion and assesses the academic performance of perspective. physics Teacher studies demonstrate that physics student effectiveness is a strong predictor of achievement and motivation in physics (Dou et al., 2016; Dou & Zwolak, 2019). Students who believe that they are capable of mastering physics concepts and solving problems are more likely to be motivated to engage with the subject matter and persist as a result of difficulties. Interest in physics is also a key factor in motivating students to learn and achieve in the subject. According to studies, physics-loving students are more likely to interact with the material and continue their studies in the subject (Bircan, 2015) . Teachers can help foster student interest in physics by making the subject matter relevant and engaging and by providing opportunities for hands-on exploration and discovery.

Research has demonstrated that students are more driven when they can see the relevance of physics concepts and skills to their own lives and future goals (Maltese, & Tai, 2015) . Teachers can help to promote this sense of the relevance of physics by providing opportunities for students to apply their knowledge and make good use of their abilities. Overall, this research indicates that inspired behavior is an important factor in physics learning and accomplishment, and teachers can help promote student motivation by fostering self-efficacy, interest, and relevance in the subject matter.

2.9 Perception in learning laws of motion

Munhall (2008) asserts that perceptions serve as a tool for understanding both experience and fact, which makes it possible to distinguish between form, figure, language, behavior, and action. Perception is frequently described as a perspective. An individual's perception of something reveals how they feel about it or what impression they have of it. Munhall (2008) contends that a collection of lenses through which people perceive the world can be used to explain perception. The human can recognize the sensory data from their surroundings and use it to meaningfully interact with their environment.

The individual student’s opinion depends on their perception, their understanding of the meaning of an experience, their judgment, and their ways of responding to a situation. Moreover, how something is perceived depends on the circumstances surrounding its experience. Perceptions vary, and different people have different perceptions about the same object or situation Astrat (2019) but an individual’s perceptions can be understood through their interpretations and behaviors. As opposed to that, Jiao (2004) suggested that because thought drives conduct, understanding teachers' views will help us better understand instructors' behaviors in classrooms and provide a guide for improving teachers’ practices and preservice teacher preparation.

Aydin & Biyikli (2017) conducted a study in which they looked at graduate students' prior quantum mechanical expertise. The findings demonstrate that students frequently misunderstand and have difficulty comprehending fundamental concepts in quantum physics, such as superposition and entanglement. Similarly to this, Alkiş-Küçükaydin and Uluçinar Sağir (2016) showed how inquiry-based learning affects the growth of physics teachers' pedagogical content knowledge. The study's conclusions showed that implementing inquiry-based education has an advantageous result for instructors' opinions of the approach's effectiveness as well as their ability to design inquiry-based courses. The association between students' physics identities and their performance in basic physics courses was also explored by Holmes et al (2022). According to the research, physics-identified students do better in their classes and are more likely to stick with the subject. Since preservice physics instructors' perceptions encompass their ideas, identities, attitudes, and knowledge of physics and physics education.

According to studies, preservice physics instructors frequently join teacher education programs with a solid understanding of the subject matter, but they may not have the pedagogical topic knowledge required for efficient instruction. It may be difficult for physics professors in training to communicate knowledge to students if they have prejudices and misconceptions about particular physics topics. They may have made these errors because of how physics has been portrayed in popular culture or because of their own prior educational experiences. Additionally, prospective physics teachers could have a negative opinion of teaching physics and believe that it is challenging or dull. As a result, they might not be eager to join physics classes, and they may even be discouraged from pursuing a career in the field.Studies have shown that preservice physics teachers often enter teacher education programs with strong physics content knowledge but may lack the pedagogical content knowledge necessary for effective teaching.

Preservice physics teachers could also have misconceptions and biases regarding specific physics topics, which can make it challenging for them to impart knowledge to pupils. These mistakes could be the product of their own prior educational experiences or popular cultural portrayals of physics. Additionally, preservice physics instructors could have a bad impression of teaching physics, thinking that it is difficult or boring. Due to this, they might not be motivated to attend physics lectures, and they might even be dissuaded from pursuing a career in the subject.According to Handhika et al (2016) perception has a substantial impact on how people learn physics. The fundamental unit of knowledge is perception. Hence, if the perception is not correct, the acquired information will also not be correct (Mukrimaa et al., 2016). According to Cheung and Slavin (2011) perception is the method through which the mind processes data after it has been taken in by our experiences and mental states. The process through which pupils build perception involves building a cognitive understanding (perception) of a stimulus. What a learner perceives influences their cognitive processes and underlying notions (Ellingsen & Engle, 2020)

The way that students perceive things changes depending on the information they get and how they process it. The perception of the students is crucial to science; it can lead to misconceptions. When exposed to sources of inconsistent presentation, students may have various notions of how information is processed. The conception and students' perceptions of Newton's laws are crucial, as can be inferred from the aforementioned explanation. Perception is more fundamental than conception since it serves as a major source of knowledge about the world, while conceptions are dependent on data from experience (Bueno, 2013) . An illustration of a student's perception of their learning is provided by Handhika et al (Handhika et al., 2016) . The laws of inertia state that there is a force acting on a stable object, and the resultant force on the object working on it is zero. But the students perceive that Newton's first law gives the information that ∑_F=.0, meaning the object experiences no force acting on it. As a result, they interpret legal concepts incorrectly.

Newton's second law is defined as the net force being zero if the velocity is uniform. They realized that $F=m$ can equal zero if $m=0$, $a=0$, or both from the mathematical formulation of the law of dynamics. The student's understanding of the laws of motion was erroneous on account of the visual data and symbol that emerged, which showed how the force is also affected by speed and direction. Two things illustrated motion's third law. When two forces are acting on an item, they believe the laws of motion apply. They had the wrong idea about the third rule of motion.

In general, preservice physics teachers' perceptions are key in laying the groundwork for students to understand the ideas of laws of motion. But it also determines the motivation of the preservice physics teacher to learn facts, concepts, procedural knowledge, and problem-solving skills in laws of motion (Samosir & Gurning, 2020). .Information about the perception of a learner in Laws of Motion was explored using interview questions adapted from the Force Concept Inventory test (Hestenes et al., 1992).To investigate how college students perceive the ideas of laws of motion, data from an interview with a preservice physics teacher was examined using a deductive coding technique (Soiferman, 2010). To codify the interviewee's response, it was decided to use the fundamental attribution of the subtopic of laws of motion based on the ontological and epistemological commitment to normative force concepts connected with major themes. In this regard, the attribute described in Table 2.8 illustrates the various features used for classifying students' responses to a specific interview. Table 2.8 can be taken as the epistemological and logical commitment of the concepts of laws of motion, wherein the justification and reasoning (Khiari, 2011) .

Table 2.8.coding characterstics in subtopic of concepts of laws of motion

No	Laws/ Categories	Attributes/Characteristics
1	Conceptualizing concepts of the force	Conceptualizing laws of motion in our day-to-day activity: Laws of inertia ,Newton second laws ,Action-reaction laws of motion
2	Advantage of frictional force	Movement of something ,transform the objects' shapes ,deformation ,heat creation
3	Laws of Inertia	The intrinsic property of an object that always strives to oppose a change of state is revealed by inertia. Therefore, from an inertial perspective, rest and constant velocity motion in a smooth straight line are identical
4	third law of motion	A model for the relation of the cause of force, action, and reaction response
5	Nature of frictional force	Smooth surface and Rough surface

Poor instruction and uninterested students could be the outcome of preservice physics teachers frequently lack experience with inquiry-based learning and other student-centered teaching strategies, which causes them to opt for more conventional lecture-based teaching strategies.One of the issues that teacher education programs can address is the development of preservice physics teachers' pedagogical topic understanding.Other concerns include clearing up preservice instructors' misunderstandings and different perspectives and advocating for student-centered teaching techniques. Additionally, steps can be taken to promote optimistic viewpoints on teaching physics and to provide preservice physics instructors with opportunities to engage with the greater physics education community In general, preservice physics instructors' perspectives are a key area for study and application since they have a big impact on the quality of physics instruction provided to future student generations.

2.10 Research Gap

Numerous studies have shown that the traditional approach is the most common teaching strategy used in physics classrooms at all grade levels in general and at the college level in particular. Fortunately, this approach falls short of aiding students in comprehending concepts (Negassa, 2014; Noel et al., 2015) . Educational researchers from all around the world have tried to intervene by utilizing various active learning strategies to address pupils' lack of conceptual comprehension and problem-solving abilities.To remedy students' inadequate comprehension of physics topics and their inability to solve issues that call for the ability to problem-solve, educational researchers frequently use problem-solving techniques and jigsaw-4 teaching methods as intervention strategies (Iliyasu et al., 2022; Montalbano & Benedetti, 2013) .

The Jigsaw-4 technique is a group learning strategy that involves dividing students into small groups, assigning each group a specific topic to research and present to the class, and then reorganizing the groups to share information and develop a more comprehensive understanding of the material. According to studies by Akkus and Doymus (2022) and Kallio et al.(2016) students have been proven to increase student achievement, motivation, and engagement. The effectiveness of Jigsaw-4 teaching methods has been studied by a large number of academics worldwide(Dincer et al., 2013; Yimer & Feza, 2019) .They asserted that Jigsaw-4 teaching techniques improved students' intellectual knowledge while offering chances for social interaction. Positive dependency is produced by the contact. Although it has a relative advantage in improving students' motivation and conceptual understanding, it fails to create individual rivalry and limits people's capacity for problem-solving on their own (Aydin & Biyikli, 2017; Huang et al., 2014).

On the other hand, a problem-solving approach entails the identification of a problem, the creation of an action plan, the execution of the plan, and the evaluation of the outcomes. Without the help of others, this approach inspires students to think critically and creatively and to solve problems personally. Various studies have shown that problem-solving strategies may enhance students' academic performance in a variety of subject areas, including mathematics, science, and language arts (Knopik & Oszwa, 2021; Loria Jr., 2014). Problem-solving approaches have been shown to improve learners' problem-solving skills by researchers who have studied their effects (Esan, 2015; Selçuk et al., 2008) .However, this approach ignores social interaction and a shared goal in favor of an individualized approach and individual competition that disregards learning from one another, which results in good conceptual understanding (Aydin & Biyikli, 2017; Gemeda & Tynjälä, 2015; Huang et al., 2014; Ince, 2018; Mann & Tan, 2021; Mohammad & Hamadneh, 2017; Shakerian et al., 2020).

This study identifies 10 gaps between the strategy of problem-solving and the Jigsaw-4 method from the literature review that need to be filled to improve physics education.

1. **Individual Thinking**: Jigsaw-4 frequently overlooks the value of individual thinking in problem-solving in favor of collaborative learning. Building problem-solving abilities requires individual reflection and critical thinking (Mystakidis, 2021). According to County & Makini (2020) Jigsaw-4 techniques of learning often place a greater emphasis on group accountability, whereas problem-solving techniques often place more of a focus on individual responsibility. For example, Habtamu et al (2022) found that while students in a cooperative learning group were not individually held responsible for finishing the physics lab report, those in a problem-solving approach group were expected to complete their lab reports.

2. **Sequential Problem Solving**: Jigsaw-4 places a strong emphasis on breaking large problems down into manageable chunks for group discussions. The sequential problem-solving method, in which students learn to dissect an issue step by step to find a solution, may be hampered by this strategy (Ohlsson, 2012) . Techniques for solving issues often emphasize the material being studied and concentrate on finding answers to physics-related puzzles. Contrarily, cooperative learning typically focuses on the learning process itself, highlighting how students interact with and comprehend physics concepts. While Fu and Hwang (2018) discovered that students in a cooperative learning group concentrated on the technique of learning physics subjects, Sabah and Du (2018) revealed that problem-solving strategies frequently prioritize the content being learned.
3. **Conceptual Understanding:** Jigsaw-4 encourages knowledge exchange, but it could not place enough emphasis on conceptual understanding growth. Physics problem-solving needs a solid conceptual knowledge base, which may be disregarded in a purely collaborative learning environment (Heller & Heller, 2010). Jigsaw-4's learning techniques are less successful than problem-solving techniques in generating a thorough understanding of physics concepts. As shown in the study by Baring et al (2022) and Hand et al(2021) found that problem-solving techniques were more effective in fostering a full comprehension of the physics idea of the relationship between force and motion as opposed to Jigsaw-4's techniques of learning.
4. **Metacognitive Skills**: Problem-solving calls for metacognitive abilities including self-awareness, planning, and strategy evaluation. The Jigsaw-4 framework may not explicitly promote these abilities, even though they are essential for pupils to become autonomous problem solvers (Mogashoa, 2022).

5. **Transferability:** Jigsaw-4 focuses on finding solutions to particular issues in a group context. However, problem-solving abilities have to be adaptable to many events and contexts. Jigsaw-4's limited exposure to a variety of problem-solving scenarios could make it harder to transfer skills (Chaudhari et al., 2021) .

6. **Time management**. Jigsaw frequently necessitates a large amount of time for group discussions and information exchange. This emphasis on teamwork could make it harder for pupils to practice solving problems alone, which is crucial for skill development. Comparing cooperative learning to conventional problem-solving methods may result in a longer learning period. As seen in the study by Lodge et al (2018) and Appiah-Twumasi et al.(2020) indicated that cooperative learning groups may spend more time on physics lab activities than problem-solving method groups.

7. **Analysis of Errors**: Correct problem-solving entails examining errors and taking lessons from them. Jigsaw-4's collaborative character, however, could not provide pupils enough chances to critically evaluate their errors and improve their problem-solving techniques .

8. **Scaffolding:** Students gradually develop their abilities via supervised practice, which is sometimes necessary for problem-solving. The collaborative style of Jigsaw-4 may not offer sufficient scaffolding for children who require extra assistance with problem-solving. In Mogashoa (2022) the teacher's position varies between the two methods. According to Adu-Gyamfi (2014), problem-solving techniques frequently feature a more focused teaching style in which the teacher gives students clear guidelines and directions. Contrarily, Jigsaw-4 usually necessitates a facilitative teaching role, where the teacher serves as a mentor and a source of support. According to Ellerani & Gentile (2013) the teacher acted as a facilitator

in a problem-solving method group but provided more detailed instructions and guidance in a Jigsaw-4 Techniques of Learning group.

9. **Assessment**: Jigsaw-4's assessment techniques mainly emphasize cooperative learning and group performance. Individual problem-solving abilities, however, might not be properly evaluated within this paradigm. Both problem-solving and evaluation strategies must be in place for the assessment of students' growth (Pagander & Read, 2014). Students are commonly given individual grades based on their ability to solve problems while applying problem-solving techniques. Jigsaw-4's techniques of learning, on the other hand, frequently employ group assessment approaches in which the entire group is evaluated collectively. Jigsaw-4's technique of learning frequently incorporates group assessment (Azmin, 2016).

10. **Motivational diffirence.** Safkolam et al (2023) found that Jigsaw-4's learning techniques had a greater impact on students' motivation than problem-solving strategies. Students in the Jigsaw-4 technique learning group had a greater willingness to study physics than those in the problem-solving technique group (Akkus & Doymus, 2022).

In conclusion, the study has highlighted the gap between jigsaw-4 techniques of teaching and problem-solving techniques of learning instruction in physics. There are many areas where there are differences, including individual vs. group responsibility, the teacher's role, group size, an emphasis on content rather than procedure, evaluation techniques, student motivation, understanding of physics principles, time management, and student engagement. Understanding these differences can help instructors choose the appropriate teaching strategies based on the needs of their students and their learning objectives. It is critical to consider the particular situation, learning objectives, and expected outcomes when choosing between problem-solving techniques and cooperative learning in the context of physics teaching.

In the field of education, it is crucial to combine the Jigsaw-4 teaching methods with a problem-solving approach. This combination can enhance student learning outcomes, foster cooperation and critical thinking skills, promote deeper conceptual understanding, and create a welcoming and encouraging learning atmosphere. The benefits of integrating these two instructional methodologies have been highlighted in several studies. The Jigsaw-4 technique, created by Turkmen and Buyukaltay (2015) is a cooperative learning system that includes breaking up students into smaller groups to focus on specific tasks or knowledge pieces. Each member of the group develops into an expert on the subject assigned to them, and they then share their knowledge with the other members of the group to build a full understanding of the subject.

Students' active participation, cooperation, and interdependence are encouraged by this approach. The solution-focused approach, on the other hand, places a strong emphasis on pairing students with everyday life projects that challenge them to solve problems and use their knowledge and abilities in a variety of circumstances. This approach promotes the development of metacognitive capacities, critical thinking, and problem-solving abilities. Students are expected to research topics, weigh many possibilities, and make informed decisions.

There are several benefits to combining these two approaches. First of all, integrating Jigsaw-4 techniques with problem-solving techniques promotes group learning. Students work together to solve problems in their Jigsaw-4 groups while simultaneously exchanging skills and information. Each group member contributes to communication, interpersonal skills, and teamwork to solve the problem and get a general understanding of the topic. Additionally, the ability to think critically is improved by combining these techniques. Students can study content, assess opposing points of view, and synthesize information through in-depth discussions in Jigsaw-4 groups. They apply critical thinking abilities to solve complex problems by considering many elements and experimenting with various solutions. Through this integration, teachers may assist kids in developing skills like the ability to combine dissimilar ideas and exercise critical thought.

Furthermore, combining the problem-solving approach with Jigsaw-4 strategies encourages better conceptual comprehension. By diving thoroughly into the content, conducting in-depth research, and completely grasping it, students using the Jigsaw-4 technique may become experts on a particular subject. To better understand the content, students apply their knowledge in pertinent ways to real-world circumstances. The depth and significance of learning may rise with incorporation. Together, these strategies foster a welcoming and inclusive learning environment. When students cooperate and share information using the Jigsaw-4 technique, these principles are emphasized. By doing this, the group members are encouraged to participate actively and to feel a sense of community.

The problem-solving strategy promotes a comparable student-centered approach where each student's ideas and efforts are valued. Teachers may use these techniques to create a welcoming classroom environment that encourages good social interactions and gives every student a feeling of ownership. Several studies have shown how effective it is to employ Jigsaw-4 techniques in conjunction with the problem-solving approach. For instance, similar techniques were used by Ting et al (2019) in a study they conducted in a science classroom. They found that, as compared to youngsters who received traditional instruction, those exposed to the mixed technique showed much better improvements in their ability to solve problems, engage in critical thought, and comprehend a variety of topics. Similar to this, research by Mogashoa (2022) found that Jigsaw-4 and other collaborative instruction techniques, as well as problem-solving exercises, increased student engagement and student performance in school.

To sum up, integrating the problem-solving strategy with Jigsaw-4 teaching approaches provides various benefits in the educational context. By combining these methods, educators may foster more collaborative learning, strengthen students' critical thinking skills, foster a deeper understanding of subject matter, and create an inclusive and encouraging learning environment. Teachers may create engaging classes that motivate students to participate actively in their learning and find solutions by combining these two components.

Combining problem-solving strategies with Jigsaw-4 teaching techniques in physics education offers several benefits. By integrating these approaches, students are encouraged to think independently, engage in both individual and collaborative problem-solving, and get a more profound conceptual grasp of the fundamentals of physics. The use of problem-solving strategies also promotes the development of metacognitive skills, enhances the transferability of problem-solving skills to real-life situations, and allows for error analysis and feedback.

Additionally, this combination supports effective time management, provides scaffolding and guidance for students, enables individual assessment, and enhances student motivation. Overall, integrating problem-solving strategies with Jigsaw-4 techniques offers a comprehensive and effective approach to physics learning that fosters critical thinking, cooperation, and a deeper understanding of physics principles. This study will fill the gap in research by using blended instruction of Jigsaw-4 problem-solving strategies. The learner interaction in a group leads to the promotion of the following theories: the theory of sociocultural development of learning, the social interdependence theory, the cognitive developmental theory, and the motivational theory from different points of view.

2.11 The theoretical perspective that guides the current study

The effectiveness of instructional practice should be based on solid theoretical foundations and scientific support. There are four theoretical perspectives underlying and guiding research on Jigsaw-4 problem-solving strategies: sociocultural theory, social interdependence theory, cognitive developmental theory, and motivational theory. These four theoretical roots provide insight into why students in Jigsaw 4: Problem-solving strategies learn more effectively and happily than those exposed to traditional.

Sociocultur al Theory: Lev Vygotsky's sociocultural theory places a strong emphasis on the contribution that social interactions and cultural background make to cognitive development (Blake & Pope, 2008). This hypothesis claims that social interactions and cooperative learning activities promote learning. Sociocultural theory indicates that the Jigsaw-4 technique may support the construction of knowledge and a richer conceptual understanding via cooperative problem-solving, in which students pool their knowledge and work together to solve challenges. Instructors must change to become facilitators rather than teachers, in accordance with the sociocultural theory of learning approach (Bransford et al., 2004). Unlike a teacher who only imparts knowledge via lectures, an instructor helps the student understand the content.

.According to Adom et al. (2016), students participate actively in the teacher-centered scenario while taking on a passive role in the former.The Jigsaw-4 cooperative group work approach is a component of educational sociocultural theory, which recognizes that learning is a social process and promotes the acquisition of knowledge through the process of facts, concepts, problem-solving skills, inspiration, dedication, and perception (Isa, 2019).

According to David and Roger Johnson's social interdependence theory, cooperative learning is crucial for both individual and collective results (Choi et al., 2011; Johnson & Johnson, 2009). This is consistent with the Jigsaw-4 problem-solving method, which depends on group members' interdependence. Emotional traits like drive and self-efficacy as well as intellectual understanding may be enhanced via collaboration. The cooperation and competition theory of Tjosvold as well as Gestalt psychology have an impact on the theory. Goal frameworks may be classified as cooperative, competitive, or individualistic (Johnson & Johnson, 2009). Negative interdependence is linked to hostile relationships and competitive circumstances, and positive interdependence is linked to good interactions. The goal of educational collaboration is to highlight the importance of group members communicating and cooperating to achieve common goals. Since 1898, cooperative learning has been researched extensively, and the results suggest that it is superior to other learning modalities in terms of general well-being and enhanced learning outcomes. Fostering cooperative, communicative, and collaborative learning is the goal of the Johnson Approach, which promotes positive interdependence among students.

Cognitive Developmental Theory is mainly based on Blake & Pope (2008). Both sociocultural theory and cognitive developmental theory stress the significance of peer interaction and the value of social context for generating cognitive development and effective learning. Likewise, sociocultural theory, developed by Lev Vygotsky, emphasizes the role of social interaction and collaborative learning in cognitive development.The idea contends that social interaction facilitates learning and that information is produced through social mediation. In other words, learners acquire knowledge and skills through interactions with more knowledgeable others, who provide guidance, feedback, and support.

Similarly, cognitive developmental theory, developed by Jean Piaget, emphasizes that individuals actively construct their understanding of the world through their own experiences and environmental interactions. Piaget believed that social-cognitive conflicts during social interaction create cognitive disequilibrium, which stimulates perspective-taking ability and cognitive development(Blake & Pope, 2008). Thus, both sociocultural theory and cognitive developmental theory recognize the significance of interaction with others and peer collaboration in cognitive development and effective learning. They suggest that learners can benefit from interactions with more experienced people, whether they are experienced or diverse, as these interactions can stimulate cognitive growth and enhance learning outcomes.

It is argued that during jigsaw-4 problem-solving strategy efforts, participants engage in discussions where cognitive conflicts occur and are resolved, and inadequate reasoning is exposed and improved. From Piaget‘s perspective, socially arbitrary knowledge, such as language, values, and morality, which are culture-specific, can only be acquired through social interaction with others (Maguchu, 2019) . Approaches to teaching mechanics that focus on social, cultural, and cognitive development argue that creating interactive learning environments where students actively participate in real-world scenarios is crucial. This can be achieved through cooperative learning and peer collaboration, where learners exchange information, provide support, and help each other improve. According to Vygotsky's sociocultural theory, knowledge is social, and learning is constructed through collaborative efforts. Therefore, building a classroom environment that fosters peer interaction and collaboration is essential for promoting effective learning in mechanics.

Learners can benefit from collaborating to resolve issues, engage in discussions, and provide feedback to each other. In summary, sociocultural and cognitive developmental perspectives suggest that creating interactive and collaborative classroom environments is essential for promoting effective learning in mechanics. Learners can benefit from working together, exchanging information, and providing support to each other, which can lead to better learning outcomes and overall success. Vygotsky’s theoretical construct of the area of nearby development (ZPD) is predicated on the premise that collaborative activities with adults or more capable peers will promote cognitive growth and less competent Very young children can gain from peer interaction and collaborative activities (Denhere et al., 2013) .

In addition to sociocultural and cognitive developmental theories, there are also controversial theories, cognitive elaborative theories, and cognitive restructuring theories that provide different perspectives on the function of relationships with others and cooperation in cognitive development and effective learning. Controversial theories, for example, posit that being confronted with opposing views and perspectives can create uncertainty and conceptual conflicts, which can lead to reconceptualization and cognitive development. According to Evans & Jeong (2023) this process of confronting and resolving controversies can result in learners developing a more sophisticated and deep comprehension of a topic. Conversely, elaborate theories propose that peer interaction and cooperation can lead to cognitive restructuring through processes such as receiving instructions from others, elaborating, or explaining.

According to Slavin (2018) the students who gain the most from these processes are typically more competent learners who are better able to provide elaborate explanations and tutoring. Cognitive restructuring theorists, meanwhile, argue that learners can only retain and integrate learning materials into existing cognitive structures through cognitively rehearsing and restructuring them. According to Sorden (2012) this process involves learners actively engaging with the material, organizing it in meaningful ways, and connecting it to existing knowledge structures. Overall, these controversial, elaborative, and restructuring theories provide different perspectives concerning peer interaction and cooperation in cognitive development and effective learning. While they may differ in their approach, they all understand the significance of social interaction and collaboration in promoting effective learning outcomes.

Motivational theorists assert that teachers are almost the only source of reinforcement for positive learning behaviors in the traditional teacher-centered classroom, where students tend to feel negatively interdependent and compete against each other for reinforcement from the teacher in such forms as praise and grades. In the jigsaw cooperative teaching strategy, students work together in small groups to complete a task or solve a problem. It is designed to promote positive interdependence among group members, where individuals feel that their success is based on the achievements of others in the group. The techniques for jigsaw puzzles involve dividing the class into small groups and assigning each group member a specific task or role.

Each team member develops their specialization in their assigned task or topic and then shares their knowledge with their group members. This information exchange fosters a feeling of interdependence and positive reinforcement among group members, as each member is reliant on the other members to complete the task successfully. Overall, the jigsaw method is a productive method for encouraging learning together that can foster relationships among students and enhance learning outcomes by creating a sense of mutual dependence and positive reinforcement among group members. Motivational perspectives focus on three elements: goal structures, reward structures, and group dynamics (Dörnyei & Muir, 2019). Cooperative goal structures are thought to create a condition where group members can only achieve their personal goals if the collective is successful (Robert E. Slavin, 2014) .

As a result, group members try to support one another while also putting in their best effort. The majority of the reward structure is focused on group rewards, which means that students are evaluated collectively based on their performance as a group or the total of their performances. Although group rewards are typically considered extrinsic motivators, building in external reasons for students to cooperate can lead to internal motivation to work in groups (Filippou et al., 2022). In other words, students who are constantly extrinsically motivated to learn in cooperative groups are likely to exhibit intrinsic motivation for learning, especially with their school (Dörnyei & Muir, 2019).

According to UNCTAD/TIR (2021) group dynamics, which are intimately linked to beneficial relationships and personal responsibility and are supportive of strong group cohesiveness, can be intentionally and methodically used to foster creativity and strength. In addition, researchers contend that some features of the Jigsaw-4 method involve teamwork, providing a means of promoting learners ‘intrinsic motivation (S et al., 2021) . These characteristics incorporate input from others and are based on standards assessment, the greater sense of control and ownership of students' continuous learning, as well as their satisfaction from aiding others and participating in collaborative efforts. There is a body of contrastive research that suggests that, in comparison with those in traditional classrooms, students in JTT groups are seldom absent from class; they feel that their classmates want them to learn and support each other, and consequently, they are motivated to try their best (Jacobs, 2004; OECD, 2010; Priyana, 2020; Slavin, 2018). They go on to say that real learning happens when people participate in social activities, and that learning is not just a process that happens within our heads or a passive growth of our behavior that is controlled by outside influences.

This is evident in Jigsaw Teaching Techniques (JTT), where there is social interaction with learners and teachers in the learning process in group work. JTT is one method for getting students from different backgrounds and ability levels to work together on assignments and discussions to settle on what is true in a subject. This suggests that a J4PSS is crucial for fostering social contact among learners so they may exchange ideas and practice. In a college mechanics course utilizing J4PSS, teaching and learning are guided using the TECMRER framework. Based on his extensive teaching experience, the researcher of this study developed the theoretical framework, using evidence from the difficulties with laws of motion topics, the student's learning capacity, and the low academic records that compelled him to find a new instructional design to deal with such difficulties.

2.12 TECMRER-Model

The above model has seven Processes; Thinking, Exploration, Choosing strategies and Discussion, Manipulation, Reflection, Evaluation, and Reteaching (TECMRER-Model) was adopted from Krulik and Rudnik heuristic strategies Istiandaru (2017), Minnesota problem-solving strategies Docktor and Heller (2022), and Turkmen & Buyukaltay (2015) Jigsaw-4 Techniques of teaching, all of them operated together as a blended instructional method for the lesson implementation in laws of motion. The following educational theories served as its foundation: sociocultural theory, social interdependence theory, cognitive-development theory, and motivational theory. The researcher arranged these theories methodically and deliberately to support the use of integrated Jigsaw -4 problem-solving procedures. A schematic of the TECMRER model is seen in Fig.2.1

As depicted in Fig. 2.1, it was based on the educational philosophies of sociocultural theory, social interdependence theory, cognitive-development theory, and motivational theory and organized by the researcher in a systematic and planned manner for the application of the blended instructional process of Jigsaw-4-problem-solving strategies in the instruction of college-level teachings. Thus, the activities in college instruction are arranged in such a way that encourages students to construct their meaning through their existing knowledge and their new experiences. The college lesson instruction in mechanics in this research integrates problem-solving strategies to improve student mastery of problem-solving knowledge and problem-solving skills in mechanics. Learners were given a problem-solving guide where they were instructed to apply the Jigsaw-4 techniques for tackling concerns after being introduced to the blended teaching approach. To assist them in solving the difficulties given to them, they offered an example of how techniques for problem-solving are employed in mechanical problem-solving based on an expert worksheet.

Students' comprehension of the facts, ideas, steps, and ability to solve problems in outcomes of mechanics, particularly in-laws of motion, was impacted and driven by the application of the blended instructional strategy of Jigsaw-4 methods and problem-solving through a college education. This showed that the blended instructional method for Jigsaw-4-problem-solving strategies integrated into college instruction is appropriately applied in the teaching-learning of mechanics. Students employed the following tactics to help and arrange problems in a systematic manner, which is a crucial stage in preparing beginners or novices for more complex problems that they will often meet in the actual world. In addition, it is unquestionably true that any creative techniques for teaching and learning in the current lecture-centric classroom setting are always welcomed in the training of future generations in both research and development. See Figure 2,2

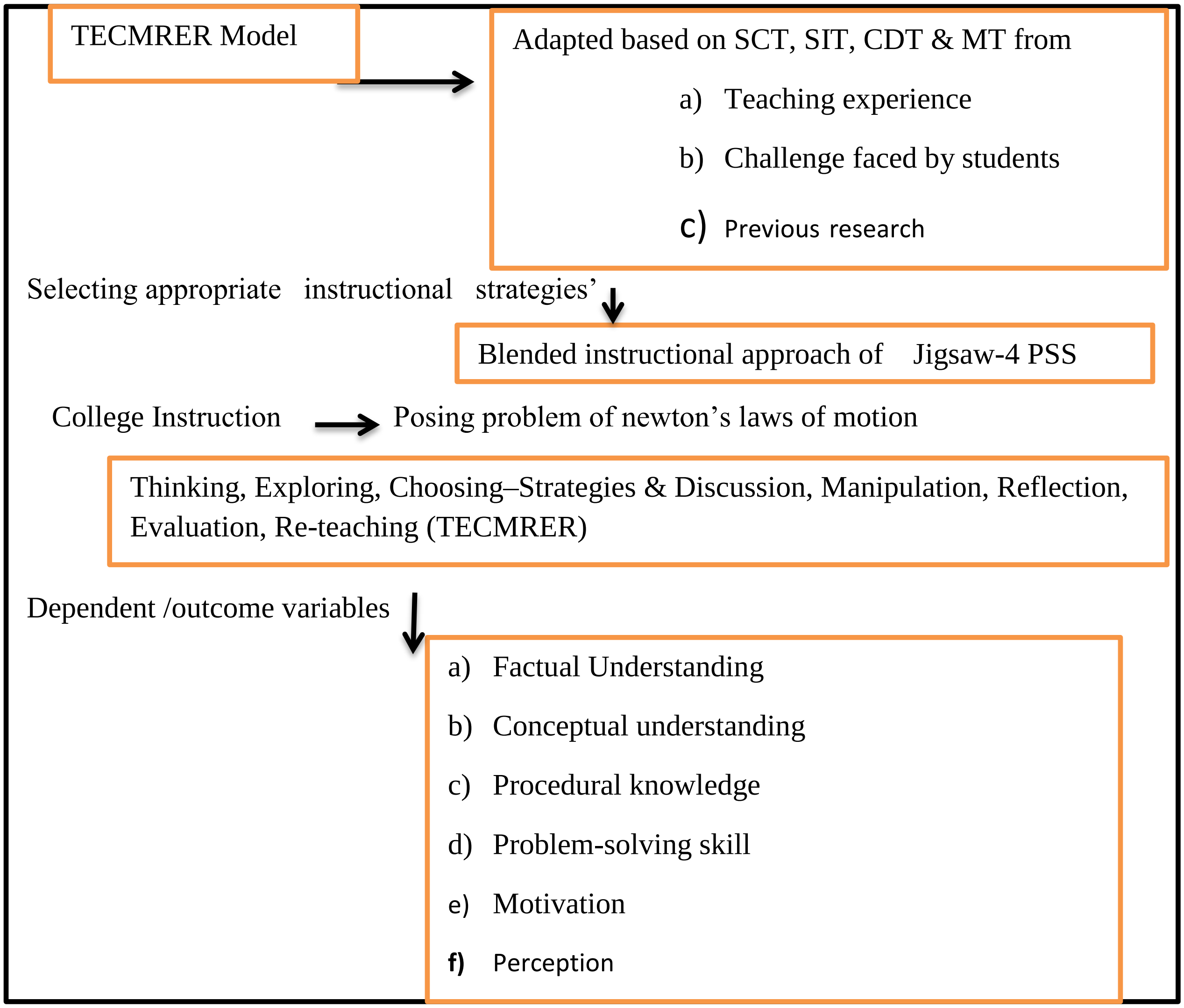


Figure 2. 1. Represented the arrangement of the TECMRER model

The five-step problem-solving ability technique proposed by Krulik and Rudnick Istiandaru (2017) is the basis for the problem-solving learning strategy that was employed in the construction of collegiate mechanics training. The TECMRER model's 7 steps are described in the sections that follow:

1. **Process of Thinking:** The student must read the question and identify what is required by the question, write what is given in the problem, and think about the next solution.

2. **The process of exploring** includes the student identifying and selecting, organizing information found in the problems, finding appropriate information required to solve the problem, and making an illustration model or drawing.

3. **Process of Choosing Strategies,** Plan, and Discussion: The stages that make up the solution should be prioritized by the students. The steps comprise the five stages listed below, which have been adapted from MPSS Docktor et al. (2016), and the five stages of the manipulation process from the University of Docktor, Ay, et al. (2016), an assessment of solving problems.

4. Process of Manipulation

    1. Distinguishing a problem and graphically describing it organizing information from the problem statement symbolically, visually, and in writing.

    2. Drawing significant physics laws and principles can help with problem-solving and choosing the right physics ideas and principles.

    3. Applying specific laws and principles to solve a specific problem of physics—applying the physics approach to the specific conditions in the problem.

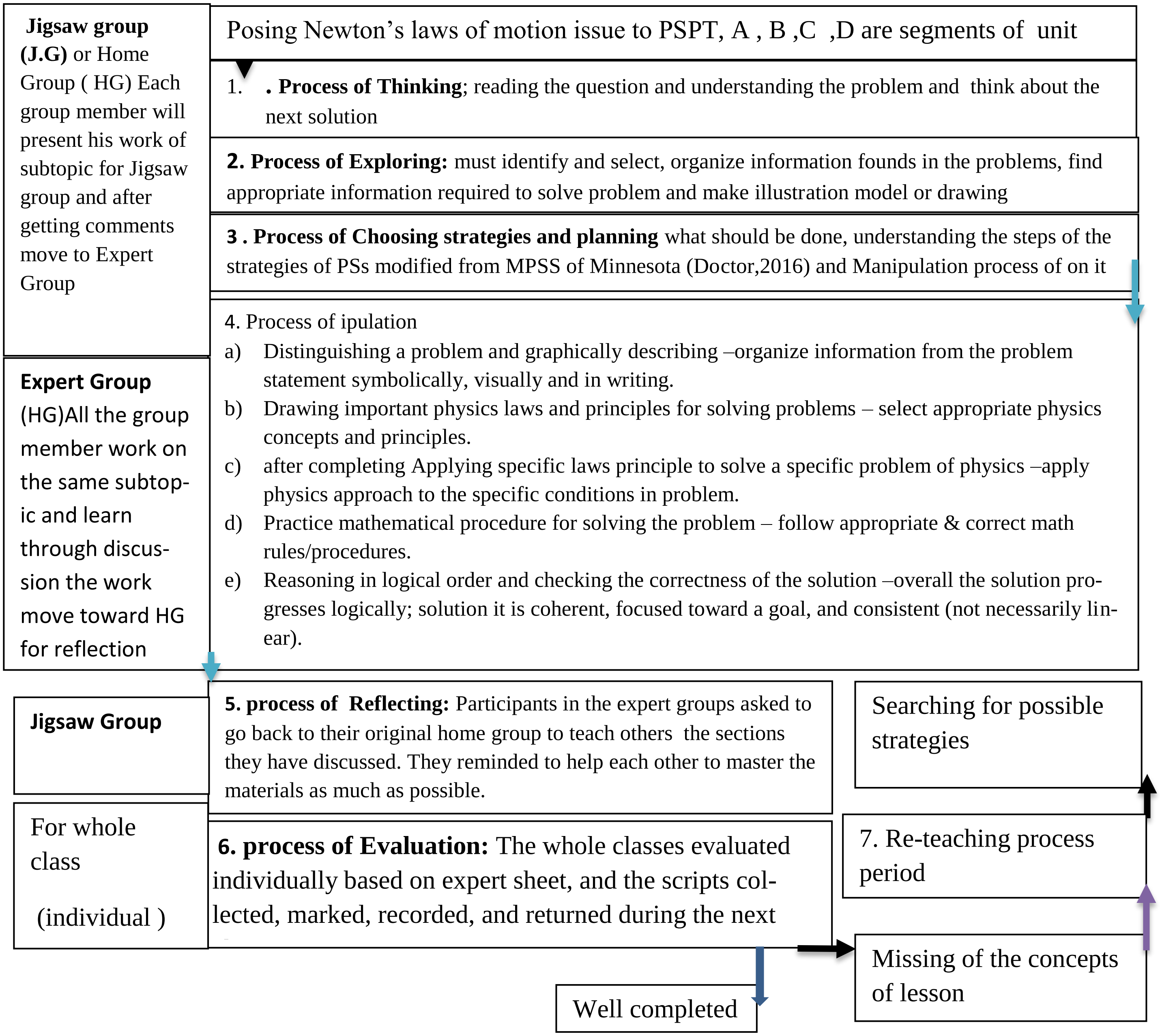
    4. Practice mathematical procedures for resolving the issue; follow appropriate and correct math rules and procedures.

    5. The solution generally advances logically; it is coherent, goal-focused, and consistent (although not necessarily linear). Reasoning in a logical order and confirming the validity of the result.

5. **Process of Reflection::** Participants in the expert groups were asked to go back to their original home group to teach others the sectionsthey hade discussed. They reminded each other to master the materials as much as possible. Each student who studied a particular segment was asked to present his or her segment to the rest of the group members. Questions for clarification from other group members were welcomed. After that, the teacher went from group to group to see what was happening. To become skilled in each daily lesson subject, each ExpertGroup (E)) covers every single one of the components.

6. **Process of Evaluation:**The students" responsese to askedquestions ares based on the stated specific objectives of the lessons. The whole class was evaluated individually based on the expert sheet, and the scripts were collected, marked, recorded, and returned during the next class.

7. **Process of Re-teaching:**Reteachingg is the core idea and the missing material after each lesson after conducting an individual assessment. The researcher emphasized to students the need for J4PSS before the treatment. Students were taught about the existence of the group’s goal, the need for sharing opinions and materials, and the division of laborgroup wards. Students in J4PSS groups also learned skills that they need to facilitate their groupinteractions.



Jigsaw group (J.G) or Home Group (HG) Each group member will present his work of subtopic for Jigsaw group and after getting comments move to Expert Group

Posing Newton’s laws of motion issue to PSPT, A , B ,C ,D are segments of unit

1. **. Process of Thinking**; reading the question and understanding the problem and think about the next solution

2. Process of Exploring: must identify and select, organize information founds in the problems, find appropriate information required to solve problem and make illustration model or drawing

3 . Process of Choosing strategies and planning what should be done, understanding the steps of the strategies of PSs modified from MPSS of Minnesota (Doctor,2016) and Manipulation process of on it

4. Process of ipulation

a) Distinguishing a problem and graphically describing –organize information from the problem statement symbolically, visually and in writing.

b) Drawing important physics laws and principles for solving problems – select appropriate physics concepts and principles.

c) after completing Applying specific laws principle to solve a specific problem of physics –apply physics approach to the specific conditions in problem.

d) Practice mathematical procedure for solving the problem – follow appropriate & correct math rules/procedures.

e) Reasoning in logical order and checking the correctness of the solution –overall the solution progresses logically; solution it is coherent, focused toward a goal, and consistent (not necessarily linear).

Expert Group (HG)All the group member work on the same subtopic and learn through discussion the work move toward HG for reflection

Jigsaw Group

5. process of Reflecting: Participants in the expert groups asked to go back to their original home group to teach others the sections they have discussed. They reminded to help each other to master the materials as much as possible.

Searching for possible strategies

For whole class

(individual)

6. process of Evaluation: The whole classes evaluated individually based on expert sheet, and the scripts collected, marked, recorded, and returned during the next

7. Re-teaching process period

Missing of the concepts of lesson

Well completed

Figure 2.2: Shows the implementation process of TECMRER Model

The implementation of Jigsaw-4, a mixed instructional strategy, had a notable impact on students' understanding and application of mechanics concepts, particularly pertaining to the laws of motion. This approach successfully integrated problem-solving techniques into college teaching, proving to be an effective method for imparting knowledge in the field of mechanics. Students were able to employ various strategies to effectively organize and solve problems, which are vital skills for navigating the complexities of the real world.In the realm of traditional lecture-based classrooms, innovative teaching and learning methods are highly valued and enthusiastically embraced. These methods play a crucial role in shaping and equipping future generations for the challenges of research and development.

A visual representation, Figure 2.3, illustrates a cyclic process comprising seven distinct steps. The first step, known as the process of thinking, involved students in the Home Group engaging in reading, thinking, and understanding the material. This was followed by the process of exploration, where the Home Group further delved into the subject matter. The third step encompassed the process of selecting and discussing a strategy within the Home Group. Subsequently, the fourth step, referred to as the process of manipulation, required students to collaborate in Expert Groups to apply the chosen strategy in problem-solving scenarios.

The process of reflection, constituting the fifth step, facilitated introspection and occurred within the Home Group. The sixth step involved individual evaluation, allowing students to assess their own understanding and progress.However, the information provided does not include details about the seventh step, which is the process of reteaching. Nonetheless, the Jigsaw-4 problem solving strategy demonstrated its positive influence on students' grasp and application of mechanics concepts. By integrating problem-solving strategies into college teaching, students developed valuable skills that are essential for tackling complex challenges beyond the classroom.

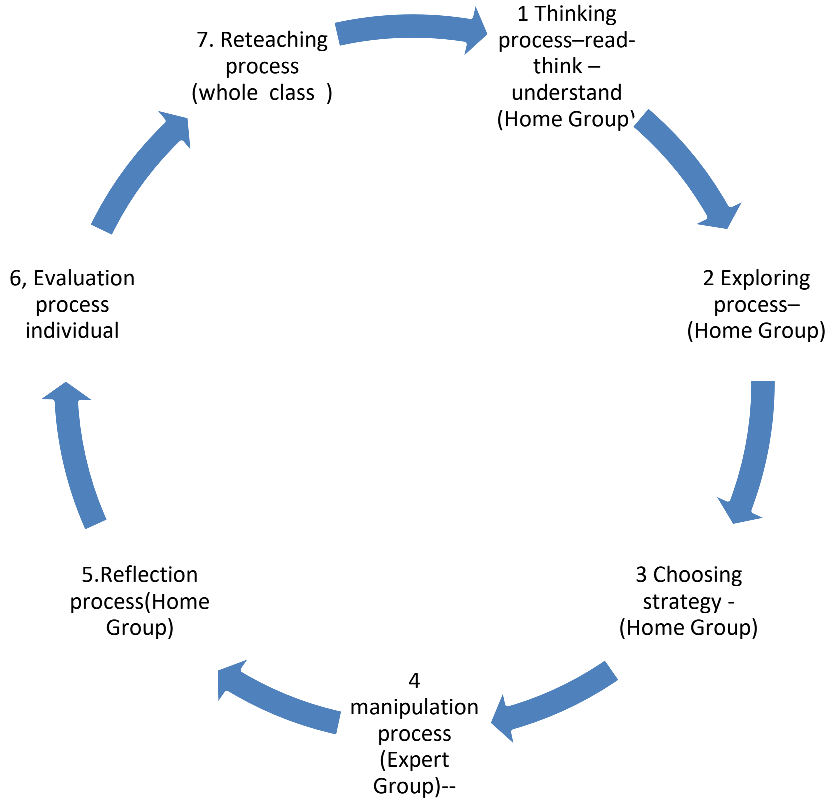


Figure 2.3:TECMRER MODEL is the cyclic implementation process of J4PSS

Source adapted from Heuristic strategies developed by Krulik and Rudnik;(2017), Minnesota problem-solving strategies Docktor & Adrian (2022) , and Cochon et al (2023).

2.13 Conceptual Framework of the Study

The entire investigation is directed toward the research's conclusion, using the framework of concepts as a guide. The sociocultural theory, social interdependence theory, cognitive developmental theory, and motivational theory of learning serve as the foundation for the conceptual framework of the study. To master physics, one must learn to solve problems. So many educational techniques may be used for problem-solving. According to Gok (2014) cooperative group problem-solving is used because it is effective at teaching complicated skills and is also useful since it makes it easier to solve complex problems by giving groups the chance to share solutions. Several theories, such as sociocultural theory, social interdependence theory, cognitive developmental theory, and motivational theory of learning, have been proposed by researchers to explain cooperative learning. Priyana (2020) explained the social interdependence theory as a way of structuring goals that determine how individuals interact and turn into the groups' outcomes.One of the major tenets of the social interdependence hypothesis is mutual benefit, along with responsibility for one's actions, personal responsibility for building connection, successful social skill utilization, collective processing, and prerequisites for congruence and autonomous effort. Furthermore, compared to competitive or individualistic efforts, social interdependence theory tends to encourage stronger attempts to accomplish goals, more beneficial connections, and improved psychological wellness. Additionally, it has been demonstrated that the effectiveness of cooperation depends on the presence of a strong, supportive interdependence (which includes individual accountability) that leads to endorsed engagement (which involves the effective application of social skills and group processing).Given the substantial range and generalizability of the validating research, these findings offer strong validation of sociocultural theory, social interdependence theory, cognitive developmental theory, and motivational theory of learning (Priyana, 2020).The framework portrays the Jigsaw-4 problem-solving methodology as an intervention in the process of instruction and comprehension of the Laws of Motion. Figure 3 depicts how theories, concepts, or variables relate to one another inside the conceptual framework. It displayed the dependent variables in this study's knowledge of the facts, understanding of conceptual issues, knowledge of procedures, ability to solve problems, inspiration, and student perspective. The independent variables are Jigsaw-4-Technique of Learning, Problem-Solving Strategies, Conventional Instructional Approach, and Jigsaw-4-Problem-Solving Strategies. A Jigsaw-4 problem-solving strategy is hypothesized to have an effect on students 'understanding of Newton's Laws of Motion. Extraneous is the term for the variable that has the potential to influence the results of the current investigation. The extraneous variable, such as the teacher's "characteristics, was controlled by using teachers who have a minimum qualification of a master’s in education and have taught for a minimum of 5 years”.

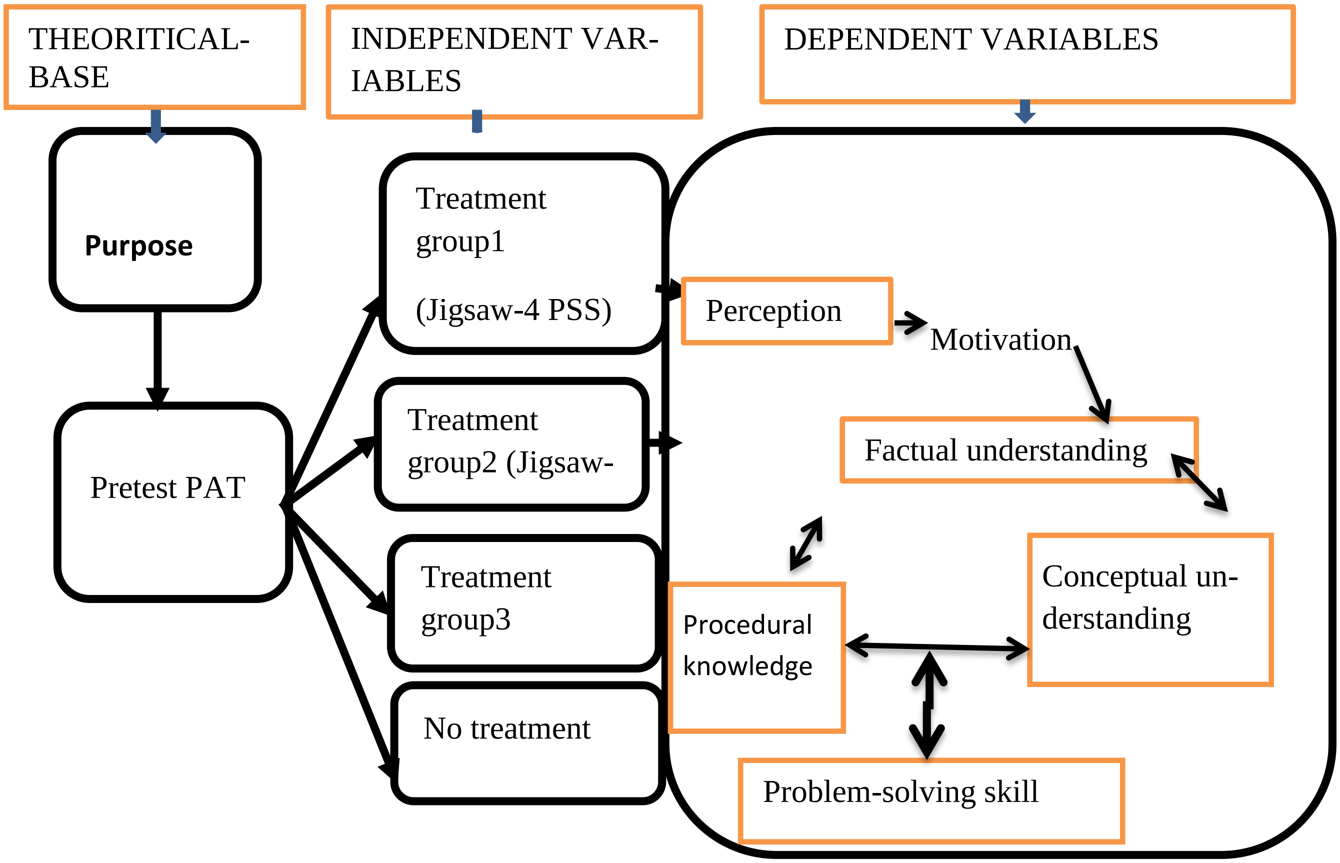


Figure 2.4 Conceptual framework of the study

2.14.**Summary of Chapter Two**

The intended objective of the study was to ascertain the relationship between students' use of Jigsaw-4 problem-solving techniques and their success when researching laws of motion. This review of the literature looked at the consequences of Jigsaw-4 problem-solving techniques in cooperative learning strategies on the motion and academic success of students in the College of Teachers' Education located in Southern Nation and Nationalities Regional State. This is because pupils have struggled to perform badly and occasionally fail in local and national tests when the motion has been a subtopic in the mechanics. The review was conducted under the following subheadings: theoretical framework, conceptual framework, conceptual understanding, procedural knowledge, problem-solving skills, cooperative problem-solving strategy, Jigsaw4 method in physics learning, motivation and perception in the learning of laws of motion, conceptual comprehension, factual knowledge, and conceptual knowledge.

Chapter Three: Research Design Methodolagy

3. Introduction

This chapter covers several essential components that laid the groundwork for the entire study. These include the philosophical orientation or research paradigm that guided the research, the chosen research design and method, the population being studied, the sample and sampling methods used, and the variables being investigated. Additionally, this chapter also discussed the data collection instruments being used and their reliability and validity, as well as the procedures for collecting and analyzing data. To ensure the accuracy and trustworthiness of the research, a pilot study was also conducted. This chapter also covers questions of ethics relating to the study.

3.1. Research Paradigm

According to Creswell (2014) a worldview is the overall philosophical perspective that a researcher brings to a study on the nature of research and research design. A research study is, at its core, dependent on specific philosophical presumptions on what constitutes a legitimate study and which research procedures are suitable to enhance one's capacity for understanding a certain topic. Therefore, it is crucial to be aware of current philosophical presumptions when undertaking a research study. The methodological selection is not just determined by the research questions but also by beliefs on how the world should be studied and interpreted. The ontological reality and epistemological constructivism of the researcher fundamentally influence the choice of a specific methodology. Ontology, epistemology, methodology, axiology, and rhetorical disposition in research are collectively known as research paradigms (Kivunja & Kuyini, 2017).

The research paradigm determines how the study should be conducted, the focus of the study, and the approaches utilized in the interpretation of the data (Kivunja & Kuyini, 2017; Ramírez- & Lugo, 2020). It is helpful to approach scientific research with a good knowledge of the ontological, epistemological, methodological, axiological, and rhetorical elements since the conceptualization of these dimensions influences research activities significantly. The ontological foundations and conceptual perspective of the researcher inform the theoretical positions, such as positivist, post-positivist, and interpretive, and the theoretical perspective, in turn, determines the choice of methodology. Finally, the research methodology influences the choice of data collection techniques and instruments.

The current research is therefore built on a post-positivist research paradigm (Panhwar et al., 2017) . Thus, the choice of methodology will be guided by this paradigm. The post-positivism research paradigm is selected because it emphasizes utilizing data that is both subjective and objective to quantitatively investigate the phenomenon, with a heavier emphasis on the quantitative data (Panhwar et al., 2017). Even though the assumption of single reality is admitted in the post-positivist research paradigm, unlike the positivism paradigm, it believes that single reality is not absolute and uncertain (Habib, 2020). As a result, some emphasis is given to assessing the findings with the help of qualitative data (Wildemuth, 1993). Similarly, the present study confirms the findings with qualitative data as supportive of statistical results.

3.2. Research Design

A study design is a strategy or plan that specifies the participants to be chosen, the data collection tools to be employed, and the data analysis techniques after outlining the underlying philosophical assumptions.A research design covers the specific phases of the study, the rules for gathering data, the tools to be used, the sample size, and the sampling methods (Creswell, 2014) . A method for investigating is the rationale or master program of how the task is to be carried out to achieve this. As a result, it includes all techniques that aid in answering the study's questions. As a result, mixed-method (specific technique) research was chosen for this work while taking the research questions and hypotheses into account. According to Creswell and Plano Clark (2018) mixed method research incorporates quantitative and qualitative research methodologies in a specific study topic; the weightings given to each approach are different in percentages.

A single data collection is insufficient to answer many research issues, which is the premise for using mixed-methods research. Therefore, strategies for doing both quantitative and qualitative research required the use of a qualitative research approach. A mixed-methods research approach was used in this study to examine the impact of the jigsaw-4 problem-solving strategy on the knowledge of facts, knowledge of concepts, procedural knowledge, ability to solve problems, perception, and inspiration of preservice primary teachers (Wisdom & Creswell, 2013). As a consequence, the sequential explanatory mixed research design technique was used for this study. According to Harrison and Reilly (2011) and Ramirez-Lugo (2020) QUAN and qual, respectively, are employed to represent quantitative and qualitative data (see Figure 3.1).

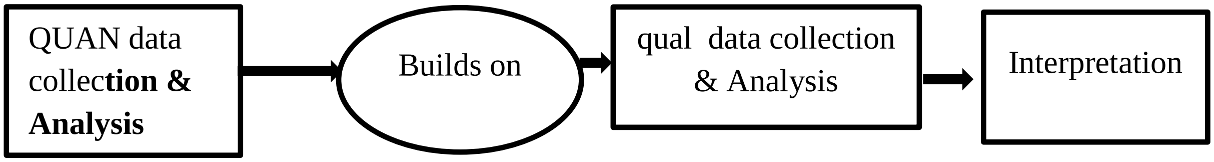
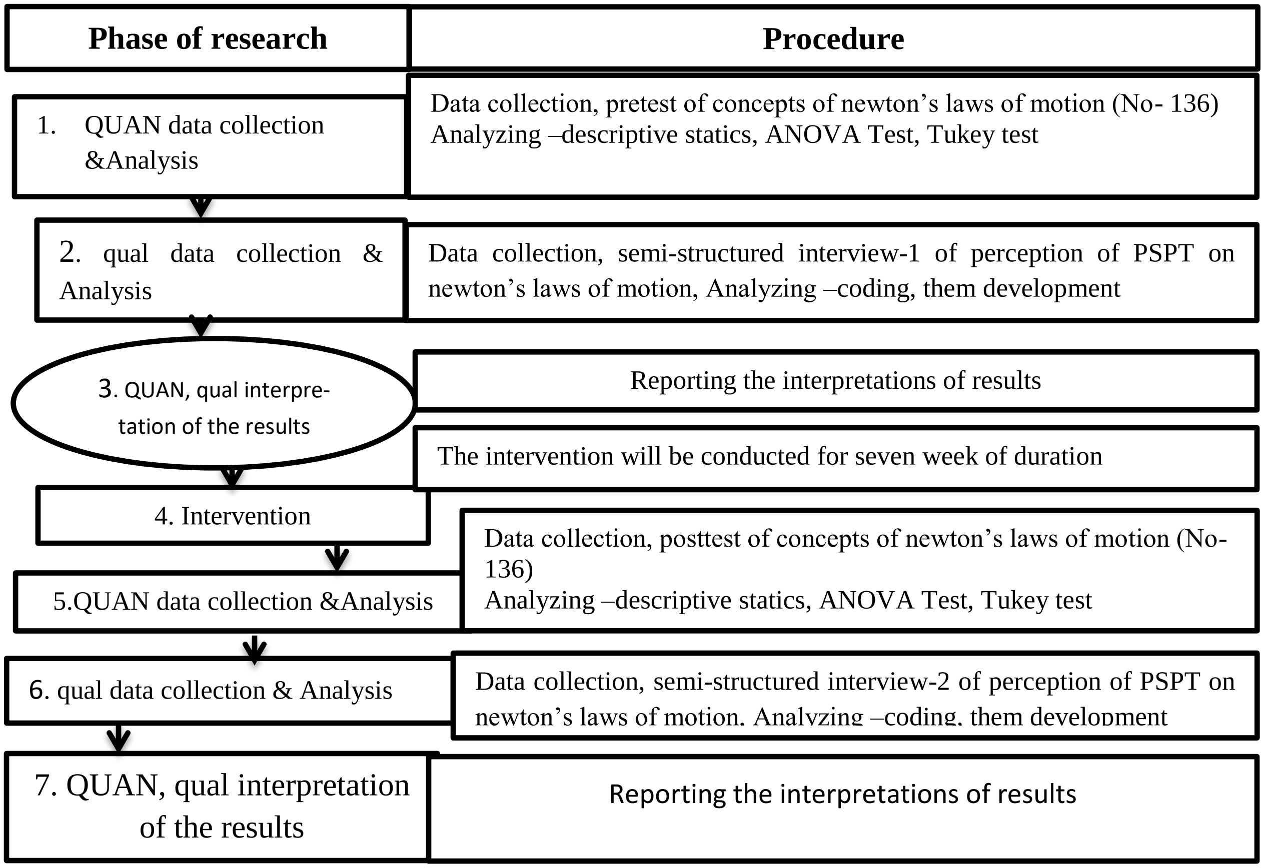


Figure 3.1. Adapted from Sequantial explanatory reserch design by Wisdom, Creswell, and others (Wisdom & Creswell, 2013) .

Figure 3.1 . shows the design in which the results of the QUAN (qual) analysis have been incorporated into the interpretation in a Sequantial explanatory research approach. In an explanatory sequential design, the research process begins with the quantitative phase, where numerical data is collected to identify patterns or trends. This phase is followed by the qualitative phase, which aims to provide explanations and a deeper understanding of newtons laws of motion using jigsaw-4 prob-

lem solving strategy (Airey, 2021; Hayes et al., 2013). For example, in the context of physics education, a researcher may start by administering a survey to assess students' attitudes toward physics. The survey results may reveal a correlation between students' attitudes and their academic performance. In the subsequent qualitative phase, the researcher can conduct interviews or focus groups to explore the underlying reasons and factors contributing to this correlation in greater detail (Lieber, 2009; Salehi & Golafshani, 2010) .

After selecting the appropriate mixed methods research design, the researcher proceeded to develop a visual representation of the data collection and analysis process, which is depicted in Figure 3.1 on the following page. Please refer to the diagram in Figure 3.2 for a detailed illustration of the seven-step procedure.



Phase of research	Procedure
1. QUAN data collection &Analysis	Data collection, pretest of concepts of newton's laws of motion (No- 136) Analyzing –descriptive statics, ANOVA Test, Tukey test
2. qual data collection & Analysis	Data collection, semi-structured interview-1 of perception of PSPT on newton's laws of motion, Analyzing –coding, them development
3. QUAN, qual interpretation of the results	Reporting the interpretations of results
4. Intervention	The intervention will be conducted for seven week of duration
5.QUAN data collection &Analysis	Data collection, posttest of concepts of newton's laws of motion (No-136) Analyzing –descriptive statics, ANOVA Test, Tukey test
6. qual data collection & Analysis	Data collection, semi-structured interview-2 of perception of PSPT on newton's laws of motion, Analyzing –coding, them development
7. QUAN, qual interpretation of the results	Reporting the interpretations of results

Figure 3.2 for a detailed illustration of the seven-step procedure.

3.2.1. The Quantitative Research Design

It is challenging to conduct a true experiment in the classroom environment of the school because variables cannot be controlled completely and randomization is not simple (Dawadi et al., 2021; Hanson et al., 2005) . As part of the quantitative data collection, a sort of quasi-experimental strategy approach with a non-equivalent pretest, posttest control group, and multiple treatments was used. The design has one comparison group (CG) and three intervention groups (IG), with a pretest and a posttest. Accordingly, the summary of the nonequivalent treatment and comparison group research design is shown in Table 3.1 below.

Table 3.1 Quantitatie research design

Treatment group 1	N	O_1	X_1	O_2
Treatment group 2	N	O_1	X_2	O_2
Treatment group 3	N	O_1	X_3	O_2
Comparison group	N	O_1		O_2

N represents the non-randomization of subjects into groups.

O1 represents the pretest

O2 represents the posttest.

X1 represents the jigsaw-4 problem-solving strategy instructional approach.

X2 represents a jigsaw-4 instructional approach.

X3 represents the problem-solving strategy and instructional approach.

According to Harris et al (2006) the non-equivalent quasi-experimental design has some methodological drawbacks. Because of the non-random assignment of participants to the comparison and treatment groups, there are several challenges associated with comparing groupings that aren't equivalent, such as the problem of controlling auxiliary variables and the statistical challenges. The non-equivalent quasi-experimental design's methodological flaw was therefore acknowledged in this work. Several significant efforts were made to lessen the impact of variances in the three treatment groups and one comparison group. Here are a few of the majors: For example, their past class grades and GPA were taken into consideration while establishing the criteria to equalize the groups. Additionally, a pretest was administered to each group as a benchmark for later comparison (Berry, 2008).Additionally, several regulatory systems were put into place to lessen the differences that came from the instructors. Among the strategies for preventing data contamination was the selection of four college physics instructors with comparable experience, training, and willingness to take part in the study.

3.2.2. The qualitative data collection

For the qualitative approach, the case study design consists of the intensive study of an incident used as per the recommendation of the following scholars (Owens & Hospital, 2014). A case study

was chosen as it is a preferred approach when ‘‘how’’ or ‘‘why’’ questions are being posed, when the researcher has minimum control over events when the focus is on process rather than outcome, and when the focus is on a contemporary phenomenon within some real-life context (Baxter & Jack, 2008) . Hence, the case study research design provides a close examination of research problems and provides in-depth information about the research. In this context, the researcher collected qualitative data after the intervention to support quantitative results.

Preservice physics teachers' conceptual knowledge of Newton's laws of motion as well as the advantages they obtained from the intervention were evaluated using a case study. For this reason, six people from each group (a total of 24 people) were chosen based on their performance on the college admissions exam, with two students from the top, two from the center, and two from the bottom. There were five interview questions from all subtopics in Newton's Laws of Motion unit. Each student's interview lasted between 15 and 20 minutes and was audio recorded and transcribed (Appendix 6).

3.3. Sample and Sampling Techniques

The population of the study was obtained from the College of Teachers' Education of SNNPRS. There were five active governmental Colleges of Teacher Education in SNNPRS. However, four Colleges of Teacher Education (Arbamich, Dilla, Hosanna, and Bonga) were chosen by a lottery system for current students. Thereafter, simple nonrandom sampling techniques were employed to take intact classes within the college for the treatments and comparison groups, and the existing section was nonrandomly assigned to the treatments and control groups. This is to avoid the disturbance of the college programs. Regarding, the subjects of the study, first-year upper preservice teachers were part of the sample.

3.4. Study-related variables

Variables are key components of research. A property of the subjects or environment for a particular research study is referred to as a variable when it has various values in that study. A variable needs to be able to take on numerous forms or intensities. If there are several treatments, the type of therapy or intervention is a variable. Variables are operationally defined in quantitative research and are frequently separated into independent variables, dependent variables, and superfluous variables.

We consider the independent variable to be the one that might influence the outcomes. It is changed to see what impact it has on the dependent variable.

As a result, this study has one independent variable, with three value of teartment which is the method of teaching. These include problem-solving strategies, Jigsaw-4 Techniques of Teaching, Jigsaw-4 problem-solving strategies, and conventional method is the controlled variable . Quantifying variables and determining how they relate to one another is one method of statistical analysis. This enables researchers to discover how a variable that is not connected could impact the variable under study. According to Taasoobshirazi et al (2022), this procedure of putting variables into numerical form and examining how they relate to one another is essential to the analysis of statistical data and can provide significant fresh viewpoints on challenging situations. The factual information, procedural knowledge, conceptual understanding, problem-solving abilities, motivation, and perception involved in learning laws of motion are therefore the dependent variables in this study. These factors are briefly listed in Table 3.2 below.

Table 3.2 Variable of the study

S/N	Variables Type	Variables
1	Independent variables	Jigsaw-4 method of instruction Problem-solving strategy approach Jigsaw -4 problem-solving strategy
2	Dependent Variables	Factual knowledge, procedural knowledge Conceptual understanding, Problem-solving skills, Motivation, Perception.

3.5. Data-Collection Instruments

The growth of students' factual, conceptual, procedural, problem-solving, motivational, and perceptual skills, as well as the efficacy of teaching techniques for physics, particularly the law of motion, were assessed using several instruments. In this part, the gathering device and related approaches were discussed.

3.5.1. The mechanics-factual and conceptual understanding diagnosis test

A test for factual and conceptual understanding was modified and used to examine the impact of tactics utilized on the factual and conceptual understanding of upper primary preservice physics teachers. The preservice upper primary physics teachers' misunderstandings and challenges were revealed after a pilot study. The purpose of the exam was to gauge the knowledge of the Laws of Motion that preservice teachers had created during the intervention. To determine the goals of the course and the ideas that should be covered throughout, the college mechanics curriculum was examined.

Following that, a table of requirements was created to show how the questions related to important concepts. A pool of questions concerning these objectives and ideas was created using literature and college entrance and exit tests as a starting point. Following this, it was decided which questions would be on the test by comparing them to the curriculum's stated goals (Hestenes et al., 1992; Suprapto et al., 2016). A Force Concept Inventory Test was used to develop the test. After deciding on the course's goals and the ideas that should be covered throughout the subject, 14 multiple-choice items (Appendix 1) were chosen to gauge pre-service teachers' mastery of knowledge of facts in the law of motion.

A table of requirements (Table 3.3) was made to demonstrate how the questions and key concepts connect with one another. However, a pool of questions was compiled from various genres of literature and books that contain material relevant to college entrance and exit exams to evaluate students' conceptual understanding of laws of motion(Fazio, & Battaglia, 2019; Stoen et al., 2020). (Appendix 1).Following this step, the questions that were included in the instrument were determined by matching the questions with the objectives stated in the curriculum as per the recommendations given by Sulistri (2017). Science teachers have advised utilizing the two-tier test to diagnose students' conceptual knowledge (Tsai & Chou, 2002; Wu et al., 2010) . Hence, 19 multiple-choice items made up the test, which was designed as a two-tier test. Each item's response was followed with a reasoning question to help determine the results. The preservice physics teacher's conceptual understanding is evaluated in two stages: the first evaluates students' knowledge of the misunderstanding, and the second examines students' justifications for the decisions they took in the first stage.

Several studies have been conducted on how to assess two-tiered multiple-choice items. They looked at things in various ways. For instance, Chandrasegaran et al (2007) consider a question to be accurate if both the content and reasoning components of a two-stage test question are properly answered. Hubbard et al (2017) state that if students provide correct answers in both tiers, they are considered to have a full understanding; if they provide correct answers in the first tier but incorrect answers in the second, they are considered to have specific misconceptions; and if they provide incorrect answers in both tiers, they are considered to have no understanding at all of the concepts. Furthermore, according to Ozkan et al (2015) full understanding was defined as students scoring both tiers correctly (T-T), specific misconceptions were defined as first-tier correct and second-tier incorrect (T-F), or (F-T), and no understanding was defined as both tiers incorrect (F-F).

The recommendations given by Eryilmaz (2010) to diagnose students' alternative conceptions, the dual-stage test, have been proposed by science educators (Chandrasegaran et al., 2007). As a result, the exams were developed; the factual knowledge test had 14 multiple-choice questions, and there were 19 two-tier tests for the diagnosis of preservice physics teachers' conceptual understanding. The first tier assessed preservice physics teachers' knowledge of the misconception, and the second layer evaluated preservice physics instructors' conceptual knowledge. See Appendix 2.

Table 3,3 the specfication ofthe item indicated the key concepts of the laws of motion

Topic	Sub-topic areas	Item no	Concepts to be inventory
Laws of Motion	First law	3,4,13	Application of First law, With no force The velocity with constant direction, Constant speed
	Second law	5,14,16, 18,19	Application of the Second law, Net force/impulsive force Constant force implication, Constant acceleration
	3RD law of motion	6,12,15 2,17	Application of Third Law Action-reaction impulsive force The resultant force of action-reaction
	Kind of force	1,7,9,11 8,10	Gravitational force (non-contact), Electrostatic force (non-contact) Magnetic force (non-contact)Frictional force
	Total	19	

3.5.2. Mechanics Procedures Knowledge test

According to Czuk and Henderson (2005) and Robayo et al (2020) procedure knowledge comprises knowing how to do a task as well as the standards and techniques of inquiry for using algorithms, strategies, and sequences to solve a problem. Three open-ended questions were constructed using the Force Concept Inventory Test. Luangrath et al (2011) to assess the procedural competency of the laws of motion in preservice physics teachers. The preservice physics teacher's written response to the three-part open-ended problem of laws in motion (see Appendix 3) was evaluated using the indications, dimensions, or categories listed below: identifying and comprehending the issue, formulating a solution, and using the solution. Important physics laws and concepts are written down, and the solution's correctness is evaluated using a procedural knowledge test rubric. Thus, three open-ended problems were used to assess the procedural knowledge of the PSPT.

The MAPS Problem Solving Rubric is frequently used to evaluate procedural knowledge and problem-solving abilities in physics and other courses (Mckagan & Madsen, 2022) . It offers a methodical framework for assessing college students' abilities, putting an emphasis on standards such as procedural knowledge and application, correctness and efficiency, flexibility, and self-reflection. Using the rubric, educators proceed methodically, determine the particular procedural abilities necessary for addressing physics problems, and then build the rubric around those skills. Performance levels and descriptors make up the rubric, which can be customized to match certain learning objectives.

Teachers employ a variety of evaluation techniques, such as written assignments or lab reports, to evaluate their preservice physics teachers. The rubric aids in scoring and providing feedback to students, promoting their development of problem-solving abilities. Teachers can distinguish between several levels of procedural knowledge by giving each level or descriptor a score or rating. This enables them to provide pupils with individualized feedback and guidance to improve their problem-solving skills. Educators can pinpoint college students' procedural knowledge strengths and areas for development by analyzing assessment outcomes. Decisions about how to deliver instruction and how to intervene to assist student learning are informed by this information.

The MAPS Problem Solving Rubric has many advantages. It offers a uniform framework for assessing performance, enabling accurate comparisons between schools and districts. The criteria are supported by research and correlate with the finest physics teaching approaches. It provides ongoing feedback and measures progress for both formative and summative assessment purposes. By assisting teachers in identifying areas where children struggle and changing instructional tactics accordingly, the rubric encourages professional development.

In conclusion, the MAPS Problem Solving Rubric is a useful instrument for evaluating procedural knowledge in physics. It offers a defined framework that enables differentiation and focused feedback. To improve students' ability to solve physics problems, teachers gather knowledge about their students' learning styles and aptitudes.The Procedural Knowledge Rubric (PKR) was adapted from the University of Minnesota Assessment Mechanism of Ability to Solve Problems (MAPS) to assess procedural knowledge about PSPT's degree of quality of performance in the physics workout activity. According to Moore & Crouch (2018) and Docktor (2009a) PKR has three dimensions or categories that include determining and comprehending the problem, articulating important physics rules and principles, and verifying the accuracy of the result. Each written solution to a problem was given a score between 0 and 5 for each of the three rubric categories, and the sum of all the scores was used to determine the overall rubric score for that solution. This total score (up to a maximum of 25) was then broken into five categories, resulting in a score out of five that was then downgraded or reweighted. The three items' reweighed findings were combined, and the maximum number of outcomes was 15. The total scores for the three items were then multiplied by 100 and divided by the maximum category score (15), as displayed in Table 3.4.

Table 3. 4 Level of performance quality on procedural knowledge tests adapted from the MAPS Rubric

Dimensions (indicator)	Likert scale to assess participants’ procedural Knowledge Test (P K Rubric)						Level of performance
	5	4	3	2	1	0	In percentage & PQ
Determining and understanding the problem	Fully determined & understand the problem	Recognizing & comprehending some of the problems	Identifying but not comprehending the issue	determination & understanding of the problem are not correct	NA	No Answer	[0-20) = Very Poor [20-40)= Poor [40-60)= Acceptable [60-80)= Good >= 80 = Very Good
Writing important physics laws and principles	Fully choose appropriate law & principles	Choosing the majority of the appropriate laws & principles	Choose some of the appropriate laws & principles	Choose while failing to choose appropriate laws & principles	NA	No Answer	[0-20) = Very Poor [20-40)= Poor [40-60)= Acceptable [60-80)= Good >= 80 = Very Good
Correctness of the solution	Fully adapt laws to the specific problem	Adapt laws to the specific problem with few mistakes	Adapt some laws to the specific problem	Adapting laws while failing to the specific problem	NA	No Answer	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

3.5.3. Mechanics problem-solving skill test

Problem-solving, according to Tambunan (2019) is a course of action through which a learner comprehends, creates, and implements a strategy to address a situation or problem for which there is a demand but no immediate response or solution. The problem-solving guidelines used in this study were built from the problem-solving criteria put out by the following researchers (Docktor et al., 2016; Saygılı, 2017).They included the capacity to grasp the issue, to identify it, articulate it, and describe it; to study the problem, analyze it, and predict it; to develop a strategy and plan to address the problem (by thinking through the problem); to implement the strategy and plan; and, lastly, to assess the results.

Three open-ended activities make up the exam, which the researcher created based on the Force Concept Inventory (FCIT). The five categories of the University of Minnesota assessment mechanism of the Problem-Solving Rubric (MAPS) were moderated based on written responses to physics problems provided by the physics instructor in training who was evaluating the exercise problem in this research. Choosing the appropriate physics laws and principles, tailoring physics laws to the specifics of a problem, pursuing the appropriate mathematical procedures, and MAPS, as defined by Moore and Crouch (2018) and Jennifer Lynn Docktor (2009b) include having a systematic, goal-oriented logical progression. Each of the five rubric sections was assigned a score for each written response to a problem, ranging from 0 to 5, on a scale of 1 to 5. The total of all the scores was used to calculate the written response's overall rubric score. This cumulative score (up to a maximum of 25) was then broken into five categories to re-grade or reweight the final score out of 5. By combining the reweighted results of each item and dividing by the total number of items (3), the aggregated results of the three items were produced.

The three items' combined values were then divided by the category's maximum score, which was 5, and multiplied by 100 to produce a percentage. The percentages were then evaluated using a performance quality scale for problem-solving abilities, which spans from really poor performance to very good performance, as can be seen in Table 3.5 below. The three workout tasks' grand mean scores were additionally used to compare mean variations across groups. The rubric was applied to many different physics disciplines and different kinds of problems, ranging from those that are frequently encountered in textbooks.

Table 3. 5. Level of performance quality on problem-solving skills tests adapted from the MAPS Rubric.

Dimensisions(indicator)	Likert scale to assess participants' Problem-solving skills (Rubric)						Level of performance
	5	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	No Answer	[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 laws & principles	Choose some of the appropriate laws & principles	Choose while failing to choose appropriate laws & principles	NA	No Answer	[0-20) = Very Poor [20-40)= Poor [40-60)= Acceptable [60-80)= Good >= 80 = Very Good
Adapting physics laws to the specific 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	No Answer	(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	No Answer	(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 the expected	NA	No Answer	(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

3.5.4. The Motivational Questionnaire for Physics

The Physics Motivational Questionnaire (PMQ), which was modified from the literature, was used to gauge how students in the treatment and comparison groups were motivated to learn about motion-related subjects in physics. The PMQ created by Abak (2003) developed, verified, and updated by Nilüfer (2014) and Peşman (2015) was utilized in the study. Learners were requested to score each of the 30 items on this version of the PMQ on a scale of strongly disagree (1) to strongly agree (5). Five-point Likert scales were employed.The questionnaire consists of six motivational constructs: intrinsic motivation questions (1–11), extrinsic motivation questions (12–14), test anxiety questions (15–18), self-efficacy questions (19–22), self-determination questions (23–27**),** and career motivation questions (28–30). All of the groups received copies of the questionnaire indicated in Appendix -5

3.5.5. Semi-Structured interview

To strengthen the validity and reliability of the study's findings, data from PSPT were collected via a semi-structured interview to evaluate their perceptions of studying physics (Kallio et al., 2016). As a result, semi-structured interviews were conducted in addition to the mechanic's diagnostic exam, problem-solving skill test, and procedural knowledge test to evaluate students' grasp of laws of motion ideas and the value they received from the intervention. A total of 24 people were scheduled for interviews, i.e., six from each of the groups: two students from the higher achiever group, two from the medium achiever group, and two from the low achiever group were chosen to participate in the interview from each study group based on their cumulative grade point average (CGPA). All of the subtopics in the mechanics-III course were represented by the five interview questions indicated in Appendix 6. Each student's interview with the researcher lasted 15–20 minutes and was audio recorded and transcribed. The questions and subjects posed were meant to be thoroughly discussed by the participants.

3.6. Validity and Reliability of the Test Tools

In the evaluation of any measuring instrument or tool for high-quality research, validity and reliability are the two most crucial and essential characteristics (Saregar et al., 2019). What an instrument measures and how well it does so are two aspects of validity. Regarding the degree to which any measuring equipment compensates for random error, reliability refers to the level of confidence that may be placed in the results produced via the use of an instrument. Here, there has been an attempt made to examine their veracity and authenticity, as well as the threat to them in certain specifics.

3.6.1. Validity of the tools

The degree to which an instrument assesses the things it was designed to measure is known as validity. The validity of the research also reflects how accurate its findings were (Porter, 2007). Content and face validity are frequently used when evaluating validity from various angles. The degree to which a measuring tool adequately covers the subject under investigation is referred to as content validity. For an instrument to establish content validity, it must also demonstrate that it fairly and thoroughly covers the domain or items that it claims to cover (Nebesniak, 2007).

According to Kimberlin and Winterstein (2008) and Richard and Bagozzi (2013) content validity often rests on the opinions of subject-matter experts. By employing a panel of individuals who will assess how well the meaning instrument complies with the norms, it may be decided (Richard, and Bagozzi, 2013). Obtaining feedback from a group of specialists when we are creating a measuring instrument can help us design our instruments (Campbell, 2016) . As a result, the expertise of teachers of physics, particularly mechanics courses, psychology, curriculum, and teaching, is used to evaluate the content and validity of instruments. To verify consistency between the test items and the textbook's aims and ideas, as well as for clarity and errors in the answer key, colleagues with expertise in physics education and college physics teachers assessed the test items. As a result of the comments and suggestions, the items have now been fixed.

For the same purpose, specialists in psychology and language received scientific motivation questionnaires (SQM) and observation protocol questionnaires. Taking into account the feedback, the instruments were modified. Furthermore, according to Richard and Bagozzi (2013) validity may be enhanced by careful sampling, proper apparatus, and appropriate statistical procedures for the analysis of the data (Mishra et al., 2019).Experts from related fields such as curriculum and instruction subject areas (mechanics) were given the instructional material created on the TECMRER model that contains brief descriptions of the model on each stage of the model with specific examples of a specific unit of mechanics.

3.6.2. Reliability of the Instruments

According to Panepinto et al (2017) reliability is a measure of how accurate each measure is in detecting measurement error and how consistent the many item measures or evaluations are with one another. According to Marshall and Miller (2019) reliability refers to how well a test assesses the subject matter. In addition, Kimberlin & Winterstein (2008) contend that reliability estimates are used to assess (1) the consistency of measures administered to the same person at various points in time or using the same standard (test-retest reliability) or (2) the comparability of sets of items or instruments from the same test (internal consistency) or even using the same instruments (inter-rater reliability). To analyze the instruments' items and confirm their reliability, a pilot study was then carried out..

3.7. Pilot Researches

Pilot tests were administered at randomly chosen teacher education institutions in SNNPRS to determine the viability of models, the degree of difficulty and discrimination of test items, and the dependability of instruments. The pilot and research data were gathered through classroom observation notes and discussions with participants (the instructors and some selected students), and it was from these discussions that helpful input was gathered on the timing of the steps and stages of each treatment method. It was decided to change the implementation strategies after taking into account participant and observational feedback.

The mechanics conceptual understanding test (MCUT), science motivational questionnaires (SQM), interview questionnaires (OPQ), and mechanics factual knowledge test (MFKT) final versions of data collection instruments were pilot-tested to determine their reliability. In the second year of teacher education at Hawasa College, the instrument was administered to 37 physics preservice teachers. Analysis of the factual knowledge exam and the conceptual understanding test was done using the results of the pilot test, and variables like the difficulty index and discrimination index were used. Additionally, for the scales SQM, MFKT, and MCUT, the Kuder-Richardson coefficient alpha was used to assess the internal consistency and dependability of the instruments.

Item analysis is the process of looking at test items to see if they fit the criteria for difficulty (P) and discrimination (D). Checking whether the exam properly distinguishes between prospective physics teachers who score better and lower on tests, as well as if the items are not too challenging or too simple, is necessary. Using the item difficulty and item discrimination indexes, the test outcomes were examined. The value of the item difficulty index ranges from 0.0 to 1.0. has been used to indicate the item's level of difficulty; the higher the score, the easier the item; the lower the score, the harder the item (Yimer & Feza, 2019).

To put it another way, a higher score indicates that many students chose the right response, whereas a lower score indicates that fewer students chose the right response. Shanmugam et al (2020) emphasized that the ideal p-value for item difficulty ranges from 30–70%, or 0.3–0.7, meaning that items with a p-value below 0.3 and above 0.7 are deemed tough and easy items, respectively (Note Table 3.7).

Table 3.7. Analysis of the difficulty and ease of the items based on the p-value

p-value	Interpretation
> 0.7	Too easy
0.3—0.7	Average
< 0.3	Too difficult

The D-value varies from -1 to +1, and the item discrimination shows how well the item separates students who score poorly from those who score highly. A more discriminating item is one whose D-value is closer to +1, whereas a more discriminating item is one whose D-value is closer to 0. Musa et al (2021) recommended that items with a discriminating index value (D) range of 0.2-0.29 be investigated and those with a value (D) less than 0.2 be thoroughly examined. Following the analysis of item difficulty and discrimination in the previous section, these variables were examined in the current study.

The mechanical diagnostic test of the factual knowledge exam had a mean difficulty level of 0.34, indicating that it was average and that the items were fairly challenging for pupils. Out of 14 things, the mechanical factual knowledge test contains items with difficulty ranging from 0.216 to 0.919. The majority of the items were within an acceptable range; however, two of them (items 0.216 and

0.243) have been altered. The mean discrimination index for the mechanics' factual knowledge exam was 0.34, demonstrating that it is an effective test for pupils. The factual knowledge test's discrimination index varies from 0.189 to 0.789 out of 14 items. Twelve of the questions fairly distinguished between students who were high achievers and those who were low achievers, but two of them appeared to be unsuccessful because they had discrimination indices that were low, i.e., 0.29 (Table 3.8). Two of the items were modified. (See Appendix 1). The item difficulty and item discrimination of the mechanic's conceptual comprehension test were examined, as shown in Table 3.8.The mechanics conceptual understanding exam had an average mean difficulty level of 0.49, indicating that the items were moderately challenging for pupils. The mechanics conceptual understanding exam consists of 19 items, the item difficulty of which runs from 0.189 to 0.81. While the majority of the items fell within acceptable limits, six of them (items 0.081, 0.135, 0.135, 0.27, 0.27, and 0.29) have been subject to adjustment.

The mean discrimination index for the exam on conceptual comprehension of mechanics was 0.44, indicating that it is an effective assessment tool for pupils. The conceptual understanding test's discrimination index ranged from 0.189 to 0.92 across 19 items. 18 of the measures distinguished between high- and low-achieving kids rather effectively, but one of them—with a low discrimination value of just 0.089 seemed to be less effective. Appendix 2 contains a review of one item. Using the coefficient alpha, the internal consistency and dependability may be assessed (Adamson & Prion, 2013). For scales and tests, respectively, Cronbach's coefficient alpha and Kuder-Richardson coefficient alpha are the most often used methods for evaluating the dependability of internal consistency (Anselmi et al., 2019). For the current study, I used the Kuder-Richardson coefficient alpha for the mechanics factual knowledge test (MFKT) (see Appendix 1).

Table 3 . 8. Shows the item difficulty (p) and discriminatindex (D) for the MFKT and MCUT, MFK

	Item difficulty Value	No of item	Item discrimination Value	No of item
MFK	> 0.7	3	> 0.39	10
	0.3-0.7	9	0.3-0.39	2
	< 0.3	2	0.0-0.20	2
Total number of item		14		14
MCU	> 0.7	1	> 0.39	18
	0.3-0.7	12	0.3-0.39	
	< 0.3	6	0.0-0.20	1
Total Number of items		19		19

Mechanics conceptual understanding test (MCUT) (see Appendix 2) and science motivation questionnaire (SQM) (see Appendix 5) tests as a mechanism for determining the instrument's reliability after pilot testing. Correct replies were recorded as 1, while erroneous responses were coded as 0, in the computation of the MFKT scores. As a result, the highest score was 14 and the lowest score was 0. Similar to this, the MCUT score was determined by coding correct responses for both tiers (first and second tier) as 2, incorrect responses in any tier of the two tiers as 1, and incorrect responses in both tiers as 0. As a result, the maximum score was 28 and the minimum was 5. Using Kuder Richardson-20, it was determined that this study's dependability for both factual and conceptual knowledge was 0.723 and 0.719, respectively. This demonstrated that the questions' internal consistency is credible.According to six dimensions, the Internal Motivation (IM) (0.894), External Motivation (EM) (0.892), Test for Anxiety (TA) (0.964), Self-Efficiency (SE) (0.995), Self-Determination (SD) (0.891), and Career Motivation (CM) (0.896) Cronbach alpha values are. Therefore, according to all Cronbach alpha values, the motivation-related items were more trustworthy. Each instrument's values fall within permissible bounds. The test items were therefore regarded as valid and trustworthy instruments to be used in the current investigation. The values of

KR-20 and Cronbach's coefficient alpha for MFKT, MCUT, IM, EM, TA, SE, SD, and CM are shown in Table 3.8.

Table 3.8. Instrument reliability coefficient values for Cronbach's alpha and Kuder-Richardson

Instrument Type	N. items	Cronbach alpha	Kuder-Richardson (KR-20)
MFKT	14	-	0.723
MCUTT	19	-	0.719
I'M	11	0.894	-
EM	3	0.892	-
TA	4	0.964	-
SE	4	0.995	-
SD	5	0.891	-
CM	5	0.896	-

After the instrument passed through all of this testing and the required adjustments were made, Before and after tests using the completed test and questionnaire versions were sent. This enabled us to assess the preservice physics instructors' motivation and grasp of laws of motion, as well as their factual knowledge, conceptual understanding, procedural knowledge, and problem-solving skills.

3.8. Triangulation of Data

Triangultion is described as "the use of more than one approach to the investigation of a research question to enhance confidence in the resulting findings" (Forbes & Heale, 2013). According to Ndanu et al (2015) the three primary types of triangulation are data triangulation, theoretical triangulation, and methodological triangulation. All were used to boost confidence in the current study's validity. Tests, questionnaires, and recordings of preservice physics instructors' interview responses were utilized to collect the dat. To create a framework for directing the integrated J-4PSS effects and data gathering, four theoretical strategies were used. Methodological triangulation is the process of combining various study paradigms, procedures, data collection, and analytic techniques. The current study used both quantitative and qualitative research methods to improve the overall quality of the study. It was post-positivist in perspective. An embedded mixed-method study design should gather both types of data either concurrently or sequentially, as was previously mentioned.

A study that uses both quantitative and qualitative approaches without explicitly combining the information obtained from each is essentially a collection of different methods, claim Morse & Cheek (2014) .The choice of how to integrate the data is addressed using a rigorous and trustworthy mixed-methods approach. The researcher should be able to combine the two diverse types of data sets .To ensure that, the secondary data outcomes should complement and improve understanding of the primary research questions and findings. Aschbrenner et al (2022) state that a researcher must first analyze the quantitative and qualitative data separately to address the various research questions before moving on to more integrative strategies. Because of this, the researcher combined the qualitative and quantitative data in the study's discussion sections.

Combining the data, which fully answers the research questions, leads to a more thorough representation of the issue under study.To do this, they are grouped into major study themes (such as the impact of J4PSS on the variables assessed in this particular study). A body of relevant literature, which includes both quantitative and qualitative investigations on the subject, was added to the discourse. As a result, combining the quantitative and qualitative results was required to assess the outcomes of the statistical tests.

3.8. Instructional-Materials and Treatments

In the study, three different treatment kinds and one traditional technique were used. 1) Jigsaw-4, 2) Jigsaw-4 problem-solving strategy, 3) problem-solving techniques, and 4) the conventional approach are all ways to solve problems. Lesson plans include the educational resources utilized in this study. These are discussed about in the following order.

3.8.1. Jigsaw-4 Problem-solving Strategy

J-4PSS was adapted by researcher by combining the Minnesota problem-solving techniques of Docktor and Adrian (2022) the Jigsaw-4 Teaching Techniques of Holliday Turkmen and Buyukaltay (2015) and the TECDRER-problem-solving approach from Krulik and Rudnik heuristic tactics (2017). J-4PSS contains seven processes. There are the following: thinking, exploring, choosing tactics, manipulating, reflecting, evaluating, and reteaching. As a consequence, during classroom instruction of the Jigsaw-4 problem-solving approach, the teaching process started with the learners being exposed to the target issue and several problem-solving techniques. In this instance, teachers identified the learners' prior knowledge. In the appropriate learning environment that instructors provided for J-4PSS teaching, students were free to think about and investigate the target topic in their groups. Then, teachers gave students

specialized worksheets for learning activities so they could discuss and gain expertise with the concept being studied (Jainal & Shahrill, 2021) .The ideas formed from a unit's subtopic should thus be the target concept. During the Jigsaw Group or Expert Group, teachers assisted the students in their teams. The preservice physics teacher was then given a space by the teachers to reflect on his understanding of his home group. The evaluation procedure was finished by the teachers. Students participated and structurally cooperated at every level of the learning process. Look at Appendix 7

3.8.2. Jigsaw-4 Techniques of Teaching

According to Turkmen and Buyukaltay (2015) Holliday created the structured cooperative learning approach known as the Jigsaw-4, which entails planning classroom activities that force students to depend on one another to succeed. The preservice teacher divided the class into groups and divided the assignments into as many pieces as the number in the assembled group needed to accomplish the Jigsaw activity. The Jigsaw-4 approach encourages each group member to contribute significantly to the effort required to work collaboratively as a unit to achieve a shared objective and to rely on others to succeed in academic endeavors. Teamwork is what motivates the Jigsaw-4 and makes interaction between them easier. Turkmen and Buyukaltay (2015) proposed nine procedures/steps to do J4:1. lesson's introduction. 2) The expert group has been given expert sheets 3) Before rejoining the home group, groups respond to expert questions 4) The expert group groups took a quiz to assess the content's correctness. 5) Students return to their home groups and talk to their teammates. 6) A quiz to assess the correctness of the information supplied. 7) A quiz was used to assess how well the entire group understood the instruction. 8) Grading and individual evaluation. 9) If necessary, review any information that was missed throughout the assessment.

The handbook served as a guide and source of information for the research assistants (physics instructors) who were involved in this study on the use of the J4TL in the instruction and retention of mechanics-I (Phy-101). The J4TL, like other Jigsaws, Jigsaw I, II, and III, reverse, and subjects, is a student-centered learning strategy that supports preservice physics teachers' participation in the learning process and makes learning more interesting for college physics students while also being able to cover a lot of ground quickly.

When J4TL is used to teach mechanics-I, this handbook tries to reduce instructor variability as well as the impact of a different uncontrollable variable. According to Turkmen & Buyukaltay's (2015) study, Holliday created Jigsaw-4, a cooperative learning method, from Jigsaw III. In Jigsaw-4, the class of per-service physics instructors was divided into smaller groups known as home groups (HG). Every pre-service physics teacher in the HG is required to reflect just a portion of the content from their group, the Expert Group (EG), which qualifies them as experts (masters in a certain field) in a particular piece of the larger puzzle. After teaching and debating their results with their peers, the EGs return to their HGs.The Jigsaw-4 Techniques of Learning methodology was implemented using the processes listed below.Presenting the materials; the principal allocates students to a home group made up of four future physics instructors, fosters student engagement in a plenary session, and presents the curriculum. Each home group's members split up into expert groups. Check out the J4TL depiction in Figure 1 below.

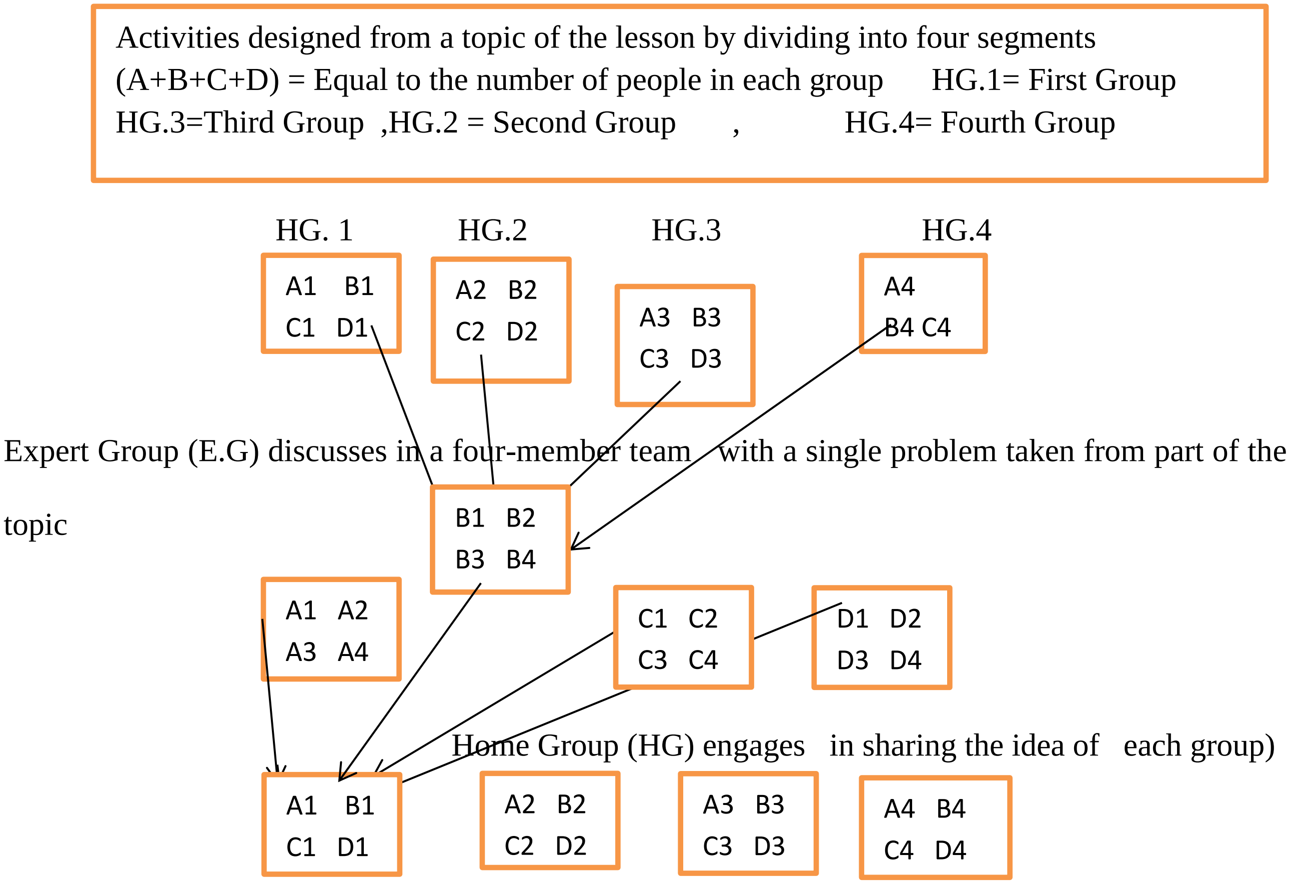
Educational Activity Making Use of Jigsaw-4 Learning; the following stages were used by the researcher to teach the Jigsaw-4 Learning Technique to the experimental group for seven weeks. As a result,1. There are four groups of preservice physics instructors, each with a four-person jigsaw group. A concerted effort was made to ensure that the groups were diverse in terms of gender demographics and aptitude. A Per-service student from each group was chosen to be the group's leader. He was in charge of organizing and directing the group discussion. Other group members were given various responsibilities, including those of leader, recorder, orator, distributor of materials, and timekeeper, who oversees the amount of time allotted for group activity.

The teacher assigned to each member of the group similarly organized the lecture for the day into four parts. Each group of students was given direct access to only their section of the course, and each group was given one segment of the lesson to study. Time was allowed for each student to read their part at least twice to get comfortable with it. The instructor counsels the pupils against memorization of the lecture material.Brief "expert groups" were created. One student from each

Jigsaw-4 group joined the other students whose segments they were allocated to do this. It was provided to the students in these expert groups time to discuss the key aspects of their segment and practice the presentations they delivered to the jigsaw group. To assist the children, the teacher circled the room. Before going back to their home groups, the students quizzed each other on the information on their expert sheets to make sure they understood.

Analysis: Participants in the expert groups were instructed to return to their original home group and instruct other members of that group on the areas they discussed. They reminded one another to assist one another in learning the topic as much as possible. The group members were allowed to hear from each student who had studied a certain portion. The teacher traveled from group to group, observing the process, and then invited other group members to ask questions for clarification. The daily lesson's topic was separated into four parts (A, B, C, and D), and each part was discussed by an expert group (E G) to become an expert in that area. Evaluation: The students responded to questions following the clearly stated particular goals of the lectures. The following class's scripts were collected, noted, documented, and returned once the whole class had been examined individually.

After conducting an individual evaluation, the primary concept and the missing components of each session are retaught. The researcher stressed to the pupils the importance of J4LS before the procedure. The presence of the group's aim, the necessity of exchanging ideas and resources, and the group reward for work division were all topics covered in class. Students in J4LS groups also acquired the abilities they needed to support their group discussions.



Activities designed from a topic of the lesson by dividing into four segments (A+B+C+D) = Equal to the number of people in each group HG.1= First Group HG.3=Third Group ,HG.2 = Second Group , HG.4= Fourth Group

Expert Group (E.G) discusses in a four-member team with a single problem taken from part of the topic

Home Group (HG) engages in sharing the idea of each group)

Figure 3.2.Home Group(HG)and ExpertGroup (EG) relecting their idea on lesson

According to Mbacho (2013), the teacher has the following responsibilities while using Jigsaw-4 in the classroom.

1. He/she organized the pupils into groups that should be varied in terms of aptitude and gender.

2. The most responsible member of each group is chosen as the leader by the person in charge.

3. The instructor broke the lecture up into tasks and wrote them on the chalkboard.

4. He/she assigns a number in the form of a code to each student in each group. Each HG issued the same work to students with the same code, and so forth.

5. He/She made sure that members of each jigsaw group collaborated with others who had the same assignment to establish an "Expert Group" (EG). The instructor allows the expert groups enough time to accomplish the assigned work, talk about it, consult their textbooks, and use other resources.

6. The teacher invites each student to submit their job to the group when they have finished the aforementioned assignment. Then, she sends the pupils back to their jigsaw groups. The teacher moves between groups, watching the activity.

7. After that, the instructor assesses the session by either posing queries or assigning homework based on what was learned as individual evaluation.

3.8.3. TECMRER- Problem- Solving-Strategy

In this treatment, the teacher who oversaw treatment group III also received instruction on how to apply the Minnesota-adapted TECMRER model and heuristic problem-solving techniques that are intended for classroom instruction and used as a means of teaching students how to understand concepts and solve problems. There are seven: bearing in mind the process, investigating the process, selecting a discussion topic, manipulating the process, reflecting the process, evaluating the process, and reteaching the process. The five-step problem-solving process, which was modified, was one of the most important methods for developing problem-solving abilities. These included differentiating a problem and graphically describing it, selecting the proper physics laws and principles, tailoring physics laws to the particular problem, pursuing the proper mathematical procedures, and goal-oriented logical progression (Docktor et al., 2016). He also introduced the lesson and engaged the students in brainstorming by asking them questions about the lesson's subject matter. (Appendix 11). This manual aims to orient and raise awareness for research assistance (physics instructors) employed in this study on the application of TECMRER-problem-solving techniques in the teaching and learning of mechanics-I (Phy-101). The issue-solving technique is a student-centered learning strategy in which, with the help of an assistant teacher who concentrates on each student's activities, the lesson is created based on the problem that is produced by the topic's material. For per-service physics instructors in the teaching and learning process, the teacher has the authority to introduce, demonstrate, and lecture and can swiftly cover a lot of subject matter. In this approach, the student uses problem-solving techniques to solve the problem after receiving a lecture-style lesson note. When the problem-solving techniques approach is utilized in the teaching of mechanics-I (Phy-101), this handbook tries to reduce instructor variability and the impact of a further uncontrollable variable.

The teaching and learning process uses a problem-solving mechanism called Problem-solving Strategies (PSS) that is overseen by an assistant teacher. By fostering logical and analytical thinking abilities in in-service physics instructors under the direction of assistant teachers, PSSs create and enhance the mathematical capacity to answer physics issues. The conversation between a teacher and a student is called PSS. In this teaching strategy, the instructor presents a problem and then offers problem-solving techniques that have been modified from Minnesota problem-solving techniques(Javier, 2019)(Docktor et al., 2016). The steps used in the manipulation process of the TECMRER Model include identifying a problem and graphically describing it, outlining significant physics laws and principles for solving problems, applying particular laws and principles to solve a particular physics problem, practicing the mathematical procedure for solving the problem, and logically reasoning and verifying the accuracy of the solution.

The issue with the topic's substance served as the basis for the lesson's design. He used brainstorming to introduce to the pupils the key ideas of the previous lecture. In other words, a conversation is used to introduce the subject. The replies from the students had been carefully considered and reviewed. The standard teaching approach was used to deliver the lesson. Following the explanation of Newton's principles of motion, the instructor answered any discussion-related inquiries, at which point the student wrote and responded while applying traditional problem-solving techniques. The instructor poses the issue resulting from the daily session and explains the material. He introduced the laws of motion and their definition. The pupils eagerly participated and took notes on the board. To study and teach Mechanics 101, the experimental group was exposed to problem-solving techniques using the traditional method. The following phases were used by the researcher to create a course plan for seven weeks of instruction and learning. The instructor urges students to use the TECMRER model of problem solving by posing open-ended questions related to the lesson's subject. The researcher taught TECMRER problem-solving strategies to the experimental group for seven weeks using the methods listed below.

Every student in the class was required to consider the issue, look into the pertinent data, select and design a solution, manipulate each stage of the process, and reflect on his work for the benefit of his peers. They reminded one another to assist one another in learning the topic as much as possible. After studying the lecture, each student was required to share their thoughts on it with their peers. The classmates were urged to answer clarifying questions. The teacher then went about the classroom to facilitate by watching the action. The processes of thinking, exploring, choosing strategy, manipulating, reflecting, evaluating, and reteaching make up the constructivist approach's TECMRER model. It is put into practice by creating a worksheet that covers the subject of laws of motion while considering the following stages:

1. In "**Thinking process"** step, the teacher poses or asks a question to pique students' interest in reading and comprehending the problem. This helps us determine the level of knowledge of

the students by establishing a link between the preservice physics teacher's prior knowledge and background and the students' acquisition of the domain of laws of motion. What do you think of laws of motion in terms of facts, ideas, rules, and how the laws may be used in the actual world, for instance?

2. **Process of Exploring**; Students do experiments and make observations based on the aforementioned issues in the "Exploring" stage. Each Member researches to learn more about the application of laws of motion in actual circumstances. The student must gain an understanding of the laws of motion, their ideas, and how they apply to a given scenario. Preservice physics instructors must select the right approaches that lead to the answer.

3. **Process of Choosing:** Each student should organize and arrange the steps necessary to discover the answer for the particular application of the problem. These steps are based on the Minnesota problem-solving techniques, which have five phases (Docktor, 2009b). The phase entails explaining the physics, using the proper physics laws and principles, applying the law of physics specifically, following a mathematical technique, and making logical progress.

4. **Manipulation**; Students must put a Minnesota problem-solving strategy plan into action to determine the answer.

5. **Reflecting:** Students are required to share their thoughts on the lesson with their peers

6. **Evaluation:** To determine whether they had understood the lesson's goal, the students posed questions. The following class's scripts were collected, noted, documented, and returned once the whole class had been examined individually.

7. **Reteaching process** After doing an individual evaluation, repeat the core idea and the missing components of each lesson. The researcher stressed to the students the importance of the lesson, the need for exchanging ideas and materials, and the necessity of facilitating their connections.

In this study, worksheet exercises for the class were utilized to execute laws of motion using the TECDRER model as a guide. Students must share responsibility and investigate the following ideas, rules, and laws as well as how they apply to particular issues. This model has the benefit over other models in that it incorporates researching and manipulating to solve problems involving laws of motion. The researcher's TECMRER model was modified using Minnesota-based problem-solving techniques and the Heuristic problem-solving strategy model of Krulik and Rudnick (Tohir, 2018) . The following stages will be followed by teachers and students as they apply the lesson plan utilizing the TECMRER problem-solving approach in Newton's laws of motion issues. (See figure3.4)

Students' understanding of the facts, ideas, knowledge of procedures, the ability to solve issues, inspiration, and perception of outcomes of mechanics, particularly in-laws of motion, will be positively motivated by the use of TECMRER-problem-solving techniques throughout college instruction. Following the Minnesota and Heuristic problem-solving processes, students are more systematically helped and structured which is an essential step in preparing the novice before encountering a more poorly structured problem which is normally encountered in the real-world situation (Docktor & Mestre,2014). Moreover, it is certainly clear that any innovative teaching and learning to the existing lecture-centric classroom situation would welcome the training of a future generation of scientists and technologists.

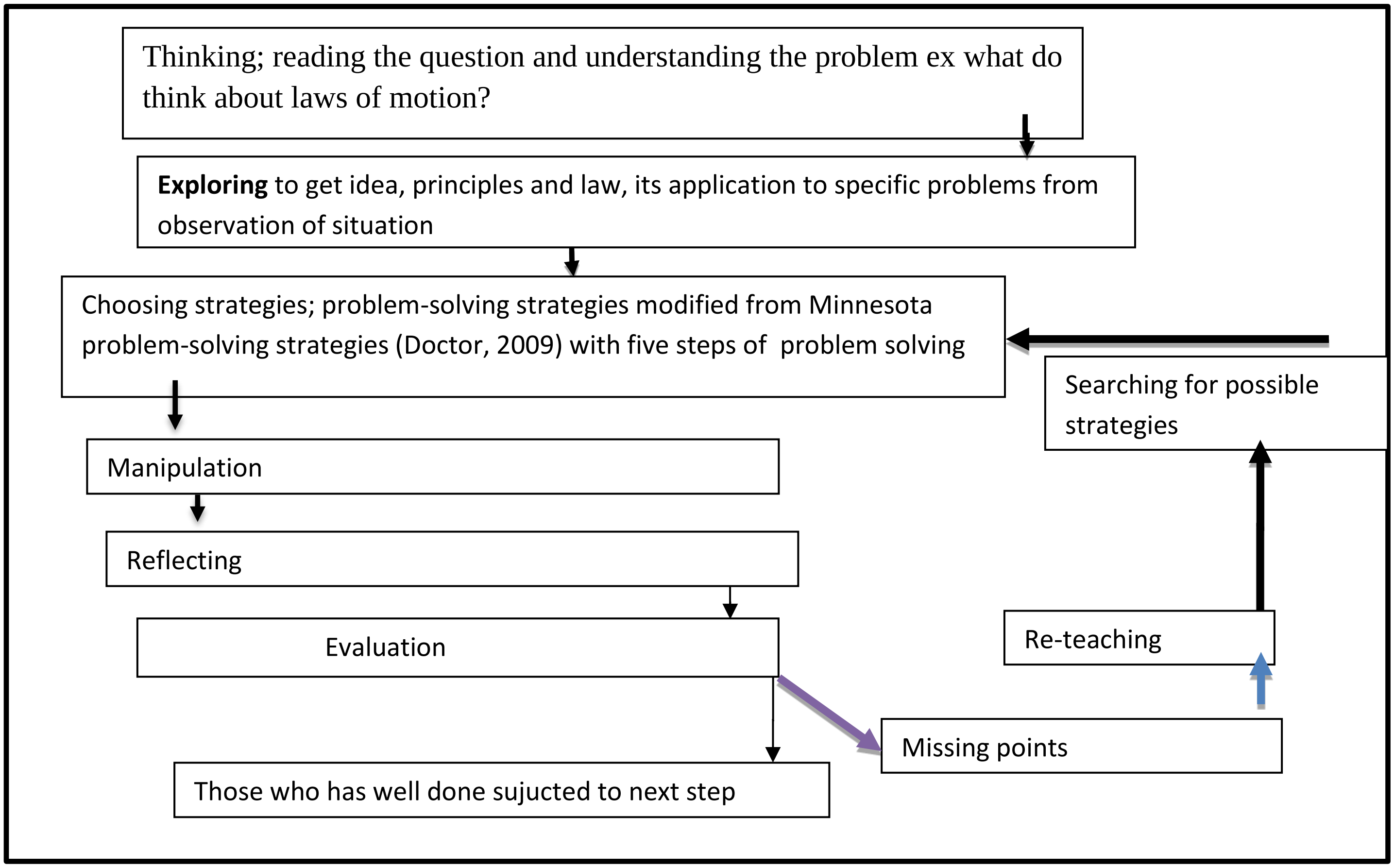


Figure 3.4.: Shows the implementation process of the TECMRER Problem Solving Strategy

The Role of Assistance teachers are implementing TECMRER-problem-solving strategies Assistance teachers must provide appropriate knowledge to establish problems for the learner to understand, clarify, and attempt to formulate procedures for a solution.

1. He /she must pose a problem ,plan and organize summarized notes on the lesson for per-service physics teachers.
2. He/she must help preservice physics teachers understand and define the problem clearly.
3. He/she must highlight the lesson related to the problem at hand.
4. He/she should encourage overcoming the shyness and fears of the per-service physics teacher during the implementation of problem-solving strategies with the conventional approach.

5. He/she must show the learner how to approach a problem and formulate and devise a strategy for a solution and verbal analysis of the problem. In a non-evaluative way teacher should accept writing and wrong /answers.
6. He/she writes the note on the blackboard.
7. The lesson is organized on the base of the problem; the teacher must consider the practical value of this procedure.
8. The discussion of the laws of motion in the lesson should place special emphasis on the reason and consequence of fundamental terms.
9. He /she has to make students participate actively in lesson implementation using problem-solving strategies with the conventional approach.
10. He/she solves the problem in the lesson using Minnesota problem-solving strategies
11. He/she leads toward the goal of the lesson.

3.9. Procedures of Data Collection

The researcher's interest in J4PSS serves as the basis for the investigation. The literature review began before the research problem was identified and lasted through the dissertation's completion. Studies, papers, and articles that were conducted internationally on a worldwide scale examined the efficiency of the teaching of science and the understanding of concepts. The problem of the investigation was decided upon after reviewing the literature. Then, specific research questions were proposed. The development of the materials used during the interventions then started using lesson plans. Some of the tools utilized to get the data were taken entirely from the written word. These instruments were then validated and subjected to a pilot study.

Permission to conduct the study was obtained from the relevant organizations and bodies after the development of the necessary materials and instruments. The section on ethical issues is covered in great detail. Then, the three treatment groups and the untreated group that were previously addressed were not ostensibly assigned at random to the specified portions (intact groups). The three physics instructors who had been chosen to instruct the groups were then trained on how to apply the treatment in the classroom before the intervention. The researcher had discussions with the teachers about the materials that were prepared. Certain portions of the teaching materials had been updated in response to the teachers' comments. As a result, before the study began, the teachers received samples of lesson plans.Performance assessments were administered to the group serving as the comparison PSPT MFKT, M CUT, MPKT, and MPSS as well as the three groups receiving treatment before the start of the classes to see whether there were any notable changes between the groups. In addition to these, before the treatment, the students in each of the groups completed the MMQ (Mechanics Motivational Questionnaires).

The application of the educational strategies was assessed by the researcher and the teachers. After the evaluation, the subsequent week's lesson instructions were reviewed and designed together before the instruction. Hence, the researcher supported the teachers through feedback and suggestions to ensure the proper implementation of the intervention.To confirm that the interventions were being used, the researcher also attended three randomly chosen classes in each of the three groups. The researcher silently observed each of the three groups from the back seat of the room. As a result, the researcher completed the checklist without pausing to rate it. The researcher had also occasionally taken a few more notes. The findings from the checklist and notes taken during classroom observations show that the teachers of the three treatment groups managed their classes according to the researcher's plans. As a result, the PSPTs actively participated in the activities throughout each class session that was observed, and the instructors adequately assisted their performance. In this research, a pretest and posttest were given to all groups to measure the dependent variable both before and after interventions. While the purpose of the pretest is to ensure comparability among groups before the treatment, the posttest was used to determine the immediate effect of the treatment on the outcome variables (Kiefer & Mayer, 2021).

3.10. Methods of Data Analysis

3.10.1 Quantiitative data analysis

Different statistical tests were used based on the nature of the data. Parametric statistics were used for data that were normally distributed.

Standard deviations, the t-test, the paired sample test, the one-way ANOVA, and the post hoc test

are examples of parametric tests. The means differences of each dependent variable's pre- and post-tests were compared using the paired sample t-test. A one-way ANOVA was used to compare the mean scores of the three treatments and one-comparison groups.A post-hoc test is performed to identify precisely which groups differ from one another.

3.10.2. Qualitative data analysis

For the analysis of the qualitative data, the learners' responses were coded using a priori theories, hypotheses, or laws related to the concept of force. Therefore, theories or ideas concerning force can be divided into the following groups: Deductive coding developed as a result, as described in the literature section. Students’ responses to interview questions were compared among the four groups. Similarly, the data obtained from the conceptual understanding test was also categorized, analyzed, and compared among the four groups: no understanding, full understanding, and misunderstanding.

The face-to-face conversation, which provided enough ground for cross-referencing or follow-up questions, has been the distinction from the mechanics conceptual understanding test. It means that questions were asked after a PSPT had taken a posttest for their conformational conceptual understanding. Furthermore, PSPT were encouraged to express their opinions even if they were afraid to react to the trigger question. Learners' deep processing and behavior governing their response to the concept of force were demonstrated in this way. The learners' responses were to be coded using a priori theories, hypotheses, or laws related to the concept of force. As a result, theories or hypotheses about force can be categorized into: as a consequence, as mentioned in the literature section, deductive coding can be conceptualized.

The ontological and epistemological commitment of the normative force idea was related to Newtonian force notions, and learners were required to understand force as a constrained-based engagement and the idea of inertia. The second characteristic of coding was dealing with the dynamic and static nature of macroscopic physical things as seen in everyday life. Force may eventually be viewed as muscular activity or as an entity that can be stored, dissipated, or transferred from one body to another Wael & Sylvain (2020) which is consistent with the Aristotelian view (Rovelli, 2013). Therefore, the two lines of thinking inspired by the aforementioned discussion might be taken into account when coding and analyzing the data gathered from the interview. Table-1

The deductive coding scheme for laws of motion was not only based on the normative scientific enterprise and the historical account but also on the epistemological commitment of normative force concepts. Accordingly, the Newtonian force concept stemmed from the ontological view, which deemed force as a constraint-based interaction (process) that always existed in pairs and acted on different objects involved in the interaction. Therefore, an object can never experience a force without exerting a force on another, as an isolated object is incapable of exerting a force on itself.Depending on the situation, the engagement could be continuous or instantaneous. Furthermore, the items participating in the contact could be in a state of equilibrium or acceleration.

According to the first law of motion, the equilibrium state describes a situation in which an item is either at rest or traveling at constant speed along a straight path. Similar to this, it was believed that the object in the accelerated slate was radically altering its slate (its speed). If the rate of motion is constant, the second law of motion explains the accelerated state of an item.To codify the interviewee's response, it was decided to use the fundamental attribution of the topic of laws of motion based on the ontological and epistemological commitment to normative force ideas connected with major themes. The possible qualities in this regard are utilized to code students' answers to a specific inquiry.

3.11. Ethical issues

Before data collection, approval to conduct the study at the college was obtained from the Addis Ababa University Department of Science and Mathematics, the SNNPRS Education Bureau, and the Dean of each college. The research's aims and objectives, independent of learner and teacher obligations, and possible benefits to the included pupils and instructors will all be well explained at the outset. Teachers and students who participated in the study were given assurances about the anonymity and degree of confidentiality of the findings (Maguchu, 2019). Codes were employed to capture data from each participant to achieve this goal. When marking and processing the data, efforts were made to reduce the likelihood of researcher bias by displaying the results to coworkers. Please refer to Appendices 14 and 15.

Chapter Four: Results

4. Introduction

The findings and data analysis are presented in this chapter. The most important objective of this study was to look at how prospective physics teachers learned about laws of motion and affective aspects after using Jigsaw-4 approaches to problem-solving. The findings on preservice physics teachers' knowledge of facts, understanding of concepts, knowledge of procedures, ability to solve problems, motivation, and views across groups about related literature were therefore presented in the chapter, along with the results of information from both quantitative and qualitative results.This section presents the study's results and findings.

4.1. Pretest Score Analysis

In this study, there were four groups: Comparison Group (CG), Jigsaw-4 Methodologies of Instruction (J-4), Problem-Solving Strategy (PSS), and Composite Jigsaw4 Approach to Problem-Solving Strategy (J-4PSS). The following variables, such as mechanics factual knowledge (MFK), mechanics conceptual understanding (MCU), mechanics procedural knowledge (MPK), mechanics problem-solving skills (MPSK), and mechanics motivation (PM), were reported in the following areas: The participants' beginning states are revealed by the pretest analysis, and the choice of test type is made with the help of assumption checking. As a consequence, a variety of methodologies were used to examine the behavior of the data that was gathered. The MFK, MCU, MPK, MPSS, and PM pretest data were visually inspected, and it was found that there was no outlier and that the data was roughly normally distributed. Additionally, the relevant Z-values, skewness, and kurtosis descriptive statistics were examined.

Table 4.1: Descriptive statistics of pretest scores

DV	Group	M	SD	SS	SE	SZ	KS	KE	KZ
MFK	J4-PSS	7.47	2.34	-0.47	0.40	-1.18	0.03	0.79	0.04
	J4	7.91	2.42	-0.21	0.41	-0.51	-0.21	0.41	-1.11
	PSS	8.31	1.74	0.10	0.40	0.26	-0.37	0.79	-0.47
	CG	7.15	2.33	0.19	0.39	0.48	-0.52	0.77	-0.67
MCU	J4-PSS	16.76	2.45	-0.05	0.40	-0.13	0.69	0.79	0.87
	J4	15.97	1.81	0.04	0.41	0.10	1.48	0.81	1.83
	PSS	16.26	2.48	0.03	0.40	0.06	-0.51	0.79	-0.64
	CG	16.32	2.27	-0.35	0.39	-0.89	-0.11	0.77	-0.14
MPK	J4-PSS	1.86	0.98	0.35	0.40	0.86	-0.85	0.79	-1.07
	J4	1.75	0.89	0.44	0.41	1.08	-0.39	0.40	-0.98
	PSS	1.74	0.95	0.24	0.40	0.60	-0.72	0.78	-0.93
	CG	1.67	0.93	0.17	0.40	0.42	-0.77	0.79	0.98
MPSS	J4-PSS	1.87	0. 402	0.12	0.40	0.30	-0.89	0.79	1.13
	J4	1.75	0.270	0.33	0.41	0.80	0.12	0.80	0.14
	PSS	1.74	0.272	0.33	0.40	0.83	-0.05	0.78	-0.07
	CG	1.67	0.318	0.19	0.40	0.47	-0.16	0.79	-0.20
PM	J4-PSS	1.48	0.18	0.18	0.03	0.40	-0.08	0.03	0.79
	J4	1.45	0.15	0.15	0.52	0.41	-1.27	1.12	0.81
	PSS	1.40	0.18	0.18	0.01	0.40	-0.01	-0.72	0.79
	CG	1.44	0.14	0.14	0.32	0.39	0.82	-0.41	0.77

SS = skewness, SE= Std. An error of skewness, SZ= skewness Z-values, KS= kurtosis, KE= Std. The error of Kurtosis, KZ= kurtosis Z-values

Table 4.1 demonstrated the mean, standard deviation, Skewness, kurtosis, and z-scores of the pre-test findings on MFK, MCU, MPK, MPSS, and PM for all four groups, which comprised the three treatment groups and one comparison group. The data revealed that the mean of the MFK for J-4

PSS, J-4 PSS, and CG were (M = 7.47, SD = 2.34), (M =7.91, SD = 2.42), (M = 8.31, SD = 1.74), and (M = 7.15, SD = 2.33), respectively. The MFK for all groups was measured out of 14 marks. The result of MFK revealed that all groups had a pass mark (50%), as shown in Table 4.1. These confirmed that all preservice physics teachers had similar background information in MFK. The mean of the MCU for all groups was measured out of 38 marks. MCU (M = 16.76, SD = 2.45), (M =15.97, SD = 1.81), (M =16.26, SD = 2.48), and (M = 16.32, SD = 2.27), respectively. The result of the MCU revealed that all groups had pass marks below 50%. These confirmed that all preservice physics teachers had low achievement in MCU.

Similarly, MPK (M = 1.86, SD = 0.98), (M =1.75, SD = 0.89), (M = 1.74, SD = 0.95), and (M = 1.67, SD =2.33) The mean of the score in MPK of PSPT revealed that all groups had poor levels of performance based on a rubric of MPK; these confirmed that all preservice physics teachers lack MPK, MPSS (M = 1.87, SD = 0.402), (M =1.75, SD = 0.270), (M = 1.67, SD = 0.381), and (M = 3.44, SD = 0.19), respectively. The mean performance of PSPT in MPSS revealed that all groups had poor levels of performance based on the rubric of MPSS; these confirmed that all preservice physics teachers had a lack of MPSS.

This implied that the level of quality performance of PSPT in MPSS in learning Newton’s law of motion at the college of South Nation Nationalities People Regional State failed at a weak level., and PM (M = 1.48, SD = 0.18), (M =1.45, SD = 0.15), (M = 1.40, SD = 0.18), and (M = 1.44, SD = 0.14), respectively. The mean performance of PSPT in PM revealed that all groups had poor motivation for physics learning, which confirmed that all preservice physics teachers had a lack of PM. This implied that the level of PM of preservice teachers at the College of South Nation Nationalities People Regional State failed under a poor level of PM.

According to the results of the mean and standard division of the pre-test scores for MCU, all groups received pass grades of less than fifty percent. These results confirmed that all preservice physics teachers had low MCU achievement, and MPK results showed that all groups performed poorly based on an MPK rubric, indicating that all preservice physics teachers lack MPK. Similarly, MPSS results showed that all groups performed poorly based on the MPSS rubric, indicating that all preservice physics teachers lacked MPSS., and PM revealed that all groups had poor motivation for physics learning. These confirmed that all preservice physics teachers had a lack of PM, which generally showed that PSPTs have similar background information and poor achievement in the test.

In terms of skewness, kurtosis, and their respective z-values for each variable (MFK, MCU, MPK, MPSS, and PM), the three treatment and comparison groups have values ranging from -1 to +1 and -2 to +2, respectively, with the corresponding z-values of both skewness and kurtosis falling within the acceptable range (-1.96 to +1.96). This revealed that every value for skewness and kurtosis that was obtained was within acceptable values and ranges. As a result, this data had a skewness and kurtosis that were roughly normal for the normal distribution. This demonstrated that the data did not significantly deviate from normality. These data were, therefore, approximately normally distributed. Thus, the findings of the results after running Kolmogorov-Smirnov and Shapiro-Wilk are presented in Table 4.2.

Table 4.2: Test of normality of pretest scores

Dependent Variable	Groups	Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
MFK	J4-PSS	.156	34	.036	.961	34	.265
	J4	.141	33	.093	.953	33	.166
	PSS	.173	35	.009	.951	35	.122
	CG	.119	34	.200*	.969	34	.423
MCU	J4-PSS	.165	34	.019	.947	34	.100
	J4	.156	33	.039	.966	33	.381
	PSS	.097	35	.200*	.973	35	.538
	CG	.145	34	.066	.977	34	.682
MPSS	J4-PSS	.157	34	.034	.951	34	.130
	J4	.208	33	.001	.938	33	.059
	PSS	.188	35	.003	.943	35	.068
	CG	.205	34	.001	.955	34	.169
MPK	J4-PSS	.151	34	.049	.963	34	.292
	J4	.133	33	.145	.952	33	.148
	PSS	.131	35	.137	.955	35	.161
	CG	.142	34	.082	.948	34	.105
PM	J-4PSS	.112	34	.200*	.972	34	.516
	J4	.137	33	.118	.952	33	.153
	PSS	.083	35	.200*	.979	35	.715
	CG	.110	34	.200*	.969	34	.447

As indicated in Table 4.2 above, the statistical test of normality for MFK test scores of PSPT was not statistically significant: W(34) =.961, p =.265, for J4-PSS; W(32) =.953, p =.175, for J4; W(34) =.951, p =.130, for PSS; W(36) =.966, p =.328, for CG. Similarly, the test of normality for MCU test scores of PSPT was not statistically significant: W (34) =.948, p =.109, for J4-PSS; W(32)

=.943, p =.089, for J4; W(34) =.973, p =.550, for PSS; W(36) =.972, p =.489, for CG. The statistical test of normality for MPSS test scores of PSPT was again not statistically significant: W(34) =.951, p =.130, for J4-PSS; W (32) =.938, p =.0.59, for J4; W (34) =.943, p =.068, for PSS; W(36) =.955, p =.169, for CG. Again, the statistical test of normality for MPK test scores of PSPT was not statistically significant: W(34) =.963, p =.292, for J4-PSS; W(32) =.952, p = 0.148, for J4; W(34) =.955, p =.161, for PSS; W(36) =.948, p =.105, for CG. Similarly, the statistical test of normality for PM test scores of PSPT was not statistically significant: W(34) =.972, p =.516, for J4-PSS; W(32) =.952, p =.0.153, for J4; W(34) =.979, p =.715, for PSS; W(36) =.969, p =.447, for CG. As a result, the test by Shapiro found no significant deviation from normalcy. For small sample sizes (less than 50 samples), uneven means, and unequal variances, the test by Shapiro was proven to be a more effective normality test than the Kolmogorov-Smirnov test (Afeez et al., 2018; Mohd et al., 2011).To verify the presumptions that the differences between the four groups (J4-PSS, J4, PSS, and CG) and MFK, MCU, MPK, and PM are equal. The results of the uniformity of variances test of Levine's test are demonstrated in Table 4.3.

Table 4.3 Levene’s test of pretest scores were displayed

Dependent variable	Levine’s Statistic	df1	df2	Sig.
MFK	1.561	3	132	.202
MCU	1.227	3	132	.302
MPSS	3.670	3	132	.014
MPK	1.387	3	132	.250
PM	.719	3	132	.542

Leine's test of uniformity of variances revealed that the variances of the MFK, MCU, MPK, and P M scores were not statistically significant different from one another, as shown in Table 4.3.F (3,132) =.202, p>.05, and F (3,132) =.302, p>.05, F (3,132) =.250, p>.05, and F (3,132) =.542, p>.05, respectively, for the variances of the MFK, MCU, MPK, and PM scores. Saying it differently, the variances were equal across the groups, implying the uniformity of variances assumption was met. Accordingly, the assumption was not violated by normality.Levine's test results (p =.014) revealed the categories of MPSS among the three treatment groups, and the comparison group was statistically significant concerning preservice teachers' general problem-solving abilities when studying the law of motion. However, the values of Levine’s test for the components of the MPSS were not statistically significant. The finding of homogeneity of the pre-test for problem-solving categories after conducting the Levene test is presented in Table 4.4.

Table 4.4: Analysis of homogeneity of pre-test results for problem-solving categories

Problem-solving skill categories	Levene’s Statistic	df1	df2	Sig.
Distinguishing a problem and graphically describing	.065	3	132	.978
Choosing appropriate physics laws and principles	2.077	3	132	.106
Adapting physics laws to the specifics of a problem	.070	3	132	.976
Pursuing appropriate mathematical procedures,	2.330	3	132	.077
Goal-oriented logical progression	.097	3	132	.962

Table 4.4 shows Levine's testing of the elements of preservice teachers' abilities to solve problems as they learned about the law of motion in physics classes. This showed that even if preservice teachers' ability to solve problems as a whole is statistically significant, individual components were

not statistically significant compared to pretest results. This implied that the problem-solving skills of preservice teachers were not statistically different between treatment groups and a comparison group in their pre-test scores in the categories of ability to solve the problem. Thus, the baseline of the preservice physics teacher in learning physics through problem-solving skills was the same. A one-way ANOVA was performed on the pretest scores following the verification of the normality assumptions to determine the participant's level of understanding of laws of motion. Accordingly, appropriate tests of assumptions were done for the pretest data.

Table 4.5: ANOVA analysis pretest scores

Dependent Variable	Source	SS	Df	MS	F	P
MFK	Between Groups	26.811	3	8.937	1.846	.142
	Within Groups	639.005	132	4.841		
	Total	665.816	135			
MCU	Between Groups	10.896	3	3.632	.772	.512
	Within Groups	621.214	132	4.706		
	Total	632.110	135			
MPSS	Between Groups	.660	3	.220	2.141	.098
	Within Groups	13.556	132	.103		
	Total	14.215	135			
MPK	Between Groups	2.614	3	.871	.594	.620
	Within Groups	193.585	132	1.467		
	Total	196.199	135			
PM	Between Groups	.119	3	.040	1.508	.216
	Within Groups	3.463	132	.026		
	Total	3.582	135			

An ANOVA analysis of the pretest data revealed that there was no statistically significant distinction between the groups in terms of the study's variables. This demonstrated that all of the groups had a similar education in physics at the College of Teacher Education. As indicated in Table 4.5 above, the ANOVA analysis of the pretest scores of MFK and MCU of PSPT is F (3,132) = 0.142, p >.05, and F (3,132) =.512, p>.05, respectively. Similarly, F (2,132) =.620, p >.05 for MPK; F (2,132) = 0.98, p >.05 for MPSS; and F (2,132) =1.509, p > 0.05 for PM. In learning the law of motion at the college of education in the area, the ANOVA F-test result for preservice physics instructors' MFK, MCU, MPK, MPSS, and PM between the control group and treatment group was not statistically significant. In conclusion, the pretest analysis indicated the participants' starting state concerning the MFK MCU, MPSS, MPK, and PM of mechanic concepts. It provided inferential and descriptive statistical data, together with tests of hypotheses, for the pretest results of the treatment and comparison groups on the study's variables

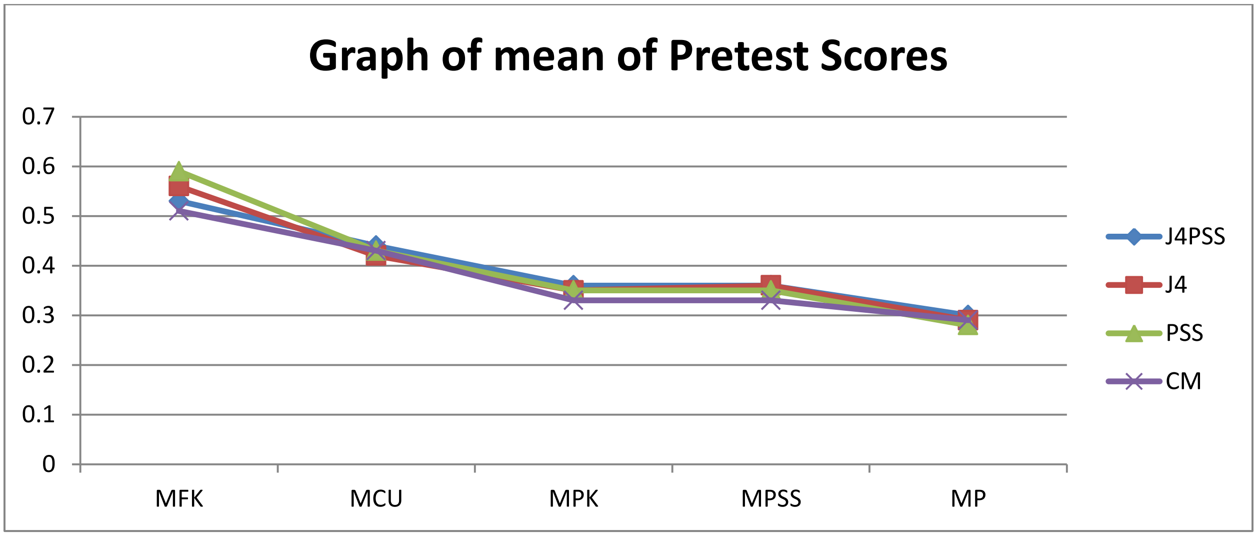


Figure 4.1 ***Mean plot of pretest of MFK.MCU ,MPK ,MPSS and PM of PSPT'S Scores***

Figure 4.-1 illustrates the understanding ideas of Newton's laws of motion and their affecting factors after exposure to various laws of motion and instructional methodologies. The outcomes shown in Figure 4.1 verified the lack of an efficient teaching strategy. ANOVA test supports the assertion since there is no significant difference between the treatment groups.

4.2 Posttest Score Analysis and Interpretation.

Analysis of posttest results showed that the intervention's beneficial effect on the outcome variables examined (MFK, MCU, MPK, MPSS, and PM) of the laws of motion concepts had been positive. A study of descriptive statistics and a test of hypotheses were carried out to compare the data collected from the J-4PSS, J-4, PSS, and CG of instruction. Posttest scores were visually inspected using histograms, normal Q-Q plots, and boxplots, and the results showed that the data were taken from a population that was roughly normally distributed.MFK, MCU, MPK, MPSS, and PM of post-test scores

4.1.1. MFK, MCU, MPK, MPSS, and PM of post-test scores analisis

The descriptive statistics shown in Table 4.6 below include skewness kurtosis and the corresponding Z-scores.

4.2.Table 4.6: Descriptive statistics of post-test scores

DV	Group	M	SD	SS	SE	SZ	KS	KE	KZ
MFK	J4-PSS	9.76	1.76	-.080	.403	-.198	-.115	.788	-.146
	J4	9.03	2.04	-.279	.409	-.683	.411	.798	.514
	PSS	9.43	1.99	.290	.398	.729	-.600	.778	-.772
	CG	9.32	2.06	.641	.403	1.59	-.195	.788	-.248
MCU	J4-PSS	34.03	.451	.290	.403	.720	-.355	.788	-0.36
	J4	24.21	1.23	-.459	.409	-1.12	. 472	7.98	0.60
	PSS	25.54	.827	-.347	.398	-.872	-.154	.778	.198
	CG	21.94	.28	-.134	.403	-.333	-.766	.788	-.972
PPK	J4-PSS	11.34	0.83	-0.71	0.40	-1.75	-1.24	0.79	-0.57
	J4	10.36	0.89	0.44	0.41	1.08	-0.39	0.80	-0.49
	PSS	10.46	0.95	0.24	0.40	0.60	-0.72	0.78	0.93
	CG	7.16	1.17	-0.06	0.40	-0.14	-0.63	0.79	-0.81
MPSS	J4PSS	3.38	0.39	-0.45	0.40	-1.11	-0.42	0.79	-0.52
	J4	2.80	0.22	-0.41	0.41	-0.10	-0.24	0.80	-0.30
	PSS	2.75	0.21	0.24	0.40	0.60	0.07	0.78	0.08
	CG	2.18	0.27	0.35	0.40	0.87	-0.42	0.79	-0.05
PM	J4-PSS	4.63	0.16	-0.51	0.40	-1.27	-0.62	0.79	-0.79
	J4	4.53	0.46	0.15	0.52	0.41	-1.27	1.12	0.81
	PSS	4.40	0.24	-0.75	0.40	-1.88	0.58	0.78	0.74
	CG	4.27	0.53	-0.65	0.40	-1.62	-0.18	0.79	-0.23

For all four groups, which were made up of three treatment groups and one comparison group, Table 4.6 provided the mean, standard deviation, skewness, kurtosis, and z-scores of the post-test results on MFK, MCU, MPK, MPSS, and PM. The data showed that the mean score of MFK for PSPTs' who were taught using J-4 PSS was relatively higher (M = 9.76, SD = 1.76) than PSS (M = 9.43, SD = 1.99), J-4 (M = 9.03, SD = 2.04), and the comparison group (M = 9.76). Similar to this, the mean MCU test score of students who were taught using a J-4PSS (M = 34.03, SD = 0.451) was relatively higher than PSS (M = 25.54, SD = 0.827), J-4 (M = 24.21, SD = 1.23), and CG (M = 21.94, SD = 0). In comparison to PSS (M = 10.46, SD =.95), J-4 (M = 10.36, SD = 1.17), and CG (M = 7.16, SD = 1.17), preservice physics instructors who were trained using J-4PSS had a mean MPK score that was relatively higher (M = 11.34, SD =.83). Similar to this, the MPSS scores of the J-4PSS students had mean values that were significantly higher than those of the J-4 students (M = 2.80, SD = 0.22), PSS students (M = 275, SD = 0.21), and CG students (M = 2.18, SD = 0.27). Both the treatment and comparison groups' PM scores were displayed, along with their means and standard deviations.

According to the statistics, the mean scores and standard deviation for the treatment group were, respectively, M = 4.63, M = 4.71, M = 4.40, and SD =.164, SD =.110, and SD =.242 for J-4PSS, J-4, and PSS. The control group's mean and standard deviations were M = 3.51 and SD =.178 after the law of motion instruction. These indicated that J-4, J-4PSS, and PSS had mean scores that were greater than the CG. This suggests that, compared to the conventional style of instruction, the J4 and integrated J4-PSS are more effective at inspiring preservice physics instructors to learn the law of motion. As opposed to the conventional ways used in the southern country and the Nationality College of Teachers' Education, the interim teaching strategies generally inspired physics preservice teachers in their study of the law of motion. Skewness, kurtosis, and their related z-values for each variable (MFK, MCU, MPK, MPSS, and PM) had values between and in three treatment groups and the comparison group.

Skewness, kurtosis, and their corresponding z-values for each variable (MFK, MCU, MPK, MPSS, and PM) in three treatment groups and a comparison group have values between -1 and +1 and -2 and +2, respectively, and their corresponding z-values of both Skewness and kurtosis are within the acceptable range (-1.96 to +1.96). This showed that all values for skewness and kurtosis obtained were within acceptable bounds. Therefore, when compared to the normal distribution, the skewness and kurtosis of these data were roughly normal. This demonstrated that there was no discernible departure from normalcy in the data. This means that the distribution of these data was roughly regular. Consequentially, Table 7 shows the findings of the Kolmogorov-Smirnova and Shapiro-Wilk tests.

Table 4.7: Tests of normality of post-test score

Dependent Variable		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Groups	Statistic	df	Sig.	Statistic	df	Sig.
post MFK	J4-PSS	.170	34	.013	.956	34	.181
	J4	.161	33	.030	.966	33	.372
	PSS	.117	35	.200*	.954	35	.148
	CG	.184	34	.005	.946	34	.093
post MCU	J4-PSS	.127	34	.177	.943	34	.076
	J4	.159	33	.034	.934	33	.047
	PSS	.111	35	.200*	.980	35	.743
	CG	.111	34	.200*	.965	34	.347
post MPSS	J4-PSS	.129	34	.166	.941	34	.068
	J4	.116	33	.200*	.957	33	.206
	PSS	.110	35	.200*	.961	35	.245

	CG	.120	34	.200*	.963	34	.299
post MPK	J4-PSS	.346	34	.000	.726	34	.000
	J4	.205	33	.001	.908	33	.009
	PSS	.171	35	.011	.907	35	.006
	CG	.114	34	200*	.946	34	.093
PM	J4-PSS	.111	34	.200*	.971	34	.484
	J4	.150	33	.058	.946	33	.104
	PSS	.096	35	.200*	.959	35	.219
	CG	.106	34	.200*	.950	34	.120

According to Table 4.7 above, the post-test scores of MFK, MCU, MPK, MPSS, and PM passed the Shapiro-Wilk statistical test of normality with the following results: MFK, (W(34) =.956, p =.181, for J4-PSS; W(33) =.966, p =.372, for J4; W(35) =.954, p =.148, for PSS; W(34). The findings of the Shapiro-Wilk test to determine the level of normality for the posttest scores of MFK, MCU, MPK, MPSS, and PM for each independent group did not reach statistical significance. As a result, the posttest results for MFK, MCU, MPK, MPSS, and PM were roughly normally distributed. However, due to the success of the intervention process and the subjectivity of the scoring mechanism, there were statistically significant differences in procedural knowledge between the treatment groups for J4-PSS, J4, and PSS (W (34) =.726, p = 0.000; W (33) =.908, p = 0.000; and W (35) =.0.907, p = 0.009, respectively). As a consequence, the Shapiro-Wilk test of MPK indicated that there is significant difference between them; therefore, the post-test results for MFK, MCU, MPK, MPSS, and PM were normally distributed. Thus, the findings of the results after running Levene's test on the posttest are presented in Table 4.8.

Table 4.8: Levene’s test for post-test scores

Test of Variance Uniformity	Levene Statistic	df1	df2	Sig.
Post MFK	.210	3	132	.890
Post MCU	9.559	3	132	.000
Post MPSS	5.661	3	132	.001
post MPK	1.359	3	132	.258
Post PM	2.709	3	132	0.048

MPK (F (3,132) =1.359, $P >.05$.) and MPSS (F (3,132) =5.66, $P < 0.05$). Additionally, PM, F (3,132) = 2.701, $P < 0.05$. The findings of the test of Levene for the MFK and MPK groups revealed that there was not a statistically significant difference between the groups; however, the results for the MCU, MPSS, and PM groups revealed that there was a statistically significant difference between the groups. To determine how much the teaching strategy used in each research group helped PSPTs' MFK, MCU, MPK, MPSS, and PM, a paired-sample t-test was used.

Table 4.9 displayed the outcome of the t-test with a paired sample of pre-post test of perspective physics teachers

Paired Samples Test

	Variable	Mean	SD	Paired Differences 95% Confidence Interval of the Difference								Effective
				M	SD	S. E M	Lower	Upper	t	df	Sig. (2-tailed)	Eta
Pair 1	Pre-MFK	7.71	2.22	-1.68	2.33	0.2	-2.07	-1.28	-8.4	135	0.00	0.343
	-Post-MFK	9.39	1.93									
Pair 2	pre-MCU-	16.33	2.16	-10.17	6.82	0.58	-11.33	-9.01	-17.38	135	0.00	0.7
	post MCU	26.5	6.83									
Pair 3	pre-MPSS-	1.76	0.32	-1.02	0.49	0.04	-1.1	-0.94	-24.31	135	0.00	0.814
	post MPSS	2.78	0.51									
Pair 4	pre-MPK	3.94	1.21	-5.89	2.21	0.19	-6.27	-5.52	-31.16	135	0.00	0.878
	- post MPK	9.83	1.86									
Pair 5	pre-M	1.44	0.01	-2.83	0.56	0.05	-2.92	-2.73	-58.62	135	0.00	0.966
	- post M	4.31	0.04									

Table 4.9 shows the findings of a paired-sample t-test used to assess the impact of interventions on preservice physics teachers' exam scores, which revealed a significant improvement in the PSPTs. The mean scores of the pre-post-test of MFK were M = 7.71, SD = 2.22, and M = 9.39, SD 1.93, respectively, t (135) = -8.397, $p < 0.05$. The average increase in test scores was -1.68, with a 95% confidence interval of -2.07 to -1.28; however, the eta squared statics (0.343) show a minor effect size. Likewise, MCU: After treatment, M = 26.50,SD=6.83 and before, M = 16.33, SD = 2.16, respectively,respectively t(135) =17.383, $P < 0.05$.

The eta square statistics (0.7) indicated a significant impact size, and the mean increase in test scores was 10.17 with a 95% confidence interval ranging from 11.33 to 9. For MPK, before treatment, M = 3.94, SD = 1.21, and M = 9.83, SD = 1.93, respectively, t (135) = -31.15, $p< 0.05$. The average increase in test scores was -5.89, with a 95% confidence interval of -6.27 to -5.52; however, the eta squared statics (0.87) show the highest effect size. Also, in MPSS, after treatment, M = 2.78, SD = 0.51, and before, M = 1.76, SD = 0.51, respectively, t (135) = -24.31, $P < 0.05$. The eta square statistics (0.814) indicate a significant impact size, and the mean increase in test scores was 1.02 with a 95% confidence interval ranging from -1.10 to -0.94. Furthermore, PM After treatment, M = 4.31, SD = 0.04, and before, M = 1.44, SD = 0.01, respectively, t (135) = -62.17, P < 0.05. The eta square statistics (0.966) indicate a very significant impact size, and the mean increase in test scores was -2.87 with a 95% confidence interval ranging from -2.96 to -2.77.

The results demonstrated by the t-test with a paired sample of the pre-post test showed the effectiveness of the intervention in motivating the PSPT participants on MFK, MCU, MPK, MPSS, and PM in learning laws of motion. Effective teaching techniques resulted in PSPT being motivated to understand the laws of motion, and PM groups revealed that the groups differed considerably from one another. Thanks to efficient teaching techniques, PSPT was inspired to understand the laws of motion. After the necessary assumptions were checked, statistical tests were selected accordingly. Thus, an ANOVA was used to examine the effect of interventions on the dependent variables of the study.

Table 4.10: ANOVA analysis of post-test scores

		Sum of Squares	df	Mean Square	F	Sig.	effect size
Post MFK	Between Groups	9.25	3	3.08	0.82	0.48	.180
	Within Groups	495.10	132	3.75			
	Total	504.35	135				
Post MCU	Between Groups	2961.30	3	987.10	39.14	0.00	.471
	Within Groups	3328.70	132	25.22			
	Total	6290.00	135				

Post MPSS	Between Groups	24.59	3	8.20	104.75	0.00	.705
	Within Groups	10.33	132	0.08			
	Total	34.92	135				
Post MPK	Between Groups	342.57	3	114.19	121.51	0.00	.734
	Within Groups	124.04	132	0.94			
	Total	466.61	135				
Post PM	Between Groups	26.95	3	8.98	112.33	0.00	.719
	Within Groups	10.55	132	0.08			
	Total	37.50	135				

*. The mean difference is significant at the 0.05 level

The mean scores for the MFK were F (3,132) =.82, p >.05, with an effect size of η2 =.180 (small), as shown in table 4.10 above. This information was obtained from a study of the data from the post-test for the groups (J-4PSS, J-4, PSS, and CG). To put it another way, 18% of the change in MFK of PSPTs on laws of motion was accounted for by the intervention. MCU, F(3,132) = 39.14, P <.05, with effect size η2 =.47 (moderate). It indicates a moderate difference or relationship between the variables or groups under investigation. It suggests that the observed difference or relationship has a moderate impact or importance in intervention. That is, 47% of the variation in MCU of PSPTs in laws of motion was accounted for by the intervention implemented over control groups. The mean score for the MPSS is F (2, 132) =104.75, P <.05, with an effect size of η2 =.71 (high). It signifies a substantial difference or relationship between the variables or groups being compared. A large effect size indicates a strong and prominent impact or association. That is, 71% of the variation in MPSS of PSPTs in laws of motion was accounted for by the intervention implemented. Similarly, for MPK, treatment F (2, 132) =89.60, P <.05, with an effect size of η2 =.73 (high). It signifies a substantial difference or relationship between the variables or groups being compared. A large effect size indicates a strong and prominent impact or association. That is, 73% of the variation in MPK of PSPTs in laws of motion was accounted for by the intervention implemented. The PM mean score was F (2, 132) =112.332, p <.05, and the effect size was η2 =.72 (high).

It indicates a significant link or difference between the groups or variables under comparison. That is, the intervention that was put into place was responsible for 72% of the variation in PM of PSPTs in laws of motion. The results of the ANOVA test of the post-test demonstrated that there were significant differences among the groups (MCU, MPK, MPSS, and PM), which implied the effectiveness of instruction in the learning of laws of motion. It revealed that there was a considerable distinction between groups to make preservice teachers more motivated to learn the law of motion. In simple terms, the one-way analysis of variance (ANOVA) tells us whether there is a statistically significant difference between any two groups. The locations of the differences are not mentioned. To assess whether pairings of the intervention groups varied significantly from one another based on their post-test results for MFK, MCU, MPK, and PM, post-hoc multiple comparison tests using the Game-Howell test were conducted.

Table 4.11 Post hoc test of post-test scores

Multiple Comparisons	Games-Howell					95% Confidence Interval	
DV	(I) Groups	(Groups J)	MD (I-J)	S. E	Sig.	LB	UB
P M FK	J4-PSS	J4	0.73	0.47	0.40	-0.49	1.96
		PSS	0.34	0.45	0.88	-0.85	1.53
		CG	0.44	0.45	0.76	-0.75	1.63
	J4	PSS	-0.40	0.49	0.85	-1.69	0.89
		CG	-0.29	0.49	0.93	-1.58	0.99
	PSS	CG	0.11	0.47	1.00	-1.14	1.35
P MCU	J4-PSS	J4	10.05[*]	1.31	0.00	6.53	13.57
		PSS	8.72[*]	0.91	0.00	6.32	11.12
		CG	12.32[*]	0.95	0.00	9.81	14.84
	J4	PSS	-1.33	1.46	0.80	-5.19	2.53
		CG	2.27	1.48	0.43	-1.65	6.20
	PSS	CG	3.60[*]	1.14	0.01	0.60	6.60
P MPSS	J4-PSS	J4	.57[*]	0.08	0.00	0.37	0.78
		PSS	.62[*]	0.08	0.00	0.43	0.83
		CG	1.20[*]	0.08	0.00	0.99	1.41
	J4	PSS	0.05	0.05	0.72	-0.08	0.19
		CG	.63[*]	0.06	0.00	0.47	0.79
	PSS	CG	.57[*]	0.06	0.00	0.42	0.73
P M	J4-PSS	J4	0.08	0.08	0.77	-0.14	0.31
		PSS	.22[*]	0.05	0.00	0.09	0.35
		CG	1.11[*]	0.04	0.00	1.00	1.22
	J4	PSS	0.14	0.09	0.39	-0.10	0.38
		CG	1.03[*]	0.08	0.00	0.81	1.26
	PSS	CG	.89[*]	0.05	0.00	0.76	1.02

*. The mean difference is significant at the 0.05 level.

For the intervention pairs J4PSS & J4, J4PSS & PSS, and J4PSS & CG, the PSPT Post Hoc Test scores for the MFK, MCU, MPK, MPSS, and PM were displayed in Table 4.11. The PSPT Post Hoc Test findings for MCU, J-4 PSS and J-4 ($P <.05$, $d = 10.05$), J-4 PSS and PSS ($P <.05$, $d = 8$), and J-4 PSS and CG ($P <.05$, $d = 12.32$). The J-4PSS paired was superior to J-4 and PSS in terms of fostering MCU, according to the post hoc test's findings. A statistically important distinction between the two interventions was shown by the post hoc Game Howell test for PSPT's MPSS: J-4 PSS and J-4 ($P < 0.05$, $d = 0.57$), J-4 PSS and PSS ($P < 0.05$, $d = 0.62$), J-4 PSS and CG ($P < 0.05$, $d = 1.20$), J-4 and CG ($P < 0.05$, $d = 0.63$), and PSS and CG ($P <.05$, $d = 0.57$).

The post hoc test for MPSS of PSPT therefore showed that blended J-4PSS was superior to J-4 and PSS. Therefore, the hybrid J-4PSS was the best teaching strategy. A statistically significant difference was found between the pairs of interventions J-4 PSS and PSS ($P <.05$, $d = 0.22$), J-4 PSS and J-4 ($P >.05$, $d = 0.08$), J-4 PSS and CG ($P <.05$, $d = 1.10$), J-4 and CG ($P <.05$, $d = 0.63$), and PSS and CG ($P <.05$, $d = 1$). This conclusion was supported by the post hoc test for PM of PSPT because blended J-4PSS was more effective than J-4 and PSS. The combined J-4PSS educational strategy proved to be the most successful, and it was superior to the J-4 and PSS. It was also superior to the CG of teaching preservice teachers about the law of motion.

Table 4.12 Game-Howell tests for analyzing post-test results of MPK.

Multiple Comparisons

Dependent Variable: post-procedural knowledge 95% Confidence Interval

Game-Howell

	(J) Gs	MD (I-J)	S.E	Sig.	L B	UB
J4-PSS	J4	.97*	0.24	0.00	0.36	1.59
	PSS	.88*	0.23	0.00	0.27	1.49
	CG	4.18*	0.24	0.00	3.56	4.79
J4	PSS	-0.09	0.24	0.98	-0.71	0.52
	CG	3.20*	0.24	0.00	2.59	3.82
PSS	CG	3.29*	0.23	0.00	2.69	3.90

* The mean difference is significant at the 0.05 level.

Table 4.12 showed the results of a post hoc test, which displayed that there was no statistically significant difference between pairings of J-4 and PSS treatments for MPK test scores, but that there was a statistically significant difference between J-4 PSS and J4, J-4 PSS and PSS, and J-4 PSS and CG. The post hoc analysis showed that integrated J-4PSS was the best method for teaching students equations of motion and improved MPK. The results revealed significant differences among the blended J-4PSS and PSS, J-4PSS and CG, and PSS and CG groups. However, there were no statistically significant differences observed between the J-4 and PSS groups. Notably, after teaching laws of motion using the J-4PSS approach, the combined J-4PSS method resulted in a significant improvement in PSPT's MCU, MPK, and MPSS scores, surpassing the other instructional methods in a statistically significant manner.

The data presented in Figure 4.1 indicates that the average scores of the Control Group (CG) in posttest performance for the subjects MFK, MCU, MPK, MPSS, and PM were lower compared to the treatment groups (J-4PSS, J-4, PSS) in terms of learning the laws of motion. Furthermore, the results demonstrate that the PSPTs who were taught using the blended J-4PSS teaching strategy achieved the highest scores.

These findings provide confirmation that the blended J-4PSS is the most effective teaching strategy for PSPTs in the context of learning laws of motion

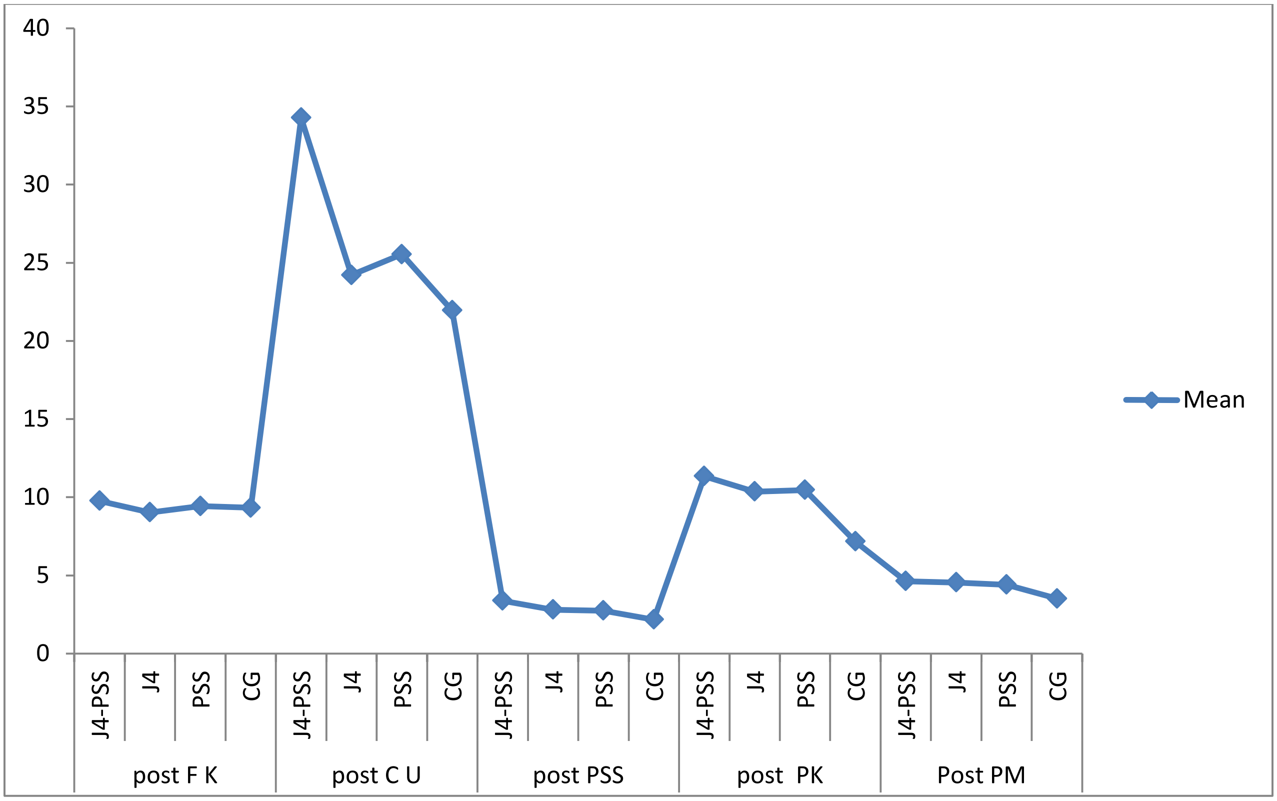


Figure 4.2 mean plot of posttest of MFK,MCU,MPSS ana MP of PSPT'S Scores

Following exposure to different laws of motion and instructional approaches, Figure 4.-2 shows the conceptual understanding level of preservice physics instructors. To classify the PSPTs' degree of understanding of ideas on the 19 questions, three categories—no understanding (NU), misunderstanding (Mis), and full understanding (FU)—were used. The results shown in Figure 4.2 confirmed the effectiveness of the Jigsaw-4 problem-solving strategy over the Jigsaw-4 problem-solving strategy and comparison method.Numerous of the preservice physics instructors who were instructed using Jigsaw-4 problem-solving approaches attained a level of full understanding in items 4, 5, 8, 9, 18, and 19. Shown in Table 4.13.

Table 4.13 Level of MCU versus study groups.

Groups					
Item	Leve	J4PSS	J4	PSS	CM
1	NU	0.00%	36.40%	36.4%	27.30%
	Mis	20.00%	0.00%	80.00%	0.00%
	FU	27.50%	24.20%	22.50%	25.80%
2	NU	24.00%	32.00%	24.00%	24.00%
	Mis	21.40%	21.40%	35.70%	21.40%
	FU	28.60%	24.70%	22.70%	25.80%
3	NU	21.10%	23.10%	26.90%	26.90%
	Mis	26.40%	23.10%	42.10%	31.60%
	FU	30.50%	5.30%	22.00%	23.10%
4	NU	9.10%	28.60%	31.80 %	45.50%
	Mis	13.30%	13.60%	40.00%	20.00%
	FU	30.30%	26.70%	22.20%	21.20%
5	NU	6.50%	16.10%	32.30%	45.20%
	Mis	4.50%	22.70%	31.80%	40.90%
	FU	37.30%	27.70%	21.70%	13.30%
6	NU	3.00%	27.30%	27.30%	42.40%
	Mis	12.50%	29.20%	29.20%	29.20%
	FU	38.00%	21.50%	24.10%	16.50%
7	NU	9.30%	18.60%	37.20%	34.90%
	Mis	18.50%	18.50%	11.10%	51.90%
	FU	37.90%	30.30%	24.20%	7.60%
8	NU	7.90%	23.70%	31.60%	36.80%
	Mis	12.50%	31.30%	43.80%	12.50%

	FU	35.40%	23.20%	19.50%	22.00%
9	NU	33.3 %	16.70%	50.00%	0.00%
	Mis	50.00 %	20.80%	16.70%	12.50%
	FU	13.20 %	28.90%	17.10%	40.80%
10	NU	5.90%	9.10%	14.30%	32.40%
	Mis	11.80%	17/6%	41.20%	29.40%
	FU	30.5	23.50%	18.40%	27.60%
11	NU	9.40%	18.80%	34.40%	37.50%
	Mis	21.10%	15.80%	42.10%	21.10%
	FU	31.80%	28.20%	18.80%	21.20%
12	NU	13.50%	21.60%	32.40%	32.40%
	Mis	16.70%	12.50%	33.30%	37.50%
	FU	33.30%	29.30%	20.00%	17.30%
13	NU	0.00%	7.70%	53.80%	38.50%
	Mis	9.10%	18.20%	45.50%	27.30%
	FU	29.50%	26.80%	20.50%	23.20%
14	NU	3.80%	26.90%	26.90%	42.30%
	Mis	11.80%	47.10%	11.80%	29.40%
	FU	33.30%	19.40%	28.00%	19.40%
15	NU	6.30%	18.80%	18.80%	56.30%
	Mis	28.60%	21.40%	21.40%	28.60%
	FU	31.10%	26.70%	28.90%	13.30%
16	NU	9.30%	18.60%	37.20%	34.90%
	Mis	18.50%	18.50%	11.10%	51.90%
	FU	37.90%	30.30%	24.20%	7.60%
17	NU	13.30%	20.00%	33.30%	33.30%
	Mis	7.10%	42.90%	14.30%	35.70%
	FU	29.00%	22.40%	26.20%	22.40%
18	NU	6.10%	18.20%	27.30%	48.50%
	Mis	5.30%	15.80%	26.30%	52.60%

	FU	36.90%	28.60%	25.00%	9.50%
	NU	0.00%	18.90%	29.70%	51.40%
19	Mis	11.10%	27.80%	16.70%	44.40%
	FU	39.50%	25.90%	25.90%	8.60%

As indicated in Table 4.13, this contains further details. That is to say, Jigsaw-4 problem-solving approaches were used while teaching these topics to the preservice physics instructors, who had the highest percentage of fully understanding the items. For questions 6, 14, 15, and 17, nearly all PSPTs who took problem-solving strategy training scored at the highest level of understanding. The majority of Jigsaw-4 groups also fully grasped items 3 and 12. Most members of the group used as a comparison were fully proficient in items 1 and 2 at their full level of understanding.

On the remaining items, there were cases where an equal proportion of PSPTs in the treatment groups or between the comparison and treatment groups reached the level of complete knowledge. For instance, an equal number of PSPTs were taught using a combination of Jigsaw-4 problem-solving techniques, and Jigsaw-4 reached the full level of knowledge on the item 11 test. On the other hand, an equal number of participants were instructed using Jigsaw-4, and the standard way of teaching attained the full level of knowledge on item 13. In four groups, J-4PSS, J-4, PSS, and CG the level of no understanding (NU) of PSPTs was compared. J4PSS got the lowest proportion of 0.0 for items 1, 9, and 13.

Similar to this, PSPTs taught using J4 had a percentage of 20.0 and came in second lowest on items 1, 9, and 13. Using a percentage of 33.5, PSPTs taught using Conventional Group (CG) received the third-worst scores on items 1, 9, and 13. Finally, PSPTs taught using PSS received a percentage of 46.5. We deduced from the results that J4, CG, and PSS alone were less successful than a mixed J-4 PSS when used to teach PSPTs. The misconception of PSPTs taught in J4PSS was less in 19 items (15%) than in J4 and lower in 19 items (30%) than in PSS. With a percentage of 80 for PSS, item 1 had the highest percentage of misconceptions, followed by items 14 and 4 for the CG and item 14 with a percentage of 47 for J4; item 18 had the lowest proportion of mistakes with a percentage of 5.3 for blended J4PSS.

Table 4.13 demonstrated that blended J4PSS is beneficial in reducing misunderstanding-based on the proportion of PSPT responses to each question as well as item samples. The basis of the study was the laws of motion, gravitational laws, and mechanical force. All responses were evaluated to determine whether there were any common misunderstandings regarding PSPTs; however, only those that differed fairly significantly between treatment and comparison groups were used as an example to illustrate the analysis and delineation of the misperception. As a result, the study and determination of the cause of PSPT misconception used examples from MCUT items 18, 17, 16, 15, 2, and 19. To evaluate students' conceptual knowledge of laws of motion, items 18, 17, 16, 15, 2, and 19 were developed using mechanics content.

Table 4.12 shows that several of the preservice physics instructors who taught with Conventional Group (CG) had a degree of misunderstanding for items 19, 18, 17, 16, 9, 12, and 13. The preservice physics instructors who received CG instruction had the greatest percentage of incorrect answers on these tests. To determine in depth the amount of comprehension preservice physics instructors had on laws of motion, six sample items, comprising 9, 12, 13, 16, 18, and 19, from a total of 19 items, were taken into account.

In item -9,Kochito throws a small ball straight upward. While flying, the magnitude of forces exerted on the ball is __ A) Decreasing, but straight upward B) Constant but directed upward C) Decreasing, but straight downward D) Constant but directing downward

E) Reason out your choice____

The correct choice for item 9 was "D". However, the results showed that PSPTs taught with J4PSS had a selection rate of 12.50%, while those taught with J-4, PSS, and CG had selection rates of 20.90%, 16.70%, and 50.00% respectively, for choices B, C, and D. In the written response, PSPTs mentioned "acceleration caused by gravitational acceleration, gravity, and the force of the earth" as the reason. The study highlighted a lack of conceptual understanding regarding the principles of gravity among the PSPTs

In item 12,Zapaw lifts a brick, which weighs 'A' with constant velocity to a certain height. The force exerted on the brick is

A) Constant, but equal to 'A' C) Constant, but less than 'A'

B) Constant, but equal to zero D) Constant, but greater than 'A'

E) Reason out your choice____

The PSPT provided the precise response to Item 12's choice: "'A'". They were trained with J-4 PSS, J-4 PSS, and CG: 33.30%,29.30%, 20.00%, and 17.30%, respectively. The following reasons played a role in their choice: the concepts of inertia, Newton's second law, and the action-reaction laws were all used. The highlighted misconception in the PSPT was a lack of conceptual comprehension of the laws of gravity.

Item 13:Assume that you stand freely in a fast-moving bus. If the bus suddenly stops, what do you feel? A) Tends to fall backward B) Tends to fall, forwards,

C) Tends to fall sideways D) No change in my position

E) Reason out your choice____

The response "B”, is prone to fall forwards" was the correct answer for question 13. However, among the participants who were instructed using different methods (J-4 PSS, J-4, PSS, and CG), options A, C, and D were selected by 9.10%, 18.20%, 45.50%, and 27.40% respectively. The majority of them acknowledged that the application of the contribution of inertia was the cause of their decision. A conceptual lack of comprehension of the consequences of inertia was the highlight of the misunderstanding in PSPT.

Item 16: Different masses of objects rest on a level frictionless surface. The force required to set in motion -- A) Increases as the mass increases B) is the same for all objects

C) Increases as the mass decreases D) is equal to the respective weight of the object.

E) Reason out your choice____

For question 16, "B" was the correct response. 18,50%, 18,50%, 37.20%, and 34.90% of the PSPTs who were taught using J-4 PSS, J-4 PSS, and CG, respectively, chose one of the following options: A, C, or D. The majority of them acknowledged that the use of friction laws affected their decision. Misunderstanding of the rules of frictional force on a conceptual level was the discovered PSPT mistake.

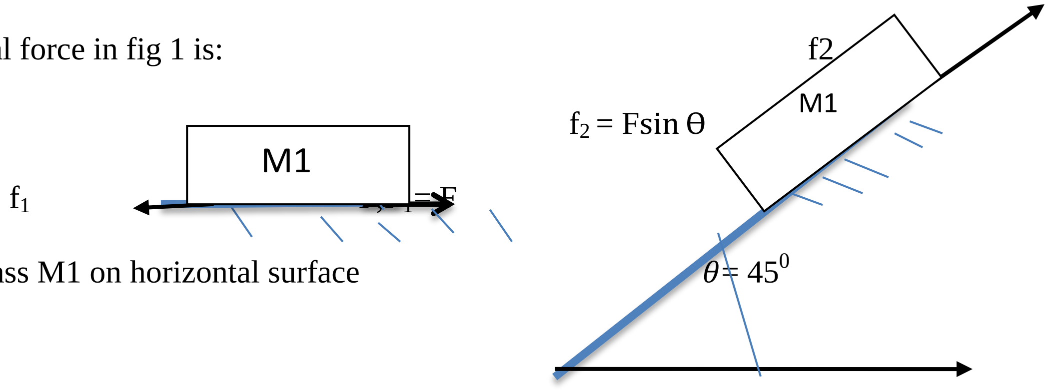
Item-18.,Assume that a body is moving by a net force. Then the body moves with ---------

A) Constant acceleration , B) constant velocity C) An increasing acceleration

D) A and B are the answer E) Reason out your choice____________

Item 18 received the anticipated response "Constant acceleration 'A' from the PSPT who were taught with J-4 PSS, J-4 PSS, and CG, respectively, in the following percentages: 5.30%, 15.80%, 26.30%, and 22.40%. They selected that response for the following reasons. Because of the effects of inertia 2) Applying the principles of inertia 3) using the rules of action-reaction. A conceptual lack of knowledge of the fundamental rules of dynamics, or the 2nd law of motion, was the identified misunderstanding in the PSPT.

Item -19 A forces ‘F’ along an rough surface as shown in diagrams a and b drags a heavy box. The force that was utilized 'F' in both instances is of equal size. The normal force in fig 2 as compared with the normal force in fig 1 is:



a) Mass M1 on horizontal surface

b) Mass M1 on inclined surface θ= 45^0

Fig 7, As seen in pictures a and b, the mass m1 object moves down the surface above

A) The same, B) Greater , C) Less ,D) None

The precise answer for item 19 was “C”. The normal force of f2 is less than the normal force of f1." The PSPT who was taught with J-4 PSS, J4 PSS, and CG scored 11.10%, 27.80%, 16.70%, and 44.40%, respectively, and replied one of the following: A, C, or D to Item 19. Their decision to respond was motivated by the following factors:1) Because of the application of the influence of the gravitational acceleration created on the M1's bulk, it is at rest on the slope. Therefore, the blended J-4 PSS reduced or diminished the misconception more successfully than J-4, PSS, and C.G. The analysis of the results of items 9, 12, 13, 16, 18, and 19 revealed the presence of misconceptions in

PSPT understanding the concepts behind the following facts: the effect of inertia, the application of the laws of inertia, the application of the basic laws of dynamics, and the application of the laws of gravity. Items on a plane inclined at a 45-degree angle are subject to gravity.

4.2.2. Posttest results of procedural knowledge and problem-solving skills

The acquisition and assessment of procedural knowledge and problem-solving skills are crucial components of effective education. In order to gauge the effectiveness of teaching methodologies and learning outcomes, posttest evaluations play a significant role. This introduction aims to provide an overview of the posttest results related to the assessment of procedural knowledge and problem-solving skills among students.Posttest results of procedural knowledge and problem-solving skills.The level of procedural knowledge of PSPT for each item is shown in Table 4.14.

Table 4.14 Level of procedural knowledge across study groups

Item	Level	Groups			
		J4PSS	J4	PSS	CG
Item 1	Poor	6.8%	25.0%	22.7%	45.5%
	Acceptable	28.1%	21.1%	35.1%	15.8%
	well-done	42.9%	28.6%	14.3%	14.3%
Item 2	Poor	0	37.0%	13.0%	50.0%
	Acceptable	29.6%	20.4%	37.0%	13.0%
	well-done	50.0%	13.9%	25.0%	11.1%
Item 3	Poor	0	32.6%	7.0%	60.5%
	Acceptable	18.8%	29.2%	43.8%	8.3%
	well-done	55.6%	11.1%	24.4%	8.9%

Detailed in Table 4.14, the level of procedural knowledge of PSPTs' on item 1 taught using J-4PSS, J-4, PSS, and CG, their performance was 42.9%, 28.6%, 14.3%, and 14.3% of each classroom number of PSPTs, respectively. This implies that prospective physics instructors who employed a Jigsaw-4 problem-solving method outperformed the comparison groups and treatments with the highest performance. But both problem-solving and the comparison group performed equally well on item 1. On the other hand, 45.5% of preservice physics teachers in the comparison group performed poorly in the procedural knowledge test. On item 2, blended Jigsaw-4-problem-solving and problem-solving strategies in the procedural knowledge of preservice teachers performed 50.0% and 25.0% in the level of well-done, respectively. On the other hand, 50.0% of the comparison group and 37.0% of the Jigsaw-4 teaching strategy performed poorly in item 2.

Table 4.15below shows the prospective physics instructors' proficiency in each area of problem-solving. As it is detailed in Table 4.15, the level of performance in problem-solving skills was categorized as very poor [0, 0.20], poor [0.20, 0.40], acceptable [0.40, 0.60], good [0.60, 0.80], and very good [0.80, 1.00]. 53.8% of PSPT participants who received instruction in the Jigsaw-4 problem-solving approach scored at the level of very excellent on question 1. None of the individuals in the comparison group performed at an exceptionally high level. On the other hand, 38.5% of PSPTs using the problem-solving approach outperformed the groups using the Jigsaw-4-problem-solving technique on a very high level.

On item 3, 55.6% of preservice physics teachers who were taught using a Jigsaw-4 problem-solving strategy performed at the level of well-done. Similarly, in the problem-solving strategy group, 24.4% performed at the level of well-done, followed by the Jigsaw-4 strategy. On the other hand, utilizing the traditional way of instruction, 60.5% of prospective physics teachers in a comparison group had poor performance.

Table 4.15: Level of problem-solving skills PSPTs across study groups

Item	Level	Groups			
		J4PSS	J4	PSS	CG
Item 1	Very poor	0	16.7%	16.7%	66.7%
	Poor	14.3%	38.1%	14.3%	33.3%
	Acceptable	31.6%	23.7%	39.5%	5.3%
	Good	42.9%	32.1%	21.4%	3.6%
	Very good	53.8%	7.7%	38.5%	0
Item 2	Very poor	0	3.7%	22.2%	74.1%
	Poor	12.5%	37.5%	12.5%	37.5%
	Acceptable	15.8%	36.8%	36.8%	10.5%
	Good	39.3%	32.1%	25.0%	3.6%
	Very good	73.7%	0	26.3%	0
Item 3	Very poor	0	6.5%	19.4%	74.2%
	Poor	8.7%	43.5%	13.0%	34.8%
	Acceptable	15.2%	36.4%	39.4%	9.1%
	Good	41.7%	25.0%	33.3%	0
	Very good	68.0%	12.0%	20.0%	0

On item 2, 73.7% of PSPTs were taught using a blended Jigsaw-4-problem-solving technique, and 26.3% of students who used the problem-solving strategy performed at a very excellent level. None of the Jigsaw-4 or the comparison groups, however, managed to perform at a very high level. On question 3, the combined Jigsaw-4 problem-solving strategy group scored 68.0% in the very good category. Those who used the Jigsaw-4 approach and problem-solving skills performed at very high levels of 20.0% and 12.0%, respectively. However, none of the comparison groups achieved the outlined level of performance.

In conclusion, the combined Jigsaw-4-problem-solving technique had the most positive impact on procedural knowledge and problem-solving ability compared to all other treatments and comparison groups. Contrarily, compared to the treatment groups, students who were taught using the standard mode of instruction had weak levels of procedural knowledge and extremely poor levels of performance in problem-solving abilities. In addition, the lowest number of PSPTs within the treatment groups achieved a level of well-done on all three items of the procedural knowledge exams.The problem-solving abilities exam consisted of three tasks, and most notably, none of the comparison groups were able to perform at a very high level on any of the three problems.

The degree to which PSPTs motivated students to comprehend the laws of motion was controlled by factors or ideas related to motivation, including intrinsic motivation, extrinsic incentive, exam anxiety, self-efficacy, self-determination, and career motivation. Results of post motivation for PSPT's are shown separately in Table 4.16.

Table 4.16: Descriptive statistics of motivational components after intervention

Motivation Component	Group	N	M	SD
Post Motivation	J4-PSS	34	4.63	0.16
	J4	33	4.53	0.46
	PSS	35	4.40	0.24
	CG	34	4.27	0.53
Intrinsic Motivation	J4PSS	34	4.62	.216
	J4	33	4.77	.196
	PSS	35	4.41	.232
	CG	34	4.76	.281
Extrinsic Motivation	J4PSS	34	4.52	.331
	J4	33	4.71	.287
	PSS	35	4.15	.453

	CG	34	4.53	.545
Test of Anxiety	J4PSS	34	4.54	.334
	J4	33	4.47	.298
	PSS	35	4.35	.438
	CG	34	4.54	.483
Self-Efficacy	J4PSS	34	4.71	.269
	J4	33	4.58	.328
	PSS	35	4.36	.455
	CG	34	4.57	.483
Self Determination	J4PSS	34	4.73	.246
	J4	33	4.84	.190
	PSS	35	4.57	.292
	CG	34	4.59	.467
Career Motivation	J4PSS	34	4.61	.283
	J4	33	4.90	.159
	PSS	35	4.57	.376
	CG	34	4.65	.465

The intervention groups' average means for PSPTs on the motivational component are shown in Table 4.16. Instructed PSPTs by J-4PSS, J4, PSS, and CG had average scores for post motivation were, 4.63, 4.53, 4.40, and 4.27, respectively. The average mean score when PSPTs were taught using J-4PSS was higher than J-4. Similar to PSS, PSPT pupils who received their education through J-4 had mean scores that were higher on average than PSS. Furthermore, PSS students outperformed C.G. in terms of average mean PSPT scores, with blended J-4PSS being the best teaching technique for helping PSPT understand the laws of motion. In Table 4.17, an analysis of variance (ANOVA) was conducted to examine the variations in motivational component scores among the treatments and comparison groups. This analysis provides valuable insights into the potential impact of these interventions on individuals' motivation. By comparing the means and statistical significance, we can gain a deeper understanding of how these different approaches may influence motivation levels. The findings from this ANOVA will contribute to the existing body of knowledge on effective strategies for enhancing motivation and provide valuable information for practitioners and researchers in the field.

Table 4.17ANOVA for Motivational component between treatments and comparison groups

		SS	Df	MS	F	Sig.
Internal Motivation	Between Groups	2.90	3	.97	17.71	.000
	Within Groups	7.20	132	.06		
	Total	10.09	135			
External Motivation	Between Groups	5.58	3	1.86	10.67	.000
	Within Groups	23.02	132	.17		
	Total	28.60	135			
Test of Anxiety	Between Groups	.87	3	.29	1.85	.141
	Within Groups	20.74	132	.16		
	Total	21.61	135			
Self-efficacy	Between Groups	2.25	3	.75	4.81	.003
	Within Groups	20.55	132	.16		
	Total	22.80	135			
Self Determination	Between Groups	1.59	3	.53	5.28	.002
	Within Groups	13.23	132	.10		
	Total	14.82	135			
Career Motivation	Between Groups	2.16	3	.72	6.18	.001
	Within Groups	15.38	132	.12		
	Total	17.54	135			

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Table 4.17 displayed the ANOVA findings; all motivational factors, except for the anxiety test, exhibited a variance that is statistically substantial between groups This shows that while the teaching techniques used had varied impacts on PSPTs' enthusiasm to study physics, they had the same impact on their anxiety during the exam. Descriptive statistics were used to evaluate the dimensions and gather precise data on the efficacy of the intervention on test anxiety by comparing the means of the posttestwith the pretest. Table 4:17 above shows the mean score on the pre-post test TAQ-15, "If I am having trouble learning physics, I try to figure out the way," for PSPTs who were taught using J-4PSS. For the pre- and posttest, J-4PSS had values of (M = 1.5, SD =0.51: M = 4.53, SD = 0.56); J4 had values of (M = 1.38, SD = 0.49:M = 4,83, SD = 0,67); PSS had values of (M = 1.47, SD = 0.51; M = 4.60, SD = 0.67); and CG had values of (M = 1.56, SD = 0.51: M = 4.53, SD = 0.53, respectively

The results of the mean scores for the pretest and posttest about TAQ-16, which measures feelings of helplessness during physics homework, TAQ-17, which assesses nervousness about performance on physics exams, and TAQ-18, which gauges concerns about failing physics tests, revealed a noteworthy increase in test anxiety among the PSPT. The percentage of participants who disagreed (score of 2) with these statements during the pretest was 40%, but during the posttest, it rose to 90% strongly agreeing (score of 4.50). According to the analysis's results, PSP experienced stress due to PSPT test anxiety. We concluded that the PSPT was under induced stress since there was an increase in anxiety, dread, and helplessness as the physics posttest approached and was carried out.

Table 4.18 Mean of posttest and pretest score of PSPTs for each of the dimensions of Test Anxiety (TA).

Item	statistics	J4PSS	J4	PSS	CG	Total	J4PSS	J4	PSS	CG	Total
			Posttest				Pretest				
Q-15	mean	4.53	4.85	4.60	4.53	4.54	1.50	1.38	1.47	1.56	1.48
	SD	0.56	0.36	0.67	0.51	0.57	0.51	0.49	0.51	0.50	0.50
Q-16	mean	4.41	4.3	4.51	4.62	4.46	1.44	1.41	1.53	1.58	1.49
	SD	0.50	0.47	0.66	0.60	0.57	0.50	0.50	0.51	0.50	0.50
Q-17	mean	4.68	4.42	4.29	4.47	4.46	1.47	1.44	1.53	1.56	1.50
	SD	0.48	0.50	0.67	0.66	0.60	0.51	0.50	0.51	0.50	0.50
Q-18	mean	4.56	4.30	4.31	4.56	4.43	1.47	1.38	1.53	1.53	1.48
	SD	0.50	0.47	0.83	0.66	0.64	0.51	0.49	0.51	0.51	0.50

4.2.3. Level of understanding of PSPT concerning higher, medium, and Low achievers scores

Following the implementation of the intervention, a comparison was conducted in order to evaluate the differences in comprehension levels between high, medium**,** and poor achievers in various groups. The study included a total of twenty-four participants, with six PSPTs selected from each group. The objective was to examine how the intervention influenced the scores of participants withdifferent achievement levels and determine if there were any discernible differences between the post-pretest mean score difference in J4PSS achiever levels (high, medium, and lower).

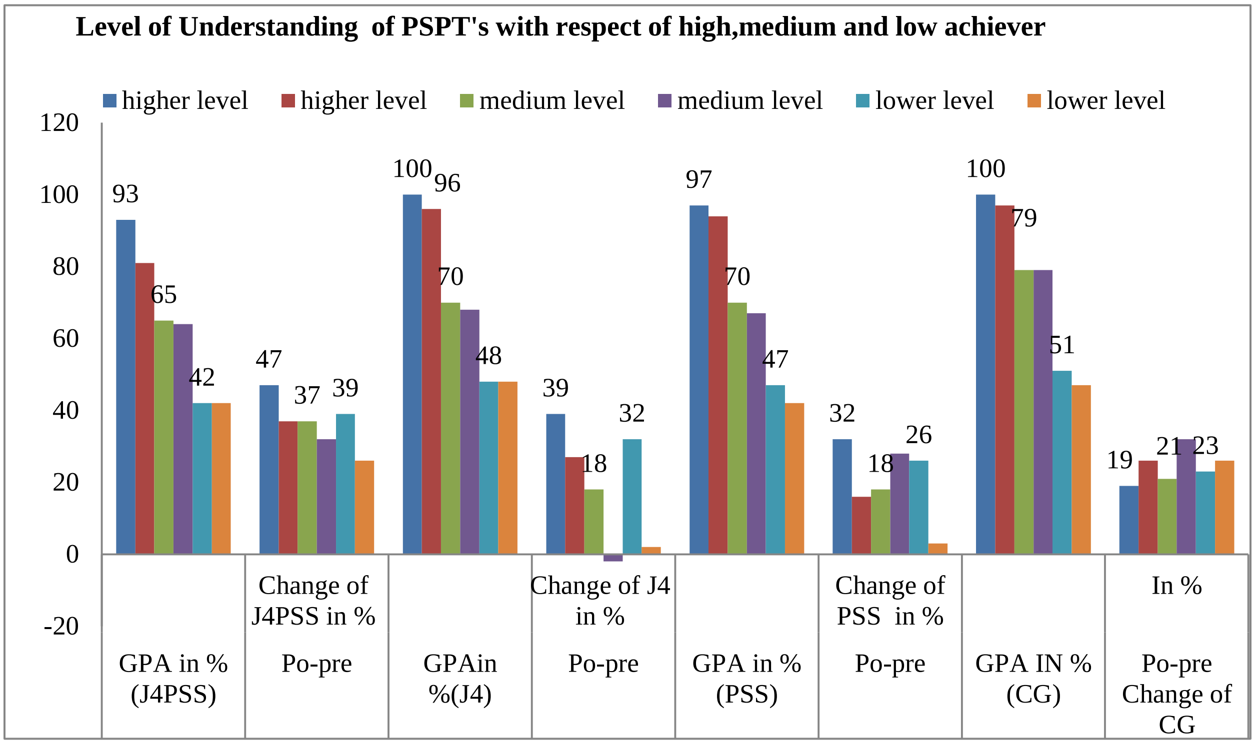

Figure 4.3 Level of understandng of PSPT concernng high ,medium,and low achieers among the groups

Figure 4.3 indicated that there were disparities in achievement levels among the groups. The post-pretest mean score difference in J4PSS achiever levels (high, medium, and lower) was 47%, 37%, 37%, 32%, 39%, and 21% achieved better than J4 (39%, 27%, 18%, -2%, 32% & 2%), PSS (32%, 16%, 18%, 28%, 26% & 3%), and CG (19%, 26%, 25%, 32%, 23% & 26), respectively. It confirmed that high, medium, and low achievers of PSPT who were taught with blended J-4PSS enhanced their conceptual understanding of PSPTs better than J-4, PSS, and CG. Hence, the post-pretest difference in achiever level among the groups resulted due to the effectiveness of the instructional method. Therefore, hybrid J-4 PSS was an effective instructional approach compared to J-4, PSS, and CG. Similarly, Figure 4.3 demonstrated that the mean of the change in achievements of post-pre-tests for lower achievers who taught with J4PSS was 33%, outperformed better than lower achievers who taught with J-4 was 17%, lower achievers who taught with PSS was 15%, and 24% for C.G. The results demonstrated the effectiveness of the integrated Jigsaw-4 problem-solving strategy in the teaching of the laws of motion.

4.2.4. Findings from interview data on the perception of teaching candidates in physics

Semi-structured interviews were conducted to collect detailed information on students' conceptual understandings and misunderstandings of laws of motion. Six PSPTs from each cohort made up the twenty-four participants in the interview.Findings from interview data on the perception of teaching candidates in physicsThe findings of the interviews were analyzed following the five subtopics of the laws of motion unit, including conceptualizing ideas of force, the benefit of frictional force, laws of inertia, the 3rd law of motion, and the nature of frictional force. Interviewees from the four groups were asked generic questions regarding these five laws of motion subtopics first, followed by more focused questions to gauge their conceptual comprehension and misunderstandings.

Theme-One: Perceptions of preservice physics teachers on the conceptualization of laws of motion

The first general question focused on conceptualizing the laws of motion. In the preservice physics teacher’s response, most of the interviewees from all groups described that there are three kinds of laws of motion. They mentioned the different laws of motion that can be used in our daily lives. This can be evidenced in the following transcript. *“There are three kinds of laws of motion, such as the first law, or laws of inertia; the second law, or laws of dynamics; and the third principle of action-reaction that we apply to our day-to-day activities such as pushing, pulling, and movements; and cutting objects”* (PSPT 1, J4PSS). In contrast, PSPT2 from Jigsaw-4 is also explained as: “Laws of motion are the forces that result from the product of mass and acceleration, as well as action-reaction forces in which they have the same size but are pointing in opposite directions." Regarding similar questions on the conceptualization of the law of motion by PSPT from PSS, the comparison group responded: “*Laws of motion are used for moving something, pushing, or pulling something, and for any activity* “.However, when interviewees were asked specifically what force does to a body in their daily life and the reason behind the result, only most of the interviewees from J4PSS, J4, and some of the interviewees from PSS correctly answered the effects of motion in their daily lives, but they failed to correctly answer the difference between three kinds of laws of motion. Some interviewees from the comparison group expressed confusion about the various sorts of laws of motion and how they are applied in daily life.

Regarding the daily experiences of the law of motion, different conceptualizations were explained among the groups: “I think we applied it in our daily activities to do muscular activities like cutting, pushing, pulling, and any movement. When the man kicked with a stick on the hand, then the body was swollen and created pain.” (PSPT-3, J4-PSS) The PSPT2 from Jigsaw-4 also explains the application of the law of motion: “laws of motion are defined as a push or a pull. It manifested itself in our environment through muscular activities such as digging, doing something, and running." Similarly, preservice physics teacher PSPS2 from PSS also mentioned its application’: “The presence of rules of motion is demonstrated by the motion that surrounds us. As a result, the rivers flow continuously until they reach the ocean." Also, one of the comparison group preservice teachers explained: “The object at rest has no force applied to it because it is at rest.”.

Based on the nature of the force conception category, it indicates that respondents from the J4PSS had a better comprehension of the concepts involved in equations of motion. According to the quantitative data analysis findings of the conceptualization of the law of motion items 18, 19, and 20 in Figure 4, PSPT in J4PSS had a greater understanding of the concepts in this category.

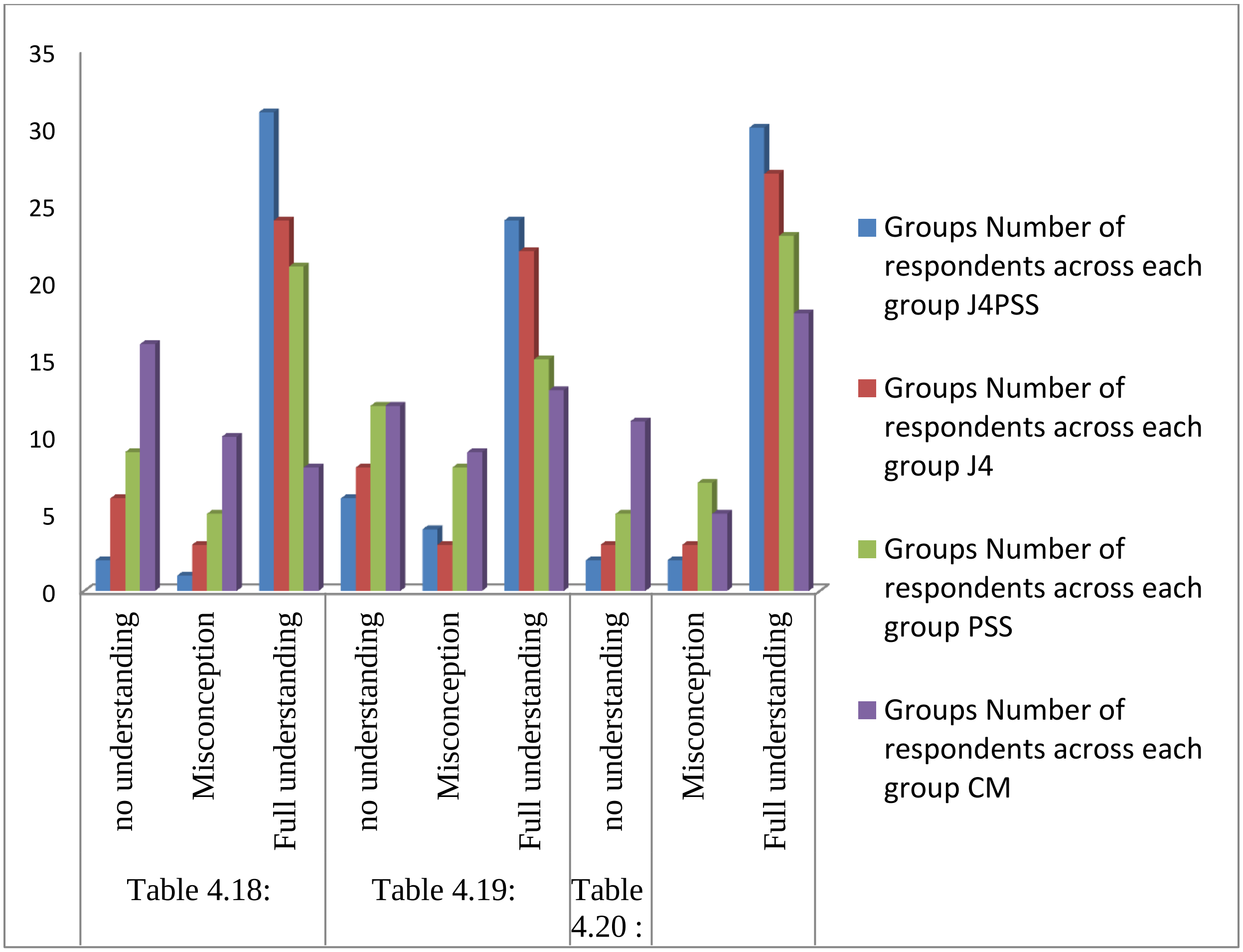

Figure 4.4.demonstrates the effectiness of J-4 PSS in nderstanding the laws of motion

Figure 4.4 indicated that there were disparities in understanding levels (full understanding, misconception, and no understanding) among the groups. The post-mean score of the test of three items (18, 19, and 20) in J4PSS understanding levels (full understanding, misconception, and no understanding) was 28, 2, and 3, which understood better than J4 (24, 3, and 6), PSS (20, 7, and 9), and CG (13, 10, and 13), respectively. It confirmed that full understanding, misconception, and no understanding of PSPTs who were taught with blended J-4PSS enhanced their conceptual understanding of PSPTs better than J-4, PSS, and CG. Hence, the post-pre-test difference in achiever level among the groups resulted due to the effectiveness of the instructional method. Therefore, hybrid J-4 PSS was an effective instructional approach compared to J-4, PSS, and CG. Similarly, Figure 4.4

demonstrated that the mean of the post-tests for no understanding who taught with J4PSS was 2 respondents lower than those who taught with J-4 was 6 respondents lower than those who taught with PSS was 9 respondents, lower than those who taught with C.G. 9 respondents. The results demonstrated the effectiveness of the Jigsaw-4 problem-solving strategy in teaching the laws of motion.

Following the implementation of the intervention, semi-structured interviews were conducted to collect detailed information on students' conceptual understandings and misunderstandings of laws of motion. Six PSPTs from each cohort made up the twenty-four participants in the interview.

Theme Two: Perceptions of prospective physics teachers on the nature of frictional force.

The second question was about how preservice physics teachers describe the ball‘s movement on a frictional surface with constant acceleration. Do you think it will stop? When we look at PSPT’s responses to the first question, it can be said that the majority of interviewees in all groups described the nature of force. In particular, all interviewees in J4-PSS, Jigsaw-4, and PSS correctly explained the nature of force concepts, but some of them failed to recognize the effect of force in everyday activities. The responses of a few students to the second question are quoted below."*Because there is friction, it opposes the motion, so the ball would stop. It will not continue moving. Describe how the first law of motion relates to what you're saying. No, because the ball is not moving, it will continue to stop. So it has a relationship with the laws of motion* "(PSPT-3, J4-PSS).

From the Jigsaw-4 treatment group, PSPT and S-4 also explained questions concerning the nature of force concept, such as: “The ball is rolling on a frictional surface; it does not have a constant velocity. Since there is resistance, the ball continues its motional condition. A force applied to a body is oppositely proportional to the mass of the body multiplied by its rate of acceleration. Yes, because it is in a state of motion on a frictional surface." When the ball is rolling in a frictional straight line at an unchanging speed, yes, it is stopped due to the force of friction making it stop" (PSPT-5, PSS). Similarly, the preservice physics teacher from the comparison group replied to the same question:” The ball is rolling in a frictionless straight line at constant velocity. No, because it continues moving as a result of acceleration due to gravity" (PSPT-b, Comparison Group (CG)).

However, with regards to specific questions on the rolling of the ball on a frictional surface, almost all the interviewees from J4-PSS, the majority of the interviewees from Jigsaw-4, and some interviewees from PSS and CG answered correctly about the rolling of the ball on a frictional surface. However, the majority of PSS interviewers and some CG interviewees were unable to explain why the ball would roll on a friction-free surface. "*I think the ball rolling on the frictional surface would stop, due to the principle of frictional force”* (PSPT-6 J4PSS). Two of the preservice physics teachers explained the frictional force concerning opposing forces as follows: “*The ball would not move in a straight line and would instead come to a stop because there is a frictional force acting on it*" (PSPT-6, J4, PSPT-5, PSS). The similar questions raised for the comparison group can be related to the motion of a ball with running water: "*The cause of the motion of a moving ball on a frictionless straight line was a gravitational force, which is similar to running water from rivers*" (PSPT d, CG).

Only a few students comprehended that the motion of the moving ball was caused by the constant force supplied to it by an external body, even though interviewees from PSS and J4 discussed the rationale behind the force of the moving ball. One of the misconceptions was that the ball had constant velocity when varying, one by the PSS group of a preservice physics teacher and another by CG, and that the cause of motion was not gravitational force. The first misconception was that PSPT had a misconception about the cause of the force behind the moving ball, and the second was also a misconception about the cause of the motion. A conclusion that can be drawn from this qualitative data is that the group had conceptual understanding issues with the force driving the moving ball and the origin of motion.

From the above report on the second theme, it appears that Jigsaw-4 interviewers were good, but J4-PSS interviewers also demonstrated a better understanding of the concepts, in particular, how force, mass, and acceleration are related. Furthermore, more J4-PSS interviewees provided additional explanations, which is a sign of their knowledge. The results of the quantitative data analysis, particularly for PSPT in J4-PSS, verified this conclusion. For instance, an examination of this category's item 8 (Table 4.19) revealed that the PSPT in J4-PSS understands its relationship to the newtons first laws of moton

Table 4. 19: CUQ8. 8. A moving ball on a level surface is seen to decrease its speed and comes to rest in the end. The reason is   .

		Groups				
		Number of respondents across each group				
		J4PSS	J4	PSS	CM	Total
	no understanding	3	9	12	14	38
	Misconception	2	5	7	2	16
	Full understanding	29	19	16	18	82
Total		34	33	35	34	136

Theme-Three: Perceptions of prospective physics teachers on the Inertia’s principle

The third question focused on how preservice physics teachers distinguish between mass, acceleration, and force. In the preservice physics teachers’ responses to these specific questions, interviewees in all groups described the difference between mass and inertia very well. In particular, the large numbers of interviewees from J4-PSS, almost all interviewees from PSS, and some interviewees from Jigsaw-4 and CG explained the difference between them very well during the interview. Sample transcripts are presented as follows: "*Mass is the measure of the inertia; hence, a large mass has large inertia and a small mass has small inertia. Yes, I can give examples of inertia. Inertia is demonstrated by the accidental displacement from the safe location while the car is stopped*.” (PSPT6, J4PSS)

On the other hand, the treatment and comparison groups also explained the comparison between mass and inertia as follows: “*While inertia refers to an object's propensity to resist motion, mass refers to an object's total amount of matter."* (PSPT6 J4), "Mass is the material contained in the body, and inertia is similar to mass." (PSPT6, PSS) "*Mass is the pull of gravitational force on an object, but inertia is mass times the square of the distance from the center*." (PSPT-e, CG). Moreover, concerning the response of PSPT to the difference between mass and inertia, most of the interviewees from J4-PSS and PSS understood the concepts of mass and inertia, but some of the interviewees from Jigsaw-4 and CG misunderstood them. Some interviewees from PSS and most interviewees from Jigsaw-4 and CG, however, did not realize the concepts of mass and inertia because they considered mass and inertia to be similar. This indicates the existence of misconceptions among interviewees, though the extent varies. Below is a sample quote from each group."*While the body's mass serves as a proxy for inertia, inertia is the capacity of the body to resist being at rest.*

The enormous mass has a lot of inertia, whereas the little mass has a little inertia. "*Inertia is a necessary condition for mass, yet it is the body's resistance to motion***."** (PSPT-4, Jigsaw-4), "*Mass is the amount of quantity contained in an object, but inertia is the tendency of the object to resist the external force acting on it*." (PSPT, PSS), "*Mass is the content of matter in the body, but inertia is when the body is moving. The meaning of weight and mass is the same*." (PSPT-P, CG)

Similarly, when PSPTs were asked to describe the relationship and difference between mass and inertia, they answered the question. Interviewees from Jigsaw-4PSS correctly explained the difference between mass and inertia. However, most of the interviewees from all groups, especially from Jigsaw-4, PSS, and CG, did not realize the relationship between inertia and mass. Most of them had misconceptions. The PSPTs are in J4-PSS. Sample transcripts are presented as follows: "Because inertia is proportional to mass, enormous masses have vast amounts of it, even though inertia is a body's ability to resist being at rest. The ideas of mass and inertia are interconnected." (PSPT-2, J4-PSS). Also, a treatment group of Jigsaw-4 PSPT-3 explained that *"the ability of a mass to resist motion is known as inertia, yet a body's mass is its internal substance*." *Preservice training, however, found in the PSS, interpreted that "inertia is the property of the body to resist its state of rest, but the mass is inertia.*" (PSPT1, PSS)" *One of the comparison group preservice physics teachers mentioned that "mass is a matter contained in objects, but inertia is not*." (PSPT5, CG).

Table -4.20. Displays the level of understanding of PSPT in understanding, among them, No-understanding, Misconception, and Full understanding.

Table 4 .20. understanding of how mass and inertia interact

		Groups				
		Number of respondents across each group				
		J4PSS	J4	PSS	CM	Total
	no understanding	0	6	18	12	36
	Misconception	3	5	4	12	24
	Full understanding	31	22	13	10	76
Total		34	33	35	34	136

The "laws of inertia" fall under this heading. It appears that interviewers from the J4-PSS have a profound understanding of the relationship and distinction between mass and inertia. This outcome is consistent with the findings of the quantitative study, which demonstrated that PSPT in J4-PSS outperformed the others. To illustrate the higher performance of PSPT in J4-PSS, consider the analysis of item 9 from this category (Table 4.20). During the interview, it was also established that the relationship and differentiation between mass and inertia were not discovered by the analysis of quantitative data.

Theme Four: Perception of the Preservice towards the 3rd Law of Motion.

The perception of preservice individuals towards the third law of motion holds significant importance in the field of physics education. By exploring how these individuals interpret and apply the laws, we can enhance our conceptual understanding. From the respondents' interviews, the following is taken: “*Mass B responds to the application of mass MA to mass MB by producing an opposing force whose strength is equal to the mass of mass A. The interpretation was based on the third law of motion*.” [J4-PSS, PSP-T1]. Furthermore, PSPT-2 in the Jigsaw-4 treatment group is described as follows: "*According to the third law of motion, when a force is applied to mass A, mass B experiences an equal and opposite force in response to the pressure caused by the upward force. This reaction force on mass B is equivalent to the weight of mass A. On both masses was applied in the other treatment group under the gravitational force's rules: small force applied on mass A by mass B, big force applied on mass B by mass A*" (PSPT-6, PSS). Mass B receives a significant force because mass A is larger than mass B: "*Mass A exerted a significant force on mass B, but mass B did not exert a force on mass.*" (PSPT-F, CM). The comparison group provided an alternative way to apply the third law of motion, CG. Based on this category, impetus, it shows that most interviewers from all groups understood the concept of action and reaction force between mass A and mass B. Interviewees from the J4-PSS and Jigsaw-4 treatment groups provided reasons for the use of force against each of them. This result validates quantitative evidence that demonstrates J4-PSS pupils have better conceptual comprehension.

The analysis of item 5 in Table 4.21 and figure 4.5 from this category clearly shows how well the students performed on Jigsaw-4. The findings of the interviews provided evidence to corroborate the quantitative conclusion, demonstrating that J4-PSS respondents had a solid understanding of the relevant concept. Both qualitative and quantitative data on the third law of motion for two objects showed that the PSPT in the J4-PSS treatment group did better than the other two treatment groups and the comparison group (Figure 4.5).

This shows that the Jigsaw-4 and PSS treatment groups, respectively, and the one receiving the treatment group in the J4-PSS, had the greatest levels of comprehension of the concept. The comparison group, however, shows a lesser degree of conceptual comprehension of the action-reaction force. From this, it can be inferred that the J4-PSS technique was the most effective way to teach the law of motion to preservice physics teachers during their first year of training. In comparison to

J-4, PSS, and CG, all treatment groups exhibit the lowest levels of misunderstanding of the law of motion's fundamental notions. In contrast, the jigsaw problem-solving teaching method was the most effective way to teach the law of motion because it encouraged students to work together and learn from one another. Figure 4.5, which shows the PSPTs' level of conceptual mastery of the third law of motion, provides an example. The graphic gives a visual picture of how well the participants have understood this particular subject.

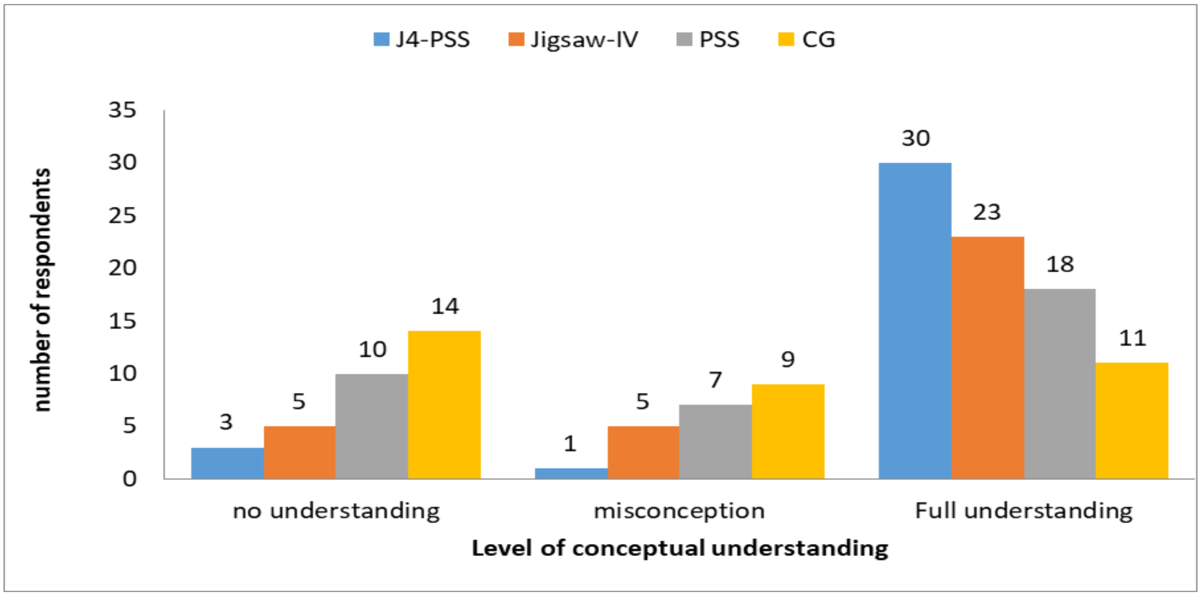

Figure 4.5 the exient to which the third laws of motion is conceptally understood by PSPT.

Theme five: the view of prospective physics teachers in training about an object's movement on a certain surface.

In the fifth question, it was determined if physics instructors in training could recognize and understand the type of smooth or uneven surface that an item was moving over. The vast majority of respondents from J4-PSS, Jigsaw-4, PSS, and CG described the sort of surface. However, when answering this specific question, they were unable to list their benefits and drawbacks, except for a few from J4-PSS and Jigsaw-4. The following transcript from the text was arranged in chronological order:*The floor surface over which the item can move has benefits and drawbacks, mostly because it can alter the frictional force between two surfaces*'". (PSPT-5, J4-PSS). "*There are two different types of surfaces: smooth and rough. Smooth surfaces are polished to minimize frictio*n." (Jigsaw: 4; PSPT: 4). "*We must smooth down the uneven layer between them to reduce the amount of friction* "(PSS, PSPT-5). "*The type of surface between two objects can affect the force between them*" (PSPT-G, CG).

PSPT specifically asked interviewees from J4-PSS and Jigsaw-4 about the benefits and drawbacks of the nature of the surface between them; virtually all of them acknowledged the advantages of the nature of the surface, such as walking, cutting, and decreasing or raising friction. Few of the PSS and CG interviewers were able to pinpoint the origin of the disparity, although several of them correctly identified it. The following are a few sample extracts: "*The benefit of a surface that's silky is that it is impossible to move on it*." (PSS, PSPT-6). "*The roughness of the surface has both benefits and drawbacks. I can walk on the surface, for example, yet someone else could hurt themselves if the fabric's surface is rough in another circumstance*." (Jigsaw-4; PSPT-5). "*A rough surface can be employed for walking and cutting other motions.*" (C. G., PSPT-T). According to the responses of preservice physics teachers in J-4PSS, J-4, PSS, and CG, both smooth and rough surfaces offer benefits and drawbacks. To answer the precise query about the surface's nature, PSPT had to comprehend the surface's kind, purpose, and natural state.

The majority of interviewees from each group acknowledged the categories and described how they worked, but there was heterogeneity in how they explained the ideas that underlie the activity. Some Jigsaw-4 interviewees and the vast majority of J4-PSS interviewees did better in this instance in describing the characteristics of the surface. From this category on the influence of friction, it appears that nearly all respondents from all groups characterized the kind of nature of the surface and the differences among them, although Jigsaw-4's PSPT was shown to be more effective at characterizing the nature of the surface. The results of the interview corroborate the numerical findings. For instance, Table 4-21 demonstrated the students in the J4-PSS groups' superior performance. However, J4 and PSS also had less conceptual understanding.

Table 4.21 showing the level of understanding of the PSPT in the effect of friction

		Groups				
		Number of respondents across each group				
		J4PSS	J4	PSS	CM	Total
Level of understanding of PSPT	no understanding	0	7	11	19	37
	misconception	2	5	3	8	18
	Full understanding	32	21	21	7	81

Chapter Five : Discussion

5. Introduction

The researcher contrasts the different teaching methods (Jigsaw 4-problem-solving strategies (J-4PSS), Jigsaw 4 (J-4), and problem-solving approaches (PSS)) against the conventional method in teaching laws of motion for physics teachers in training. The learning outcomes used to examine the effectiveness of the teaching techniques were: motivation, perception, ability to solve problems, knowledge of procedures, conceptual comprehension, and knowledge of the facts. The pretest-posttest data were collected and analyzed. The necessary tests of assumptions were checked to employ inferential statistics. Accordingly, descriptive statistics such as mean, standard deviations, paired sample t-test, and mean difference and inferential statistics such as one-way ANOVA and post hoc Tukey HSD test were used for data analysis. In this chapter, discussions are presented by relating the results of the study to previous research. The discussion begins with factual knowledge followed by conceptual understanding, procedural knowledge, problem-solving skills, and motivation of preservice physics teachers' after being taught different instructional strategies. The discussions are organized around the research questions, and finally, a triangulation of the results of the study is presented.

5.1.Students' performances on Factual knowledge and conceptual understanding in-laws of Motion

The first research question of the this study that sought an answer was

R Q1: Is there any statistically significant difference between experimental and control groups on factual knowledge and conceptual understanding of preservice physics teachers' in-laws of motion?

The main purpose of asking RQ1 was to investigate the impact of different instructional strategies such as J4PSS, J-4, PSS, and CG on preservice physics instructors' facts of knowledge and conceptual comprehension of the laws of motion. The PSPTs taught using different instructional strategies, namely PSS, CG, J4PSS, and J-4, showed mean differences in decreasing patterns, respectively. The one-way ANOVA analysis result revealed that there was no statistically significant difference in post-test means among the treatments and comparison groups. To detect in which group(s) the statistical difference existed, Tukey HSD multiple comparison tests were employed. These results revealed that a statistical mean difference was observed between J4-problem-solving strategies and the conventional method in favor of the former. The observed variations among the other combinations did not show any meaningful statistical significance. That is, a statistical significance mean difference was not observed in mean posttest scores of factual knowledge on preservice physics teachers between J-4 PSS and J-4, J-4 PSS and PSS, J-4 and PSS, J-4 and CM, PSS and CM. Those in the Jigsaw-4-problem-solving strategies were uniformly outperformed by other methods in post-test mean scores of factual knowledge in laws of motion. Thus, it can be said that Jigsaw-4 problem-solving strategies were proven to be less effective in helping preservice physics teachers develop factual knowledge of laws of motion than any other method in this study.

As per Pelobillo's (2018) research, preservice teacher-learners' factual and conceptual understanding of physics was improved by combining a problem-solving dimension with a jigsaw approach. When Jigsaw puzzles and the problem-solving approach were used to teach physics, students' performance and calculation abilities increased(Knopik & Oszwa, 2021).This was shown in research on the relative benefits of Jigsaw puzzles versus other problem-solving techniques conducted by Stephen (2020).The study's conclusions and the research results of these investigations were not opposed by those of earlier studies.The study conducted by Verma et al.(2019) and Wyk (2015) indicates that the use of the jigsaw teaching technique enhanced students' learning of physics knowledge.This research is not align with the current investigation.The study conducted by Mohammad & Hamadneh (2017) who used the jigsaw technique to teach science to students at the Bani Kinana Directorate of Education, revealed an improvement in students' knowledge of scientific topics. According to Uche & Chinelo (2021) research, academic performance and retention of knowledge in science at Anambra State Secondary School have improved as a result of the use of the Jigsaw teaching style.Simlarly the study done by Pelobillo (2018) using the Jigsaw-4 combination of problem-solving techniques is beneficial (Dincer et al., 2013; Saud et al., 2013). The study's findings demonstrated that mastery of the concepts of laws of motion by preservice physics teachers was improved. The studies investigation not aligns with this study.In addition, in this study, preservice physics teachers who learned laws of motion using problem-solving strategies showed higher posttest scores of factual knowledge than those taught using J-4 and CM. This might be because problem-solving strategies promote individual problem-solving skills but ignore the interaction between and among colleagues (Esan, 2015; Johnson & Johnson, 2011; Yasin et al., 2012). This is because individualized learning is better facilitated than social interaction between and among learners (Reddy & Panacharoensawad, 2017).

In addition, when the problem-solving strategy is employed using different models, like Polya’s problem-solving strategies, it is found to be effective in physics achievement and other learning outcomes (Stephen, 2020). In this study, there was a very slight mean difference in factual knowledge posttest scores detected between preservice physics teachers taught using conventional and Jigsaw-4 methods in favor of the former. It is consistent with studies done by Azmin (2016) on how Jigsaw-4 cooperative learning helps students grasp concepts effectively. Chaudhari et al.'s (2021) study made use of Jigsaw Design Challenge: An Inclusive Learning Activity To Promote Collaborative Problem-Solving.The study's conclusions showed an improvement in the perservice physics instructors' mastery of scientific information.It is inconsistent with current studies.

The results of the research demonstrated an improvement in the conceptual understanding of the pupils. This outcome is in line with the conclusions of several earlier investigations.For example, Taber (2018), Elsaid (2015) ,and (Omokorede et al., 2021) found that Jigsaw-4 method and the problem solving straegy improved perseriice physics teacher’s conceptual understanding of physics subjects. When it came to strengthening conceptual comprehension of physics, Jigsaw-4 fared better than the traditional method. According to the findings, students in experimental groups had a higher degree of conceptual knowledge than those in comparison groups, and the relationship between the two elements had an impact on their conceptual understanding of physics (M. Ali et al., 2019). Thus, despite variations in teaching approaches, the active learning approach influences students' acquisition of physics.Scholars claimed that the Jigsaw-4 teaching-learning strategy depends on how well students in the expert groups can communicate what they learn to the rest of the group members (Mahidol, 2020). Thus, the effectiveness of Jigsaw-4 on conceptual understanding when compared to the conventional method can be explained by how well preservice physics teachers in the expert groups can interact with other colleagues on activities that enhance conceptual understanding of laws of motion. According to the findings of prospective physics instructors' conceptual grasp of the laws of motion, the treatments generally used to improve post-test scores had larger mean differences than the traditional approach. Those who were taught using problem-solving techniques with Jigsaw-4 had a better mean difference than those who were taught using problem-solving techniques with Jigsaw-4. The conceptual comprehension posttest scores of preservice physics teachers showed a difference in the mean that was statistically significant between the treatment and control groups, according to the findings of the ANOVA between-groups comparison.The Tukey HSD post hoc multiple comparisons test, used for further examination of posttest conceptual comprehension scores, indicated a statistically significant mean difference between the conventional strategy and each of the tested treatments. To put it another way, preservice physics instructors who were taught using Jigsaw-4, problem-solving techniques, and Jigsaw-4-problem-solving strategies outscored individuals who conventionally received instruction. Additionally, there was a statistically significant mean difference in conceptual understanding scores between either of the treatment intervention teaching tactics on the posttest.

Jigsaw-4 and the problem-solving method did not differ statistically significantly from one another, nevertheless. Jigsaw-4 problem-solving methods outperformed other treatments in terms of enhancing conceptual understanding of the laws of motion in PSPTs.Previous studies compared Jigsaw-4 and conventional learning methods based on physics learning, such as conceptual understanding. For example, Jigsaw-4 and direct learning strategies were compared based on the conceptual understanding of senior high school students using quasi-experimental pretest-posttest non-equivalent comparison groups (Taber, 2018; Yaayin et al., 2017). The result revealed that Jigsaw-4 offered a more positive impact on conceptual understanding than the comparison group. Moreover, the author reported that the Jigsaw-4 learning strategy depends on the student's motivation toward the conceptual understanding of physics (Al-, 2019). Other studies that evaluated the effects of Jigsaw-instractional method and the traditional approach on students learning process in physics was conducted by Chaudhari et al (2021) . The results showed that, conceptual understanding and the achievement of experimental group improved. The study's findings are consistent with this one.

Preservice physics teachers who were taught using the conventional teaching approach in this study performed the least when compared to those who were taught using the other three methods of interventions, according to the analysis of mean differences and Game Howell post hoc multiple comparisons on post-test scores for conceptual understanding. In contrast, researchers who used FCI as a measure believe that some problems may be to blame for students' inadequate conceptual comprehension of mechanics courses. Husin & Hairan (2019) suggest that the physics teaching technique may be one of the reasons for the comparison group's PSPTs' low results on their posttest scores of conceptual comprehension.

This form of conventional physics teaching methodology places a greater focus on material delivery and straightforward mathematical and quantitative problem-solving by giving knowledge of concepts less weight. Similarly, other active learning methods are better than the conventional method in enhancing the conceptual understanding of students in physics (Mahidol, 2020) . This is because group projects, including active learning methodologies, have intrinsic motives for communication and collaboration (Forslun & Hammar, 2018) .Another study looked into how Jigsaw in Grade 6 affected students' understanding of motion and force (M.J. & M., 2021) . The results indicated that students who received instruction through the Jigsaw-4 method outperformed those who were taught using traditional instructional approaches when it came to grasping concepts. Hence, the results of the study are consistent with the present study. In contradiction to the above study, Pelobillo (2018) reported that the effect of using the jigsaw-4 method showed no significant difference among the groups. Qualitative findings also provided support for this quasi-experimental investigation. The Jigsaw-4 Problem-Solving Strategy is more effective than other approaches to improving conceptual understanding in learning laws of motion because it employs different methodologies. The outcome also offers more empirical support for studies that found Jigsaw-4 to be significantly more successful than traditional instruction at improving students' conceptual understanding and physics achievement. The findings indicate that while using Jigsaw-4 by itself is essential for enhancing students' learning, doing so in Conjunction with problem-solving approaches significantly enhances students' learning compared to doing so without them.

In summary, the findings of this study showed positive changes in preservice physics teachers' conceptual understanding of the laws of motion both quantitatively and qualitatively, despite some conceptual difficulties or misconceptions. The success of the Jigsaw-4 problem-solving strategy was not only demonstrated by this, but it also increased interaction, collaboration, and cooperation among the groups. This potential Jigsaw-4 problem-solving strategy was the best instructional approach for improving the conceptual understanding of preservice physics teachers in laws of motion.

5.2.Students Performances on Procedural Knowledge & Problem-Solving Skills in Laws of Motion.

RQ2: Does the procedural knowledge of preservice physics instructors in the laws of motion change statistically significantly between the treatment and conventional groups?

RQ3: Is there any statistical significance difference when comparing both the control and experimental groups on the problem-solving skills of preservice physics teachers in-laws of motion?

Investigating the impact of J4PSS on preservice physics instructors' procedural knowledge and problem-solving abilities was the major goal of RQs 2 and 3. The J-4PSS was more effective than PSS, J-4, and the conventional manner of instruction in disseminating a procedural grasp of laws of motion. According to the findings of the post hoc Tukey HSD test, the J-4 PSS approach was also found to be effective in teaching the problem-solving skills of PSPTs in laws of motion. Though there was no statistically significant difference between the PSS and J-4 in teaching the items of procedural knowledge and problem-solving skills, the blended approach was the best of all the methods implemented.

According to the study done by Gravino (2012), Mahidol (2020) ; Radha K. & Vijayanarayanan (2019) using a problem-solving strategy and the jigsaw-4 method, preservice teachers' problem-solving skills and procedural knowledge in physics. The results of the study confirmed that their knowledge of procedures and ability to solve the problem had improved. The results of this study support the current study. Karacop (2017) studied the effects of Jigsaw-4 on the learning of several topics by prospective physics instructors' problem-solving skills and procedural knowledge in comparison with the traditional method. The findings indicated their problem-solving skills and procedural knowledge had improved. Similarly, many scholars have studied the use of problem-solving techniques on college students, and they discovered students' procedural knowledge and problem-solving abilities were improved (Abubakar & Dr. Danjuma, 2012; Docktor et al., 2015; Gok, 2014; John, 2013).The results of the above study align with the outcome of the present study.

The new study's findings are in line with other investigations.The impacts of Jigsaw 4 on aspiring physics teachers' learning of various topics were found in a study (Kandemir & Apaydin, 2022; Karacop, 2017).The findings indicated that, in comparison to the traditional teaching approach, pre-service physics teachers performed better across a range of physics topics. According to the research conducted by several authors (Abubakar & Dr.Danjuma, 2012; John, 2013).The results of the studies confirmed that problem-solving strategies enhance a learner's procedural knowledge. Also, the relative effectiveness of Jigsaw and problem-solving strategies, according to research by Stephen (2020), Omokorede et al (2021),and Knopik & Oszwa (2021) showed that students' achievement and capacity to solve the physics problem improved. The results of the research align with the current study.

In addition, Jigsaw-4's impact on university students' mechanical learning was discovered by Özdemir and Arslan (Özdemir & Arslan, 2016) . The academic performance of the student improved, according to the results. Numerous scholars have examined problem-solving techniques and discovered that they improve a learner's capacity for problem-solving (Abubakar & Dr.

Danjuma, 2012; Argaw et al., 2017; Docktor et al., 2016; Taasoobshirazi et al., 2022) . The existing study is supported by the results of the previous investigation. Since neither of the approaches works well on its own, the combined Jigsaw-4 approach to problem-solving raises preservice physics instructors' performance on Newton's equations of motion. According to Gravino (2012),Ulu (2017) and Yaayin et al (2017) students' critical thinking abilities, ability to express themselves, and problem-solving abilities all improve when they use the Jigsaw-4 teaching approach to learn physics. However, Mahidol's (2020) study, which employed the Jigsaw-4 technique to teach preservice teachers procedural knowledge and problem-solving skills in physics, revealed that the preservice teachers' problem-solving skills were inferior to those of the comparison method. It is the opposite of the current study.

According to certain studies, the Jigsaw 4 method of instruction is beneficial for students' theoretical course learning as well as for the growth of their critical thinking abilities and communication skills (Kilic, 2008).The study compared the effectiveness of two different approaches, namely the Jigsaw-4 method and an innovative linear model, in implementing STEM activities. The findings of the study indicated that the innovative linear model was more effective than the Jigsaw 4 method (Mahidol, 2020) . Nevertheless, it was suggested that the Jigsaw 4 method be employed when instructional time is restricted. Studies have indicated that the use of problem-solving strategies improved academic achievement in science education (Saputro et al., 2019).The use of problem solving teaching enhanced students' problem solving skills in physics learning, as per the study conducted by Doctor et al (2016).The research findings above are consistent with this investigation. However, students who use the Jigsaw-4 teaching techniques in the classroom generate a mutual internal source of positive reinforcement for one another due to their positive interdependence, which contributes to the improvement of preservice physics teachers' problem-solving skills (

Hancock, 2004; Ning, & Hornby, 2014; Priyana, 2020).Research has shown that academic success in scientific education remains low even after problem-solving techniques because these methods tend to emphasize greater individuality and minimize the importance of social connection, teamwork, and interactions (Cavagnetto et al., 2010; Hancock, 2004; Priyana, 2020) not align with the present study.Instead, Jigsaw-4 Problem-Solving Strategies (J4PSS) students build positive relationships with one another, generating a shared internal source of support and encouragement for one another as well as enhanced procedural knowledge and problem-solving abilities.

5.3. The motivation of a physics teacher in the preservice learning of the laws of motion

RQ4. Do the experimental and control groups' levels of preservice physics instructors' motivation to teach mechanics statistically differ?

The main purpose of asking RQ4 was to investigate the effects of J4PSS, J-4, PSS, and CG on the inspiration for teaching the laws of motion in preservice physics classes.

At every level of education, motivation is a widespread and significant factor in determining the behavior of students, instructors, and all other interested parties (Çalişkan et al., 2010).The motivation of future physics instructors is, in this view, one of the most crucial facets of a teacher's job. The findings of this study revealed that preservice physics teachers are likely to be more motivated to learn laws of motion using the blended Jigsaw-4 Problem-Solving Strategy, which is a better teaching strategy than the Jigsaw-4 and Problem-Solving Strategy. Both the Jigsaw-4 and problem-solving strategies were better than the conventional method of teaching laws of motion in the selected college of teachers’ education. However, the preservice physics teachers who were taught by the conventional method of teaching are least motivated to learn the laws of motion.

Making physics fun and interesting in the classroom is one of the most popular teaching-learning tactics and approaches used by physics instructors. Numerous teaching strategies may use physics to effectively and efficiently transmit lessons. Such modifications to physics instruction may improve students' capacity for comprehension more than usual, and the ability of their learning process can be recognized (Ryan & Guido, 2013). According to observations, students who have favorable views toward physics and preservice physics teachers who have negative attitudes toward physics are more motivated to participate in class. The above studies align with the present study. In Madrid University's teaching and learning process, similar outcomes have been established by M et al (2018) utilizing an integrated approach to the active learning method. According to the study's findings, physics education is becoming more conceptually understood and motivated. The results of the study align with this research.

A deeper understanding of today's students would enable teachers to better mentor students in careers that will shape the kind of citizens they will become in the future (Arandia et al., 2016). Motivating people across the nation to pursue science, education, and research is essential. Teachers are also necessary to characterize today's students and ascertain what motivates them to pursue science. Their requirements and interests in research are essential for the progress of the country in expanding knowledge and finding solutions to pressing issues (Torio,2015). The outcomes of this investigation are supported by the results of this study. Numerous studies have revealed that instructional tactics affect students' motivation and that different teachers use different strategies to get students interested in learning, even when there are variances in the students' knowledge levels (Korsun, 2017). Banerjee (2016) found that different teaching strategies can encourage students based on what they are doing. The author of the book suggested using it to teach physics using multidisciplinary approaches, inquiry-based learning, problem-based learning, collaboration, and experiments that varied from low-tech and basic to computer-based and remote labs. The study's findings align with the current research. In light of this, we contend that the best approach to addressing learners' motivational factors in relation to laws of motion is through the blended Jigsaw-4 technique and problem-solving strategy, which promote socio-cultural interaction between students and teachers during the teaching-learning process.

The results of this study are in line with those of Sitompul's (2010) study using the jigsaw method and the motivation of preservice teachers' learning outcomes. The study findings indicated that the utilization of jigsaw cooperative learning in instructing preservice teachers resulted in enhanced motivation compared to the traditional learning approach. In a similar vein, Vergara et al.(2020) conducted a study exploring the impact of cooperative learning methodology on the motivation and learning of students who were studying the theoretical aspects of physics. The results of the study demonstrated that the use of cooperative learning maintains students' motivation better than lecture-based learning methods. The study's investigation is consistent with the one that is underway. The study done by Shishigu et al (2017) reported no significant difference in learner motivation in learning physics after the implementation of problem-based learning. The investigation of the study is inconsistent with this study.

According to the study of John (2013) motivation and conceptual change are linked to scientific learning. Since these students produce work that demonstrates commitment and enthusiasm, the teacher may be able to discern which students are highly driven immediately away. Similar to the unmotivated student, this young person may also be an individual whose needs are not being met in the classroom. According to the study's findings, preservice physics instructors who are studying the laws of motion exhibit different motivating traits on their post-test than they did on their pre-test. If classroom activities are designed to fulfill the requirements of even the least driven learners, then they can engage completely in the process (Torio, 2015) . Similarly, the study done by Rana and Mahmood (2019) explored a cause-and-effect relationship between preservice teachers' categories of desire and accomplishments in school in science at grade eight. The results of the study demonstrated significant positive relationships among different categories of motivation. This study is consistent with the current study. Teachers incorporate intrinsic motivation into their lessons to support learners growth and a thirst for new knowledge, according to Valerio's (2012) research. This study's results align with the present study.

Extrinsic motives can appear in a variety of ways. Extrinsic motivators include things like getting compliments, getting rewards from teachers, and expecting to do well in school (Torio, 2015). As Theses & Baranek (1996) note, extrinsic incentives, which come in the form of awards, medals, and recognition, are frequently employed in contemporary society and educational institutions. However, there may be criticism of the overemphasis on extrinsic reward and motivation, given that preservice teachers lack the motivation to learn for themselves. People's innate propensity to link their interests with the acquisition and use of their talents is known as intrinsic motivation, according to scholars (Jovanovic & Matejevic, 2014) .When learning is meaningful and rewarding, particularly when students perceive the material as valuable, have confidence, and have a purpose, and these conditions are met, intrinsic motivation can have significant advantages (Chatterjee, 2018). Intrinsic motivation can help students recognize the worth and benefits of their education, regardless of their level of engagement in learning activities. However, Scholar & Early (2012) and Morphew et al (2020) may have differing opinions on this matter. Walker and Crogan (1998) conducted a study that found the use of the jigsaw technique and the assigned role-taking responsibilities had a positive impact on students' academic achievement. This suggests that Jigsaw promotes students' engagement and enthusiasm for learning. By involving students throughout the learning process and holding them accountable, Jigsaw increases their class participation and makes them feel valued and provided with opportunities (Jainal & Shahrill, 2021). The aforementioned research supports the current investigation.

The findings of this investigation support Ungvári's (2014) assertion that the realm of metaphysical theory and highly motivated thought constitutes reality for motivated thinkers. Those with high levels of motivation enjoy conceptual thinking and data analysis. They find it simple to notice crucial elements like focal points and crucial features. Comparably, the Yunita and Sitompul (2020) study examined the impact of jigsaw cooperative learning outcomes on physics students' motivation at the State University of Medan. The findings indicate that students taught with conventional learning are in low-motivation groups (20.95) and high-motivation groups (28.40), while those taught with jigsaw cooperative learning are in low-motivation groups (24.58) and high-motivation groups (32.94). The study verified that the students were more motivated by the jigsaw cooperative learning strategy than by the comparison method. This research aligns with ongoing investigations.

Similarly to this, Laher (2014) discovered that using cooperative learning increased students' learning efficiency for theoretical courses. Additionally, cooperative learning fosters students' self-worth and encourages their involvement (Tran & Lewis, 2012).Furthermore, Van & Bakker (2018) discovered that students who were in more cooperative and engaged groups were able to work through challenges more successfully as a team. Students who support one another build a cooperative society that improves performance for all members (Chen, 2017). This research supports the ongoing investigation. Giving students more independence is one of the main ways that cooperative learning enhances their drive to study. According to Tran et al (2019) students who engage in cooperative learning have the opportunity to coordinate class procedures and curate curricula in addition to actively participating in the learning process. Profile (2014) better motivation and an optimistic outlook are fostered in learners through cooperative learning. Wigfield et al (2015) backed cooperative learning by highlighting the importance of positive teacher-student interactions. These investigations supported the present study.

Three dimensions were shown to benefit from the PBL technique, according to Tosun and Taskensenllygyl's (2012) study: self-efficiency, enhancing the value of the taught material, and achieving a desired goal. Upon assessing the motivation, these three dimensions were deemed the primary products. Additionally, students who had learned using the PBL method showed higher levels of motivation to study the subject (Sánchez et al., 2022).Current research and this study are consistent.

Lepper et al (2005) discovered that this approach aided in the comprehension of the subject matter when they investigated the motivation levels of elementary school pupils who studied science. Offer backing for the present study's findings. Teachers have a vital role in providing students with a thorough comprehension of the universe (Akkus & Doymus, 2022; Amores et al., 2022; Laher, 2014).Physics is an essential topic for students to have a thorough understanding of their surroundings. Students' ability to explore the surrounding natural environment will be enhanced by the knowledge gained from comprehension (Holmes et al., 2022). Nonetheless, inadequate learning and material delivery will have a detrimental impact on physics comprehension. Teacher applicants will start to feel anxious because of this (Serin, 2018). Previous research by Fernandez et al (2002) has demonstrated that the collective efficacy of a group can be greatly influenced by the individual self-efficacy views of its members. The findings of the current study agree with these findings, impacting both its accomplishments and how it operates. The findings of this study are in line with previous investigations. In a research conducted by Macmillan (2022) the impact of the Jigsaw-4 Cooperative learning strategy on high school students' motivation to learn physics in Nigeria was examined. The overall results indicate that students in the experimental group demonstrated higher levels of motivation compared to those using the traditional teaching method.Teachers need to understand that environments for learning that support self-regulation require consistency and choice. According to Sheldon & Elliot (1998) "teacher expectations about students' capacity, humor, fairness, student autonomy, teacher enthusiasm, and clarity and pace of instruction are important elements." Teachers need to design special class structures that combine these concepts if they want to help their students develop self-regulation (Boekaerts & Cascallar, 2006).

5.4.The research's findings support this investigation. Preservice physics teachers' perception about the rules of motion

The present study's fifth research question aims to provide an answer to the following:

R5: How do preservice physics teachers view the effect of J4PSS on their understan ding of the concepts of mechanics?

The primary objective of asking RQ5 was to consider the consequences of J4PSS, J-4, and PSS on the perceptions of preservice physics teachers' in-laws of motion. Any educational level employs perception, a technique for evaluating reality and experience via the senses, to determine figure, form, language, conduct, and action (Munhall, 2008). Perception has had a positive impact on the study of physics (Handhika et al., 2016). Perception is the basic building block of knowledge. This leads to the hypothesis that if perception is off, information acquired will likewise be off (Feldman, 2005). Preservice physics instructors viewed physics as a difficult subject(Ornek et al., 2008). In this regard, preservice physics instructors' perceptions were seen as having a significant impact on their ability to comprehend laws of motion ideas (Bature, 2017).

Based on five themes of preservice physics teachers' perspectives on laws of motion, such as conceptualizing the concepts of force, laws of inertia, the benefit of frictional force, third laws of motion, and nature of frictional force views, the interview results confirm understanding concepts of laws of motion. The interview results of conceptualizing concepts of force views revealed that PSPT, who taught through J4PSS, has a superior understanding of the ideas included in principles of motion. The interview results of conceptualization of concepts of force view were confirmed by the quantitative data results of items 18: J4PSS 94%, J4 72%, PSS 60%, and CC 24% in full understanding and J4PSS 3%, J4 9%, PSS 14%, and CC 30% in a misunderstanding of conceptualizing concepts of force view. Hence, the PSPT, who learned through J4PSS, scored the highest in full understanding and less in misunderstanding in conceptualizing concepts of force views. The outcomes of the interview data provided evidence in favor of it.

The findings of the investigation align with those of previous studies. Van Tran and Lewis (2012) conducted research on the impact of Jigsaw learning on students' perceptions in a higher education classroom setting in Vietnam. The results indicate that students in the experimental group highly valued collaborative work, receiving assistance, sharing knowledge, engaging in discussions, and instructing others. Similarly, a study conducted by Chopra et al. (2023) on the use of Jigsaw-classroom instruction in science education demonstrated that students developed a positive perception towards learning science. In summary, both studies found that the implementation of Jigsaw learning strategies positively influenced students' perceptions of learning and collaboration. They also loved the jigsaw setting.Naomi (2022) studied how the Jigsaw-II Cooperative Learning Strategy affected the physics performance of senior high school students in Lafiagi, Nigeria. The study's findings showed that there was no discernible difference in the Jigsaw technique's performance compared to the conventional approach, and that the Jigsaw-II Techniques of learning were not well-liked. The outcomes did not align up with the current investigation.Elsaid (2015) conducted a study that focused on the perceptions and proficiency skills of pre-service teachers regarding their experiences with the Jigsaw instructional method in small group settings. The research findings indicated that engaging in group work using the Jigsaw method resulted in the development of a greater sense of cohesion within the groups and a heightened awareness of social responsibility towards each other's learning, when compared to the control group. This study's findings are in line with the investigation conducted in the mentioned research.

In conclusion, the interview's findings confirmed the inferences made from the analysis of the quantitative data. Students in the J4-PSS treatment group received higher mean scores for comprehending the basic concepts of laws of motion, a larger percentage of complete understanding, and a lower number of misunderstandings, according to the overall mean score and the percentage of each item. The intervention was also used to implement the lesson in the classroom, followed by a post-intervention interview. The educational model used, notably the TECMRER Model, Jigsaw-4 ways of learning, and 5-Step Solution Strategies, has received favorable feedback from teachers and PSPTs in treatment groups. According to the preservice physics teachers in J-4PSS, having the ability to interact and work together with their group members on TECMRER made it easier to prepare lessons effectively and helped PSPT concentrate on learning. Preservice physics instructors expressed that the TECMRER model enabled them to participate in their education successfully, particularly those who acknowledged using the J4-PSS for group projects while educating students in the classroom. In addition, they talked about how the J4-PSS helped them as they cooperated and completed their homework, assignments, and exam preparation.

In summary, the blended Jigsaw-4-problem-solving strategy was compared with the other two interventions, Jigsaw-4 solely and the problem-solving strategy alone, and the comparison group.

There are inconsistencies in the findings of previous research when problem-solving and Jigsaw-4 strategies were implemented exclusively. For example, in a study to investigate the effects of problem-solving strategies on physics achievement in undergraduate-level students, Academic achievement, problem-solving abilities, and strategy utilization were found to be positively impacted by problem-solving education. On the other hand, the results of experimental studies showed that student conceptual understanding and academic achievement in science education remain low even after problem-solving strategies are implemented (Caagnetto et al., 2010). The results of this study conflicted with this study.

Regarding the Jigsaw-4 strategy, different results were reported. Some studies found positive outcomes after Jigsaw-4 was implemented. For example, Boniface et al. (2021) on preservice physics teachers and Sezgin et al. (2008) on undergraduate introductory-level students comparing Jigsaw-4 with conventional methods Mohammad and Hamadneh (2017) compare Jigsaw-4 with traditional methods and others. On the other hand, Mahidol (2020) compared the effects of the linear model, jigsaw, and standalone approach for engineering students, and the results revealed that the linear model was best followed by the jigsaw strategy. The authors recommended that Jigsaw-4 be implemented when there is a time constraint.

Chapter Six: Summary, Conclusion,Contribution , and Recommendation

6. Introduction

This study's main goal was to look into the impacts of the Blended approach of Jigsaw-4 problem-solving methods on prospective physics instructors, with a focus on how they enhanced their understanding of the principles of motion and investigated the emotional elements that influenced their learning. The study's methodology, research topics, and important variables are briefly summarized in the chapter's opening paragraphs. It then discusses the key conclusions, including how well participants understood the laws of motion and how their learning experience affected them emotionally. The chapter finishes with recommendations and ideas based on the investigation's results.

6.1.Summary

The primary purpose of this study was to assess the comprehension, facts, knowledge of procedures, and ability to solve problems in mechanics by aspiring preservice physics instructors who employed Jigsaw-4 problem-solving methods (J-4PSS). According to the research, four government colleges each had two intact classes of physics teachers under training. It was studied using a concurrent embedded, mixed-method approach. The study included several specific research issues. To see if there were statistical variations, the treatment and comparison groups' conceptual understanding of mechanics and factual facts were compared. Second, it aimed to find any discrepancies between the two groups' comprehension of mechanical procedures. Thirdly, the study sought to figure out whether there were any variations in the skills of preservice physics instructors to solve mechanics-related problems between the baseline and groups participating in experiments. Fourthly, it aimed to discover if there were any significant variations in the motives of the two groups for teaching mechanics to physics instructors in training. The study also looked into how preservice physics instructors viewed the impact of J-4PSS on their understanding of mechanics fundamentals.

The learning results were evaluated using tests for knowledge of facts, conceptual understanding, and abilities to solve problems. Surveys for science motivation, perception interviews, and examinations for these measures were also used. The intervention used various teaching strategies, with one group receiving instruction using Jigsaw-4 teaching techniques and the TECMRER problem-solving instructional approach, another group receiving instruction using Jigsaw-4 teaching techniques alone, a third group receiving instruction using the TECMRER method alone, and a comparison group receiving traditional instruction.

Before the intervention, pretests were given, such as the physics conceptual understanding exam, procedural knowledge test, problem-solving abilities test, semi-structured interview to evaluate their perceptions, and a questionnaire on students' motivation in science. Following the implementation, many assessments were administered, including the force inventory exam, the physics conceptual understanding test, the test of knowledge of processes, the problem-solving skills test, a semi-structured interview, and the scientific motivation questionnaire.

The data were examined using a variety of techniques, including ANOVA, descriptive statistics, paired sample t-tests, post hoc tests, and introspective data analysis techniques. When the study's data was evaluated, it was found that the groups' post-test scores in the areas of factual understanding, grasp of concepts, knowledge of procedures, ability to solve problems, and inspiration had statistically meaningful mean differences. In every metric that was measured, the intervention group that received J-4PSS exceeded the other groups, showing that the selected instructional model was superior to traditional instruction in terms of enhancing the learning outcomes of preservice physics instructors. The J-4PSS teaching group demonstrated greater motivation than the other groups in terms of motivation. Variation across the groups was found in the assessment of conceptual understanding of the laws of motion.

The interview findings support the notion that preservice physics teachers (PSPT) who were exposed to the J4PSS teaching approach demonstrate a higher level of understanding regarding the key concepts related to the laws of motion. These concepts include the conceptualization of force, understanding the laws of inertia, recognizing the benefits of frictional force, understanding the third law of motion, and grasping the nature of frictional force.

In summary, the interviews' findings attest to PSPTs' improved understanding of the essential ideas covered by the laws of motion among those who received instruction through the J4PSS approach.A full understanding of the laws of motion was shown by preservice physics instructors who were taught using J-4PSS, followed by teachers who were instructed using problem-solving strategies. A few conceptual understanding elements, however, were fully mastered by individuals who were exclusively taught using Jigsaw-4 teaching techniques. Overall, the study found that J-4PSS increased prospective physics instructors' perception, motivation, knowledge of procedures, capacity to resolve issues, and factual and conceptual comprehension more successfully than alternative methods of training.

In the end, this study investigated how Jigsaw-4 problem-solving methods impacted preservice physics educators' comprehension, facts, knowledge of procedures, ability to solve problems, and motivation for mechanics. In comparison to conventional schooling and other teaching methods, the hybrid J-4PSS strategy is more successful at enhancing learning results. The study highlighted the necessity of instructional models to enhance preservice physics instructors' understanding and motivation in the context of mechanics education.

6.2.Conclusion

The study's findings led to the following conclusions: In the broader context of mechanics instruction, the intervention groups outperformed the standard teaching approach in terms of acquiring factual knowledge, grasping concepts, understanding processes, solving problems, perceiving, and fostering motivation in the classroom. Addressing each research question, the following conclusions were drawn:.

- The outcomes of the study showed that the treatment groups, particularly those utilizing the Jigsaw-4 problem-solving approach, demonstrated superior performance compared to the conventional teaching method in terms of factual knowledge among preservice physics teachers. This was particularly evident in their understanding of the fundamental principles related to motion.
- The Jigsaw-4 problem-solving strategies had a positive influence on preservice physics teachers' conceptual understanding of the laws of motion, making it an effective teaching approach.
- The Jigsaw-4 problem-solving strategies were particularly effective in improving the procedural understanding of Newton's equations of motion among preservice physics teachers in contrast to alternative methods.
- Intervention groups achieved superior results in problem-solving skills compared to those taught using traditional methods, especially in the course of mechanics. J-4 PSS learners ex-

hibited stronger problem-solving abilities in mechanics when compared to the Jigsaw-4, comparison method, and problem-solving strategy.

- The motivation levels of the intervention groups surpassed those of the non-intervention group, indicating that J-4 PSS learners displayed higher enthusiasm and motivation among preservice teachers in the field of mechanics compared to Jigsaw-4, the comparison method, and the problem-solving strategy.
- Based on the findings of the interviews, it was shown that students who received instruction using the J4PSS teaching approach had a greater degree of grasp and understanding of the ideas and principles covered by the laws of motion.

According to the research, mixing the Jigsaw-4 and TECMRER problem-solving methods was most successful in ensuring that participants completely understood the ideas behind the principles of motion. In general, the study indicated that the targeted teaching tactics, such as the integrated Jigsaw-4 problem-solving method, greatly increased the preservice physics instructors' knowledge of facts, comprehension of concepts, knowledge of the process, ability to solve issues, and inspiration. In conclusion, using active learning strategies, notably the integrated Jigsaw-4 problem-solving strategy, can lead to more effective teaching and improved learning outcomes in physics education, especially in the area of mechanics and, more specifically, the laws of motion.

6.3.Contribution of the study

My research offers theoretical, practical, and methodological insights for academic society.The study's theoretical contribution is that it emphasizes how important it is for Ethiopian physics instructors to get training and use good teaching techniques in their classes. Through its focus on the incorporation of active learning approaches—like the Jigsaw-4PSS method—the research offers insights into how these techniques improved students' comprehension of motion laws and their emotional components. By illustrating how certain teaching strategies enhanced physics education results, this adds to the body of knowledge already in existence.

Practical Implications: The research has two practical implications. Initially, it provides specific advice to different parties involved, such as physics professors, college physics teachers, and curriculum developers. These tips provide helpful advice on how to improve classroom instruction and learning opportunities. Students' conceptual understanding, procedural knowledge, problem-solving abilities, and general grasp of the laws of motion enhanced by teachers via the use of the Jigsaw-4PSS approach and active learning strategies. Secondly, the research recommends creating physics textbooks and modules using active learning techniques such as the TECMRER Model of J-4-PSS. This useful addition provides a workable way to enhance physics teaching tools and materials.

The study's methodological contribution is rooted in its proposition of the TECMRER Model of J-4-PSS, a cycle process designed to facilitate efficient physics classroom teaching and learning. This approach offers a structure for incorporating active learning techniques into physics instruction. The research provides a fresh method that physics instructors and curriculum designers may use to improve the teaching and learning process by introducing this model. Designing and executing successful physics education practices is made easier by the model's systematic structure and focus on active learning, which address methodological weaknesses in conventional teaching techniques.

6.4.Recommendation

The study highlights the significance of teachers receiving training and utilizing effective teaching strategies in Ethiopian physics curricula (MoE, 2010, 2020). The study's major recommendations are outlined below, along with some advice: To enhance students' understanding of concepts of the laws of motion and their affective factors, it is recommended that the following points be made:

- Instructors teaching physics should integrate the Jigsaw-4PSS method into their teaching strategies. It is advised that these educators use active learning strategies like J-4PSS, which take into account the students' prior knowledge and support efficient learning.

- College physics teacher educators have to help students improve their conceptual understanding, procedural knowledge, and problem-solving skills concerning motion equations by using J-4PSS.

- Teachers of physics should aware of how they impart knowledge and look into active learning techniques that encourage and help PSPTs apply the concept of motion in problem-solving.

- The Ministry of Education and curriculum designers have to improve organizing classroom instruction for aspiring physics instructors, incorporating the J-4PSS technique, and offering appropriate practicum opportunities and practical exercises to improve their comprehension of the laws of motion.

Moreover, to help students understand crucial physics concepts, physics modules and textbooks have to be developed using active learning strategies like the TECMRER Model of J-4-PSS, which is a cycle process used for effective physics classroom instruction and study. The researcher proposed the TECMRER model, which might be used for the successful teaching and learning of physics lessons by all concerned bodies (see Fig. 6.1 below).

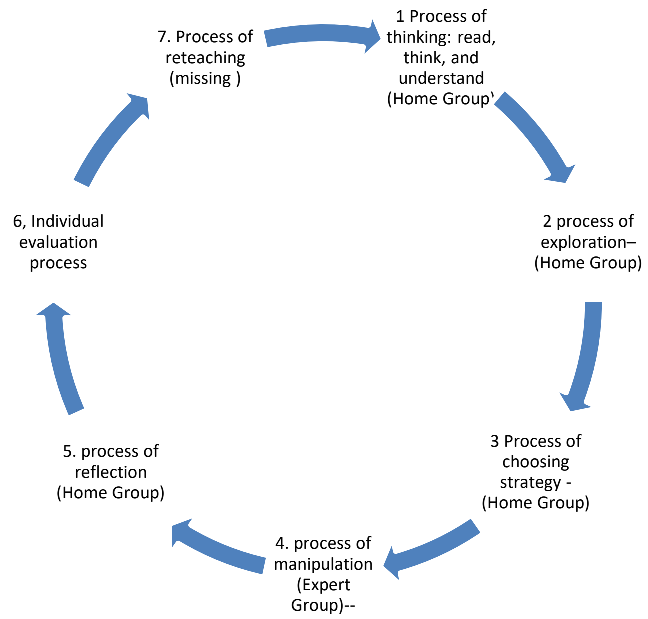

Figure-6.1 a cyclic procedure OF TECMRER MODEL is Source adapted from Heuristic strategies developed by Krulik and Rudnik;(2017), Minnesota problem-solving strategies Docktor & Adrian (2022) , and Jigsaw-4 method, Cochon et al (2023).

At all educational levels where physics is taught, more study might be done to examine the benefits of mixed active learning methods. Teaching methods like J-4PSS that are effective might be renowned and promoted at large scales. It is important to do a more extensive investigation using J-4PSS, concentrating on such physics subjects as electricity, magnetism, heat and thermodynamics, and light. In addition to evaluating other educational outcomes such as attitude, metacognitive thinking capabilities, and scientific process skills, it is important for this study to assess additional learning outcomes.

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1.2 Cashata, Z. A., Seyoum, D. G., & Gashaw, F. E. (2023). The effect of using blended jigsaw-4 problemsolving instruction on preservice physics teachers’ problem solving skill. Anatolian Journal of Education, 8(2), 35-52. https:// doi.org/10.29333/aje.2023.823a”

List of Appendix

Appendix-1, Mechanics Factual knowledge Diagnostic Test

The purpose of the Mechanics Factual Knowledge Diagnostic Test (MFKT) is designed to investigate pre-service physics teachers ‘of both the treatment and control group’s factual knowledge of Newton’s laws of motion. Fourteen test items for measuring the factual knowledge of the preservice teacher. You have been given twenty minutes to complete the test.

Thank you for your participation.

Demographic information: Direction: Please fill in the needed information by putting a check mark (√) in the box and write your response in the space provided. Full Name of student,

Department_____________________

Gender: Male ☐ Female ☐ College Code _____________________________

Year___________ Age ____ Section: ________________________________

Have you already taken the national examination in physics? (Yes/No) ____________________

If you have taken the national examination on physics, what was your grade_____GPA: _______

The secondary school accumulative GPA of the student is __________________.

Direction: Each question below refers to some concepts of Newton's laws of motion. It has three parts. Give your response to each question by choosing and circling one possible answer from the given alternatives.

1. When you push someone and you both fall back, this law of motion is illustrated by

   A) Newton's second law B) Newton's first law C) Newton's third law D) none

2. The tendency of a body to remain in its initial state of motion is called --------

   A) Mass B) Acceleration C) Inertia D) Force

3. Which of the following is not contact force?

   A) Gravitational force B) magnetic force C) Frictional force D) A and B

4. The amount of force applied on a car's brakes to make it stop, which illustration of Newton's law of motion is this?

   A) Newton's 3rd law B) Newton's 1st law C) Law of inertia D) Newton's second law

5. Which of the following objects has more inertia?

A) Car B) Truck C) Cotton D) Train

6. The cause of any motion is ------.A) Acceleration B) Mass C) Velocity D) Force

7. Newton's first law state "If an object is at rest, it remains at rest, if an object is moving with a constant velocity, it continues with constant velocity, unless a balanced force acts on it"?

   A) Newton's second law B) Newton's first law C) Newton's third law D) none

8. A kind of friction created due to the motion of something on a smooth or wet surface is called --

   A) Static friction B) Sliding friction C) A and B D) none

9. What force can keep the movement of something in a circle?

   A) Gravitational force B) Centripetal force C) Magnetic force D) none of the above

10. The force of gravity acting on an object's mass in a gravitational field called----------.

A) Centripetal force B) Magnetic force C) Weight D) none of the above.

11. Newton's second law of motion is also known as the law of ---------------

   A) Initial B) Dynamic C) action-reaction D) none of the above

12. Newton's third law states that forces must always occur in ___________________.

   A) a pair on the same object B) a pair on two different objects C) a pair on many different objects D) none of the above

13. The resultant of Newton's third law of motion is------------------------.

A) double of applied force B) zero C) we cannot add D) none of the above

14. The SI unit of the coefficient of friction is________

A) Newton B) Watt C) Meter D) It has no unit

Appendix 2, Mechanics Conceptual Understanding Diagnostic Test

The purpose of the Mechanics Conceptual Understanding Diagnostic Test (MCUT) is to investigate preservice physics teachers 'of both treatment and control group's factual and conceptual understanding of the concepts of Newton's laws of motion. The test contains eighteen multiple-choice questions. You have been given forty minutes to complete the test.

Thank you for your participation.

Demographic information: Direction: Please fill in the needed information by putting a check mark (√) in the box and write your response in the space provided.

Full Name of student, _________________________________Department_____________

Gender: Male ☐ Female ☐ College Code _____________________________

Year___________ Age ____ Section: ________________________________

Have you already taken the national examination in physics? (Yes/No) ____________________

If you have taken the national examination on physics, what was your grade? _____GPA: ----

The secondary school accumulative GPA of the student is __________________.

Direction: Each question below refers to some concepts of Newton's laws of motion. It has three parts. Give your response to each question by choosing and circling one possible answer from the given alternatives.

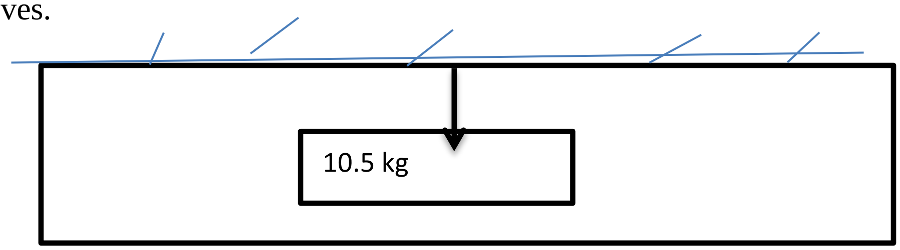


Figure 1-1 a body suspended by the cord

1. A cord from the ceiling, as shown above, suspended a 10.5-kg block. The force exerted on the block by the cord is most nearly____.(g=10m/s) A) Zero B) 105N C) 50 N D) 100 N

E Reason out your choice____

2. A layer of iron boxes ‘A’ and ‘B’ are shown in fig-2. However, the mass of box ‘A’ is greater than the mass of box ‘B’.In this regard which of the following is true?

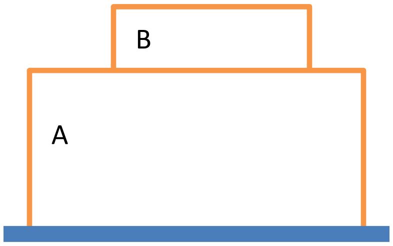


Fig-2 mass-B rests on the surface of mass-A

A) Only box ‘B’ exerts a force on ‘A’ B)Only box ‘A’ exerts a force on ‘B’

C) Both boxes exert equal force on each other.

D) No force is exerted by either box

E) Reason out your choice____

3. Let us assume the following vehicles are all moving at the same speed. Which of the vehicles would be harder to change its velocity? A) motorcycles B) track C) Bicycle D) none

E Reason out your choice____

4. Let a ball be placed on an infinitely leveled and frictionless surface. In the meantime, the ball received a momentary horizontal kick, which made it move along the arrow’s direction as in Fig. 3. Which of the following is true about the situation? F= force, V = velocity

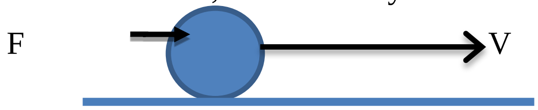


Fig 3 A rolling ball on a frictionless surface

A) The ball comes to rest in the specific condition

B) The force imparted to the ball during the kick

C) It changes the state of the ball making it moves

D) Both C and B

E) Reason out your choice____

5. Two boxes ‘A’ and ‘B’ are placed side by side on an identical leveled surface. The boxes have identical shapes and are made to move by equal net horizontal force. Assuming mass ‘A’ is greater than ‘B’. Which of the following is true?

A) Acceleration of ‘B’ is greater than ‘A’ B) Acceleration of ‘A’ is greater than ‘B’

C) Both bodies have the same acceleration D) The Velocity of ‘A’ is greater than ‘B’

E) Reason out your choice____

6. A small and big ball is moving in the opposite direction as shown in Fig. 4 in the meantime a head-on collision takes place between them. At the instant of collision, which one of the following is true?

Fig-4, two different balls are moving in the opposite direction,

A)The big ball exerts more force on the small ball, B) Only equal force on the big ball C) Only the small ball exerts the force on a big ball D) None E) Reason out your choice___________

7. Take two identical boxes, one placed on the surface of the earth and the other on the moon. The force required to lift the box in either place is-------.

A) Less on the surface of the earth, B) Less on the surface of the moon

C)-The same in both places D) Large on the surface of the moon

E) Reason out your choice____

8. A moving ball on a level surface is seen to decrease its speed and comes to rest in the end. The reason is A) The gravitational force exerted on the ball B) The normal force exerted on the ball C).The frictional force aroused between the ball and the surface

D) . All are answered

E) Reason out your choice____

9. Kochito throws a small ball straight upward. While flying, the magnitude of forces exerted on the ball is __ A) Decreasing, but straight upward B) Constant but directed upward.

C) Decreasing, but straight downward D) Constant but directing downward

E) Reason out your choice____

10. Two books (Y and Z) rest on a table. The weight of each book is indicated. The coefficient static frictional force between book Z and book Y in figure 5is -----

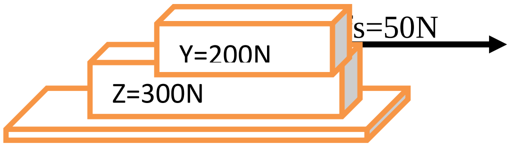


Fig 5 book Y rests on Z.

A) 0.25 B) 0.167 C) 4 D) 6 C) 200 N D) 500N

E) Reason out your choice____

11. Two spherical stones of different masses freely released from the same height of the building at the same time as shown in Fig. 6 .Which of the following is true about the situation?

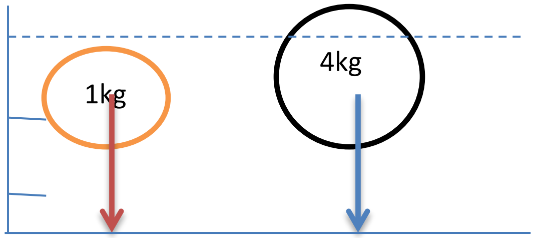


Figure 2-2 Actions of Gravity on Objects

A) The 4kg stone strikes the surface first.
B) The 1kg stone strikes the surface first
C) We can’t suggest from the given information
D) Both strike the surface at the time
E) Reason out your choice____

12. Zapaw lifts a brick, which weighs ‘A’ with constant velocity to a certain height. The force exerted on the brick is

A) Constant, but equal to zero C) Constant, but less than ‘A’
B) Constant, but equal to ‘A’ D) Constant, but greater than ‘A’

E) Reason out your choice_______________________________________

13. Assume that you stand freely in a fast-moving bus. If the bus suddenly stops, what do you feel?

A) Tends to fall backward B) Tends to fall, forwards,
C) Tends to fall sideways D) No change in my position

E) Reason out your choice____

14. The block is shown to move with constant velocity on a horizontal surface. Two forces act on it as shown in fig-7. A frictional force exerted by the surface is the only other horizontal force on the block. The frictional force is:

Fig 7. Two forces (F_1 and F_2) act in opposite direction

A) 5 N, leftward
B) 5 N, rightward.
C) slightly more than 5 N, leftward
D) D) slightly less than 5 N, leftward

E) Reason out your choice____

15. The “reaction” force does not cancel the “action” force because:

A) The action force is greater than the reaction force. B) They are acting on different bodies.
C) The reaction force is greater than the action force
D) The reaction force exists only after the action force removed
E) Reason out your choice____

16. Different masses of objects rest on a level frictionless surface. The force required to set in motion --

A) Increases as the mass increases B) is the same for all objects
C) Increases as the mass decreases D) is equal to the respective weight of the object.
E) Reason out your choice____

17. A book with a mass of 2 kg rests on a table, and the table has mass of 20kg see Fig 8. The force exerted on a book is----.

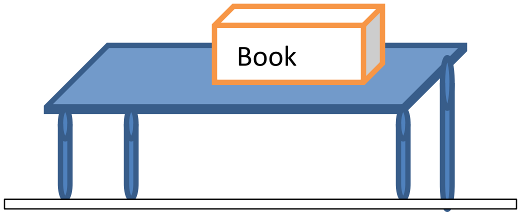


Figure 8 .a book with a mass of 2kg rests on the table.

A) Only, the book exerts a force on the table. B) The table exerts more force on a book.
C) The force exerted by the table on the book is equal in magnitude to the force exerted by the book on the table.
D) only the table exerts a force on a book
E) Reason out your choice____

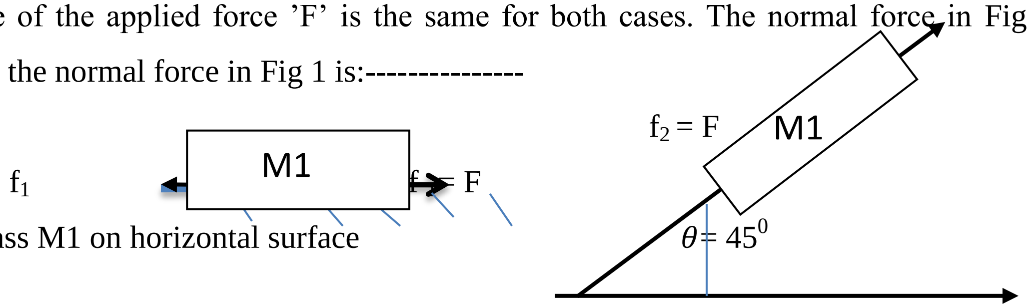
18. Assume that a body is moving by a net force. Then the body moves with ----------

A) Constant acceleration B) constant velocity

C) An increasing acceleration D) A and B are the answer

E) Reason out your choice____

19.A force ‘F’ along a rough surface as shown in diagrams a and b drags a heavy box (Figure 17). The magnitude of the applied force ’F’ is the same for both cases. The normal force in Fig 2 as compared with the normal force in Fig 1 is:---------------



a) Mass M1 on horizontal surface

b) Mass M1 on inclined surface θ= 45^0 *Figure 3. the object of mass m slides along the surface as shown in a and b above*

A) The same , B) Greater , C) Less , D) None

B) Reason out your choice____

Appendix–3, Open End Questionnaires for measuring procedural knowledge.

The purpose of open-ended questionnaires for measuring procedural knowledge(PKT) is designed to investigate preservice physics teachers ‘of both treatment and control groups' procedural knowledge of Newton’s laws of motion. The open-ended questionnaires for measuring procedural knowledge contain three open-ended questionnaires that are used to explore how they applied steps of problem-solving strategies in solving physics problems. The time allowed was twenty minutes.

To solve the following open-ended question using Traditional or Minnesota problem-solving strategies

Q-1 An object acted by an external unbalanced force of $\vec{F}$ will accelerate $\vec{a}$ in the direction of force, if the mass of the body is M, derive the relation between F ,a, and $\vec{M}$ by applying procedural knowledge.

Q-2 Apply procedural knowledge to solve the following problems. An object with a mass of 2.0 kg accelerates with 2.0 m/s2 when an unknown force is applied to it. What is the amount of force?

Q-3 Spherical metal with a mass of 10 kg freely released from a height of h=10 m. Answer the following problems depending on fig-1

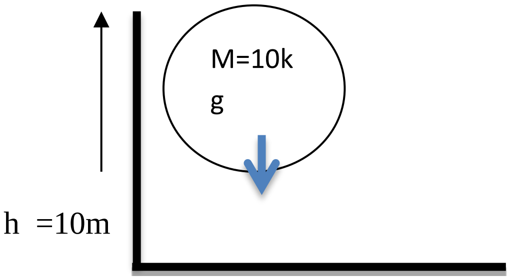


Figure 4-1 Spherical metals are freely falling.

a) Find the force exerted on the surface of the earth by the spherical object?

b) Reason out and describe for the answer you gave in "a".

Appendix – 4 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 30 minutes to complete the test.

Thank you for your participation.

Demographic information: Direction: Please fill in the needed information by putting (√) in the box and write your response in the space provided.

Full Name: ______________________________ College Code _______ Dept____________

Gender: Male ☐ Female ☐ Year __________ Section: ______________________

1) Two boxes of the same shape are placed on a frictionless leveled surface as depicted in fig1below where. But mass 'B' = 40kg and mass 'A'=25kg. A force of 500N is applied to move them with constant velocity.

Figure 5.1 Two boxes are moving with constant velocity.

Depending on the fig. 7. 1 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) The system of two blocks of masses of M1=4kg and M2=2 kg are connected by an ideal massless string on a massless pulley as shown in Figure 1. If the coefficient of friction between the table and mass one (M1) IS 0.6. Find the tension and acceleration of the system.

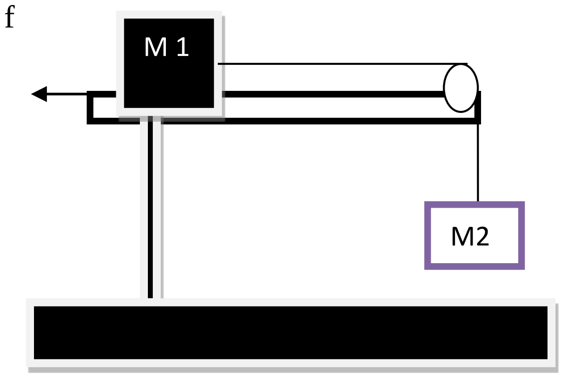


Figure 6. 1 Two blocks are connected by an ideal massless string on the table.

3) 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 7.-2 Two metal boxes A and B

You have to depend on Fig 2 to answer the following question.

a) Calculate the force exerted on the surface

b) Find the force exerted on each mass.

*Appendix -5 Physics Motivational Questionnaires adopted from SMQ-**II** "http: //www.coe.uga.edu*

The purpose of these questionnaires is to measure motivational factors that influence preservice physics teachers in understanding concepts of Newton's laws of motion. The time allowed thirty minutes

The instruction I**:** Write your school and your Code in the space below.

College Code-------------- Student code-----------------

Sex__________ Age __________

Instruction II- Read each of the items carefully. Then select your level of consensus, from the response stipulated in the right columns and circle the number on the corresponding space.

0= Strongly Disagree , 1= Disagree . 2= Indifferent , 3= Agree, 4 = Strongly Agree

No	Statements of the item	Strongly Disagree	Disagree	Indifferent	Agree	Strongly Agree
IMQ1	I find the learning physics is interesting	1	2	3	4	5
IMQ2	My learning of physics is associated with my personal goal and the objectives of the lesson.	1	2	3	4	5
IMQ3	I enjoy learning physics	1	2	3	4	5
IMQ4	I learn physics with great interest and put in adequate effort	1	2	3	4	5
IMQ5	I think about physics and learning how it will help me in my profession.	1	2	3	4	5

IMQ6	The concept of physics I learned is more important to me than the grade I received.	1	2	3	4	5
IMQ7	Understanding physics gives me a sense of accomplishments	1	2	3	4	5
IMQ8	I like physics that challenges me	1	2	3	4	5
IMQ9	It is essential and valuable for me to get high scores in physics.	1	2	3	4	5
IMQ10	I like physics that challenges me	1	2	3	4	5
IMQ11	The physics I learn has practical value for me	1	2	3	4	5
EMQ12	It always concerns me that the punishment of students has a negative result on their performance in physics.	1	2	3	4	5
EMQ13	The most satisfying thing to me would be to get a good grade in a physics course with the help of external support.	1	2	3	4	5
EMQ14	I seek to understand concepts of physics course if the teacher sets rewards for me	1	2	3	4	5
TAQ15	If I am having trouble learning physics, I try to figure out the way.	1	2	3	4	5

TAQ16	It makes me anxious about how I will perform in the physics exam	1	2	3	4	5
TAQ17	I feel helpless when doing physics homework.	1	2	3	4	5
TAQ18	I worry about failing the physics tests	1	2	3	4	5
SEQ 19	I believe I can master the knowledge and skills in the physics course.	1	2	3	4	1
SEQ20	I am confident I will do well in physics labs and projects.	1	2	3	4	5
SEQ21	I understand everything taught in physics lessons.	1	2	3	4	5
SEQ22	I am confident I will do well in the physics tests.	1	2	3	4	5
SDQ 23	I employ different approaches that ensure the learning of physics well	1	2	3	4	5
SDQ24	I use strategies that ensure I learn physics well.	1	2	3	4	5
SDQ25	I put enough effort into learning physics well	1	2	3	4	5
SDQ26	I prepare well for the physics tests and labs	1	2	3	4	5
SDQ27	I planned my time for learning	1	2	3	4	5

	physics.					
CMQ28	The concepts in physics I learn can assist me in finding an excellent career	1	2	3	4	5
CMQ29	I expect to do well and better than other students in the physics course	1	2	3	4	5
CMQ30	I think about how learning physics can help me get a good job	1	2	3	4	5
CMQ31	I want to do well in my physics course because it is important to show my ability to my family, friends, employer, or others	1	2	3	4	5
GMQ32	I believe I can earn the highest mark in a physics course.	1	2	3	4	5
GMQ33	If I can, I want to get better grades in my physics class than most of the other students.	1	2	3	4	5

Meaning of abbreviations =

1. IMQ (1-11) = Intrinsic motivation questionnaires(1-11)
2. EMQ (12-14) = Extrinsic motivation questions (12-14)
3. TAQ(15-18) = Test Anxiety questionnaires'(15-18)
4. SEQ(19-22)= Self–efficacy questionnaires (19-22)
5. SDQ(23-27)=Self-determination questionnaires(23-27)

6. CMQ(28-31) = Careers motivation questionnaires (28-31)
7. GMQ(32-33) = Grade motivation questionnaire (32-33)

Appendix 6. Semi-Structured Interview Guide

Semi-structured interviews were administered to examine the learner's perception or conceptual understanding and deep processing of information focusing on Newton's laws of motion. By inviting the per-service physics teachers to respond to semi-structured interview questions, the perception of the individuals could be examined. The response of the student may invite further questions until the saturation point has been achieved. While the interview is processing, different instructional materials such as books, balls, tables, and local materials could be used. In this way, the perception of the preservice physics teacher‘s conceptual understanding of Newton's laws of motion is examined. The time allowed maximum of 15 minutes

1. How do preservice physics teachers conceptualize Newton's laws of motion?
2. How do preservice physics teachers describe frictional force effects on the ball‘s movement on a frictionless straight line with constant velocity? Do you think it will stop? See Figure 1.

Figure 8 . 1 The ball is moving on frictionless

3. How do preservice physics teachers distinguish between mass and inertia?
4. Do preservice physics teachers have the skill to recognize and comprehend the type of surface smooth or rough on which an item moves?
5. 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 blocks are Ma and Mb respectively, and the mass of Ma >Mb then describe the relation of forces of Ma and Mb

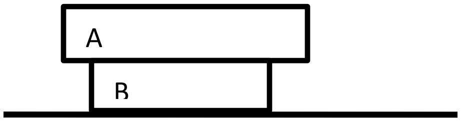


Figure 9-2 Two metal boxes A and B

Appendix 7 Training Manual on Jigsaw-4- Problem-solving Strategies for instructors-(J4PSS)

Purpose of the Manuals

The purpose of this manual is to orient and create awareness for research assistance (physics teachers) used in this study on the administration of the Jigsaw-4 Problem-solving Strategy (J4PSS) in teaching and learning mechanics I(Phy-101). The J4PSS is a student-centered learning and teaching process adapted from the Jigsaw-4 Learning Technique and Problem-solving strategies. The teacher facilitates preservice physics teachers' participation in the learning process to make meaningful learning through increasing motivation and perception of college physics students in cooperative group discussions. It can cover a large portion of the lesson in a short period.

Aim of the Manual

This manual aims to minimize variability among teachers and the effect of another extraneous variable when J4PSS is used in teaching and learning mechanics-I (Phy-101).

What are the Jigsaw-4 Problem-solving strategies (J4PSS)?

J4PSS is a cooperative learning technique through a problem-solving strategy adapted from Jigsaw-4 adapted from Holliday (2002), and Minnesota Assessment of Problem-solving (MAPS)adapted from Thaden-Koch (2005). All preservice physics teachers (class) split into small groups called Home Groups (HG) and Expert Groups (EG). Each preservice physics teacher in EG is expected to learn only part of a topic to be an expert. In HG each presenter who comes from EG shares the idea of the group (master in an area) in a part of the whole J4PSS. The EGs go back to their HGs to teach and share their findings with their colleagues.

The following procedures were used for the purpose of administering the treatment.

- Introduction

The teacher poses the open-ended question from the topic of the lessons, explores, chooses strategies, facilitates the participation of the students in a plenary session, and assigns students to a home group, containing four preservice physics teachers. The members of each home group were divided into expert groups. See the illustration of the J4PSS was given in Figure 1 below.

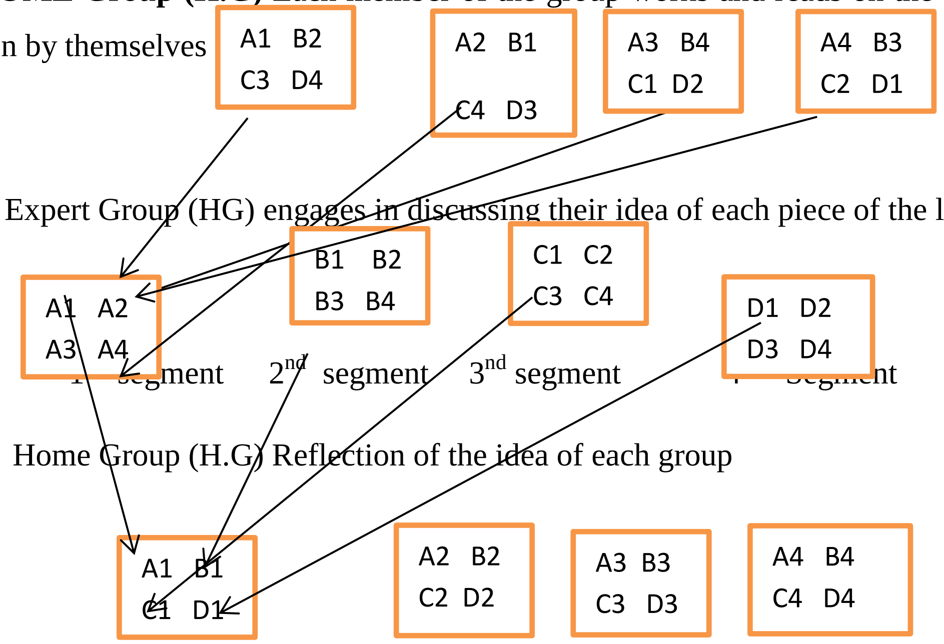
The topic of the daily lesson is divided into four segments (A, B, C, and D), and each segment is discussed by each Expert Group (EG) to be an expert.

Activities designed from a topic of the lesson by dividing into four segments (A1+B1+C1+D1=(Topic of lesson) 4 Segments of a topic is given to the member of each of Home Group.

A1 =A2=A3= A4=First segment Piece of lesson C3=C4=C1=C2=Third segment

B2= B1=B4=B3=Second segment D4 =D3=D2=D1= Fourth segment

HOME Group (H.G) Each member of the group works and reads on the specific issue of the lesson by themselves



2. Expert Group (HG) engages in discussing their idea of each piece of the lesson.

1 segment 2nd segment 3nd segment 4 segment

3. Home Group (H.G) Reflection of the idea of each group

Figure 10 . 1 is the illustration of the Home Group and Expert Group for J4PSS.

- Student Activity Using Jigsaw-4 Problem-solving Strategies

The experimental group was exposed to Jigsaw-4 Problem-solving Strategies by the researcher for seven weeks of teaching via the following steps. Thus,

1. Preservice physics teachers divided the class students into 4Jigsaw Groups or 4 Home Groups, each of the group have 4 students made in making sure that the groups are diverse in terms of **gender** ‘**demography** and v**aried ability.**

2. The leader of the group appointed from each group of Preservice physics students. His role was to coordinate the group discussion and maintain order. Other members of the group were assigned different roles such as leader, recorder, presenter, material distributor, and timekeeper.

3. The teacher corresponding to the members of the group also divided the day‟ lesson into 4 segments.

4. One segment of the lesson is assigned to each student in a group to learn making sure; those students have direct access only to their segment.

5. Students were given time to read over their segment at least twice to become familiar with it. The teacher encourages the students not to memorize the segment given to them.

6. Temporary “expert groups” were formed. This was done by having one student from each Home Group join other students assigned to the same segment. Students in these expert groups were given time to discuss the main points of their segment and to rehearse the presentations they made to their jigsaw group. The teacher went around to support the students.

7. The students asked questions based on their expert sheet to check their understanding before returning to their home group.

- Discussion and presentation of the group activity on the lesson

Participants in each of the expert groups discuss one segment of the lesson. After discussion, each member of the Expert Group was asked to go back to their original Home Group to share or teach others sections what they had discussed. They reminded each other to master the materials as much as possible. Each student who studied a particular segment was asked to present their idea of the segment to the rest of the group members. Other members of the group were encouraged to ask questions for clarification. The teacher then moved from group to group, observing the process.

- TECMRER-MODEL

TECMRER MODEL of the constructivist approach consists of the thinking process, Exploring, Choosing strategies, Maniplation , Reflection, Evaluation, and Re-teaching. It was adopted based on Sociocultural Theory (SCT), which focuses on the role of participation in social interaction and culturally organized activities. It was derived from teaching experience, challenges faced by the student, and previous researcher's evidence and model of Krulik and Rudnick (Krulik &Rudnick,2017). It is used to create meaningful learning in their mind (Fah, Y. L. (2010) in which, individual preservice physics teachers, construct/build knowledge of their own from group activities of the lesson based on prior knowledge. The appropriate instructional strategies selected for solving the above problems are Jigsaw-4 Problem-solving strategies. It is implemented by designing a worksheet based on some groups of experts in the Jigsaw-4 Technique of teaching for first-year preservice physics teachers on the topic of Newton's laws of motion by considering the TECDRER model of the constructivist approach adopted from (Krulik &Rudnick,2017). the content of these steps is as follows,

- ✓ In the "Thinking process" step, the teacher poses or asks a question to awaken curiosity for reading and understanding the problem, determining the prior knowledge and background of a member of the Expert Group and Home Group of preservice physics teacher link to students gaining of the domain in Newton's laws of motion, it helps us to know the level of knowledge of students.

Example "What do you think about Newton‘s laws of motion in terms of facts, concepts, laws, and application of the laws in a real-life situation?

- ✓ In the "Exploring" step, students perform some experiments and observations based on the above problems. Member of Expert Group investigates, to gain new information on Newton's laws of motion in real-life situations. The learner must develop an idea about the question of Newton's laws of motion, concepts, principles, and their application to the specific situation. Preservice physics teachers must choose appropriate strategies that lead to the solution.

- ✓ Choosing strategies: Expert Group Students should plan and arrange the steps involved to find the solution for the specific application of the problem, based on Minnesota problem-solving strategies (Doctor, J, 2009) has five steps. The step includes describing the physics, appropriate physics approach, specific application of the law of physics, mathematical procedure, and logical progression

- ✓ Manipulation; Expert Group Students must implement a plan of Minnesota problem-solving strategies in finding out the solution.
- ✓ Reflecting: Expert Group Students go back to their home group to share the ideas of each group. The member of the Home Group goes back to the Expert Group to present the idea of the group. In this phase, the group members share ideas about the topic,
- ✓ **Evaluation:** The students asked questions to check their gaining in three domains such as cognitive, affective, and science process skills based on the lessons. The whole class was evaluated individually, and the scripts were collected, marked, recorded, and returned during the next class.
- ✓ Re-teaching the main point and the missing parts at the end of each lesson after an individual assessment is conducted. The researcher emphasized to students the need for J4CLS (structured cooperative group work) before the treatment. Students were taught about the existence of the group's goal, the need for sharing opinions and materials, and the division of labor group reward. Students in J4LT groups also learned skills that they need to facilitate their group interactions

In this research, the TECMRER model was used as a reference for the implementation of Newton's laws of motion using worksheet activities for the Expert Group. One of the advantages of this model compared to other models is that it includes the exploring and choosing strategy. To solve problems in Newton's laws of motion, members of the Expert Group of students must share responsibility, and explore the following concepts, principles, laws, and their application to specific problems, The researcher TECMRER model adapted from the model of Krulik and Rudnick (2017) for implementation of Jigsaw-4- problem-solving strategies in college. Teachers and students will follow the following steps during the implementation of the lesson instruction on Newton's laws of motion problems.

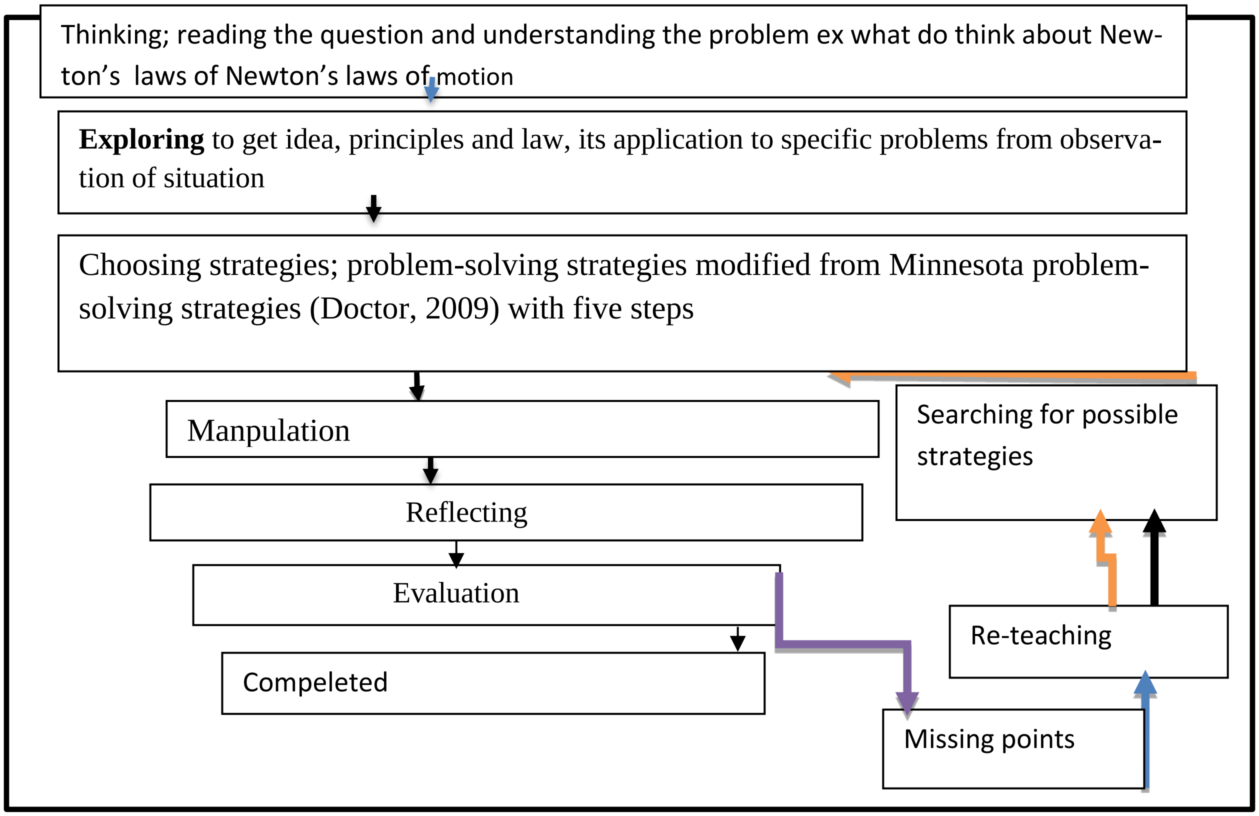


Figure 11. 12: Shows the implementation process Jigsaw-4-Problem-solving Model adapted from Krulik and Rudnick (2017)

According to Abdullahi, S. (2010), the implementation of the Jigsaw II Technique through school instruction positively motivated students' understanding of concepts of physics; therefore, using Jigsaw-four problem-solving strategies through college instruction will positively motivatestudents' understanding of the fact that concept, problem-solving skill, motivation, engagement, and perception in outcomes of mechanics, especially in Newton's laws of motion. Following the steps of Minnesota problem-solving strategies, in which students are more systematically assisted and structured (Serap Calfskin et al., 2010), is a very important step in training the beginner before facing a more ill-structured problem, which is normally encountered in real-world situations (Docktor & Mestre, 2014). Moreover, it is certainly clear that any innovative teaching and learning in the existing lecture-centric classroom situation would welcome the training of a future generation of scientists and technologists.

Appendix 8. Training Manual on Problem-Solving Strategies for Instructors

Purpose of the Manuals

The purpose of this manual is to orient and create awareness for research assistants (physics teachers) used in this study on the administration of the TECMRER Problem-Solving Strategy (TECMRER-PSS) in teaching and learning mechanics I (Phy-101). The TECMRER-PSS is a student-centered learning and teaching process adapted from Minnesota and heuristic problem-solving strategies. The teacher facilitates preservice physics teachers' participation in the learning process to make meaningful learning by increasing the motivation and perception of college physics students to participate in doing their tasks.

Aim of the Manual

This manual aims to minimize variability among teachers and the effect of another extraneous variable when J4PSS is used in teaching and learning mechanics (Phy-101).

What are the TECMRER problem-solving strategies?

The TECMRER problem-solving strategy is active learning of a problem-solving strategy using the TECMRER model adapted from Jigsaw-4, heuristic problem-solving strategy, and Minnesota problem-solving strategy (MPSS). The following procedures were used for the purpose of administering the treatment:.

Introduction

The teacher poses open-ended questions about the topic of the lessons and facilitates the participation of the students in applying the TECMRER Model of problem-solving strategy.

Student Activity Using TECMRER Problem-Solving Strategies

The experimental group was exposed to TECMRER problem-solving strategies by the researcher for seven weeks of teaching via the following steps:.

Each participant in class was subjected to thinking about the problem, exploring the necessary information, choosing and planning the strategy to solve it, manipulating each step of the problem-solving strategy, and reflecting on his task for his peer's. They reminded each other to master the materials as much as possible. Each student who studied the lesson was asked to present their idea *of the lesson to their peers. The peers were encouraged to ask questions for clarification. The teacher then moved within the class and facilitated by observing the process.*

The TECDRER MODEL of the constructivist approach consists of the thinking process: exploring, choosing strategies, manipulating, reflecting, evaluating, and re-teaching. It is implemented by designing a worksheet based on the topic of Newton's laws of motion and considering the following steps:In the "Thinking Process" step, the teacher poses or asks a question to awaken curiosity for reading and understanding the problem, determining the prior knowledge and background of a member of the preservice physics teacher linked to students understanding of Newton's laws of motion; it helps us to know the level of knowledge of students.

Example: "What do you think about Newton's laws of motion in terms of facts, concepts, laws, and

In the "Exploring" step, students perform some experiments and observations based on the above problems. Each member investigates to gain new information on Newton's laws of motion in real-life situations. The learner must develop an idea about the question of Newton's laws of motion, concepts, principles, and their application to the specific situation. Preservice physics teachers must choose appropriate strategies that lead to the solution.

Choosing strategies: Each student should plan and arrange the steps involved to find the solution for the specific application of the problem. Based on Minnesota problem-solving strategies (Doctor, J., 2009), there are five steps. The steps include describing physics, an appropriate physics approach, specific application of the law of physics, mathematical procedure, and logical progression.

Manipulation: Students must implement a plan of Minnesota problem-solving strategies to find the solution.

Reflecting: Students must share their idea of the lesson with their peers.

Evaluation: The students asked questions to check their understanding of the objectives of the lessons. The whole class was evaluated individually, and the scripts were collected, marked, recorded, and returned during the next class.

Re-teaching the main point and the missing parts at the end of each lesson after an individual assessment was conducted. The researcher emphasized the need for students to share opinions and materials and facilitate their interactions.

In this research, the TECMRER model was used as a reference for the implementation of Newton's laws of motion using worksheet activities for the class. One of the advantages of this model compared to other models is that it includes exploring and manipulating to solve problems in Newton's laws of motion. Students must share responsibility and explore the following concepts, principles, laws, and their application to specific problems: The researcher's TECMRER model was adapted from the heuristic problem-solving strategy model of Krulik and Rudnick (2017) and Minnesota problem-solving strategies. Teachers and students will follow the following steps during the implementation of the lesson instruction using the TECMRER problem-solving strategy in Newton's laws of motion:.

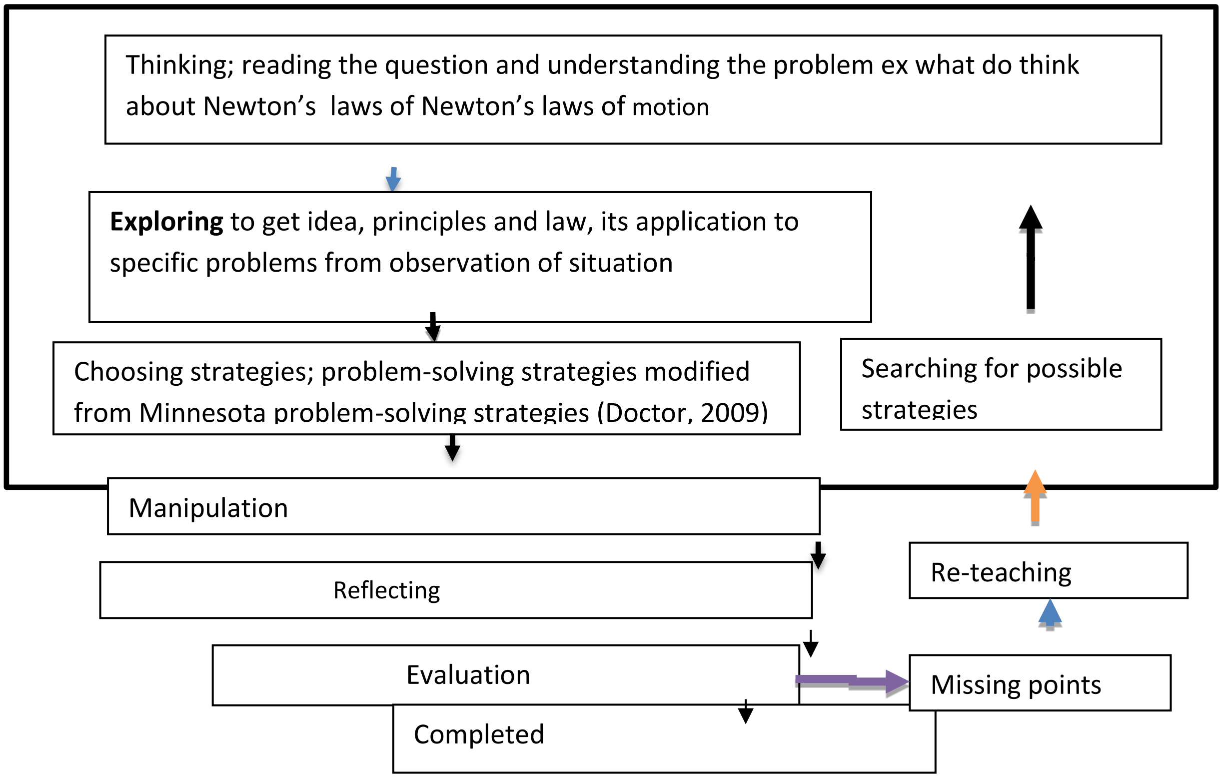


Figure 12.13: Shows the implementation process of the TECMRER Problem Solving Strategy

TECMRER-problem-solving strategies through college instruction will positively motivate students' understanding of the facts, concepts, procedural knowledge, problem-solving skills, motivation, and perception of outcomes of mechanics, especially in Newton's laws of motion. Following the steps of Minnesota and Heuristic problem-solving strategies, in which students are more systematically assisted and structured (Serap Calfskin, et. al,2010) which is a very important step in training the beginner before facing a more ill-structured problem, which is normally encountered in the real world situation (Docktor & Mestre, 2014). Moreover, it is certainly clear that any innovative teaching and learning to the existing lecture-centric classroom situation would welcome the training of a future generation of scientists and technologists.

The Role of Assistance Teachers 'are implementing problem-*solving strategies with the conventional approach.*

a) Assistance teachers (he/she) must provide appropriate knowledge to establish problems for the learner to understand, clarify, and attempt to formulate procedures for a solution.

b) He /she must pose a problem and plan and organize summarized notes on the lesson for per-service physics teachers.

c) He/she must help preservice physics teachers to understand and define the problem clearly.

d) He/she must highlight the lesson related to the problem at hand.

e) He/she should encourage overcoming the shyness and fears of the per-service physics teacher during the implementation of problem-solving strategies with the conventional approach.

f) He/she must show the learner how to approach a problem, formulate and devise a strategy for the solution, and do a verbal analysis of the problem. In a non-evaluative way, a teacher should accept writing and wrong /answer.

g) He/she writes the note on the blackboard.

h) The lesson is organized on the base of the problem; the teacher must consider the practical value of this procedure.

i) The principle of cause and effect should be emphasized in the lesson presentation of Newton's laws of motion.

j) He /she has to make students participate actively in lesson implementation using problem-solving strategies with the conventional approach.

k) He/she solves the problem in the lesson using Minnesota problem-solving strategies

l) He/she leads toward the goal of the lesson.

Appendix -9 Training manual in Jigsaw-4-Technique of Learning (J4TL)

Purpose of the Manuals

The purpose of this manual is to orient and to create awareness for research assistance (physics teachers) used in this study on the administration of the J4TL in the teaching and learning of mechanics-I (Phy-101). The J4TL like the other Jigsaws such as Jigsaw I, II & III, Reverse, and subjects is a student-centered learning strategy that facilitates preservice physics teacher‘s participation in the learning process and makes learning more interesting to college physics students and can cover a large amount of material quickly.

Aim of the Manual

This manual aims to minimize variability among teachers and the effect of another extraneous variable when J4TL used in the teaching of mechanics-202

What is the Jigsaw-4 Technique of Learning (J4TL)?

J4TL is a cooperative learning strategy developed by Holliday C.D: Holliday(2002) from Jigsaw III. In J4TL, preservice physics teachers (class) are split into small groups called home groups (HG). Each preservice physics teacher in the HG is expected to reflect only part of a material of their group called the Expert Group (EG) which makes them experts (masters in an area) in a part of the whole Jigsaw. The EGs go back to their HGs to teach and discuss their findings with their colleagues.

The following procedures were used for the purpose of administering the treatment.

1. Introducing the materials

The teacher introduces the lessons, and the principal facilitates the participation of the students in a plenary session and assigns students to a home group, containing four pre-service physics teachers. The members of each home group were divided into expert groups. See the illustration of the J4TL given in Figure 1 below.

2. Student Activity Using Jigsaw-4 Technique Learning

The experimental group was exposed to the Jigsaw-4 Learning Technique by the researcher for seven weeks of teaching via the following steps. Thus,

Pre-service physics teachers are divided into 4 -person jigsaw groups. Efforts were made to make sure that the groups were diverse in terms of gender ‘demography and varied ability.

3. The leader of the group is appointed from each group of Per-service students. His role was to coordinate the group discussion and maintain order. Other members of the group are assigned different roles such as leader, recorder, orator material distributor, and timekeeper - who remain groups of the time left for group work.

4. The teacher corresponding to the members of the group also divided the day‟ lesson into 4 segments.

5. One segment of the lesson is assigned to each student in a group to learn making sure; those students have direct access only to their segment.

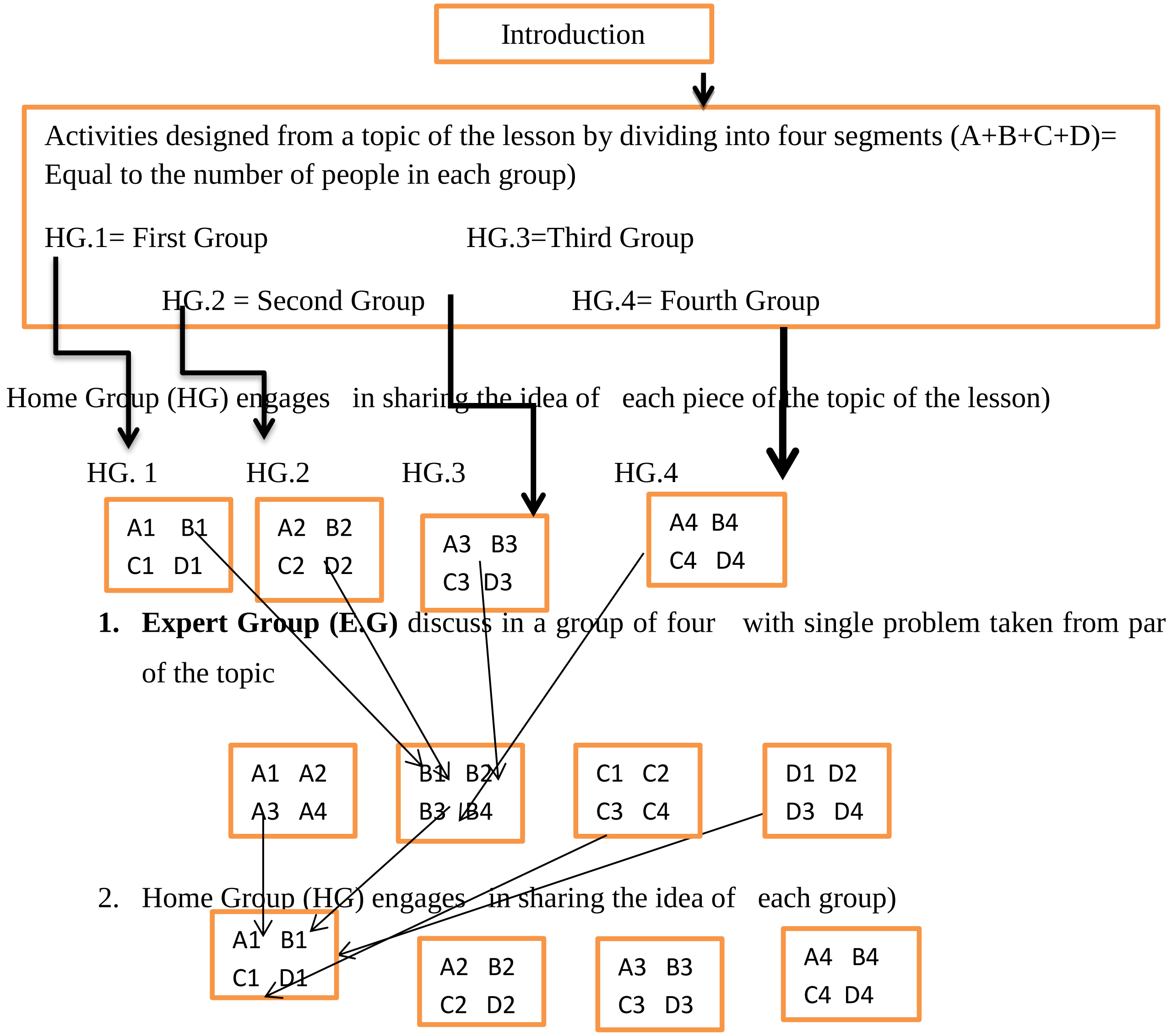
6. Students were given time to read over their segment at least twice to become familiar with it. The teacher encourages the students not to memorize the segment given to them.

7. Temporary “expert groups” were formed. This was done by having one student from each JigsawIV group join other students assigned to the same segment. Students in these expert groups were given time to discuss the main points of their segment and to rehearse the presentations they made to their jigsaw group. The teacher went around to support the students.

8. The students asked questions based on their expert sheet to check their understanding before returning to their home group.

- Home Group Discussion

Participants in the expert groups were asked to go back to their original home group to teach others the sections they had discussed. They reminded each other to master the materials as much as possible. Each student who studied a particular segment was asked to present his or her segment to the rest of the group members. Other members of the group were encouraged to ask questions for clarification. The teacher then moved from group to group, observing the process. The topic of the daily lesson is divided into four segments (A, B, C, D), and each segment is discussed by each Expert Group(E G) to be an expert it.



Activities designed from a topic of the lesson by dividing into four segments (A+B+C+D)= Equal to the number of people in each group)

Home Group (HG) engages in sharing the idea of each piece of the topic of the lesson)

1. **Expert Group (E.G)** discuss in a group of four with single problem taken from part of the topic

2. Home Group (HG) engages in sharing the idea of each group)

Expert Group (E.G) Reflection of the idea of each group

- **Evaluation** The students give a response to asked questions based on the stated specific objectives of the lessons. The whole class was evaluated individually, and the scripts were collected, marked, recorded, and returned during the next class.

- Re-teaching

Re-teaching the main point and the missing parts at the end of each lesson after an individual assessment is conducted. The researcher emphasized to students the need for J4LS before the treatment. Students were taught about the existence of the group's goal, the need for sharing opinions and materials, and the division of labor group reward. Students in J4LS groups also learned skills that they need to facilitate their group interactions.

The responsibility of the teacher in J4LT according to Mbacho (2013) the following responsibility of the teacher in the Jigsaw-4 classroom situation

1. He/She divided the students into groups, which should be diverse in gender and ability. These are the initial groups called the Home Groups (HG).

2. He/ She appoints one person from each group as a leader who should be the most mature in the group.

3. He/she divides the lesson into tasks and writes them on the blackboard.

4. He/ She gives each student in each group a number in the form of a code. Students with the same code from each HG are assigned the same task and so on.

5. He/ She ensures that students from each jigsaw group join other students assigned the same task to form ―an Expert Group (EG). The teacher gives the expert groups time to discuss their task and also refer to the textbooks and use the resources available to complete the given task.

6. The students after completing the above task, the teacher brings the students back to their jigsaw groups and asks each student to present his or her task to the group. The teacher floats from group to group observing the process.

7. The teacher then evaluates the lesson by either asking questions or giving an assignment on what has been learned. In the case of this research, an individual assessment has been taken,

Instructional Objectives of J4TL

An instructional objective refers to the outcome /end results achievable in a lesson. The lesson stated in terms of changes in learner’s behavior. Behavior includes mental (cognitive), emotional (effective), and physical (psychomotor) reactions. instructional objectives are stated in terms of learning outcome because we are concerned with products of learning rather than with the process of learning, Instructional objectives provide directions to the teaching process, set the instructional objectives provide directions to the teaching process and set the stage for the evaluation of the student's learning.

Appendix 10. Lesson plan of Conventional approach for Control groups.

Subject: Mechanics-I(Phy-101)

Topic: Newton's Laws of Motion

Group: Control Group

Class: ----------------

Age: ------------years

Sex: Mixed (boys and girls)

Main activity

Preservice physics teachers will Study, and define, concepts, laws, and application of laws in Newton's laws of motion.

Teaching Method: Conventional Method

Instructional materials: Lesson notes and chalk

Objectives: At the end of the lesson, the students should be able to:

- Define the cause of Newton’s laws of motion.

- Write the Meaning of Newton's laws of motion
- State each of three Newton's laws of motion
- Solve the problem using problem-solving strategies.
- List some applications, of Newton's laws of motion in a real-life situation.

Full name of Instructor ____

Signature ____________________ Date____

Full name of Department head ____________________Signature ______ Date___

Full name of School Director ____

Signature ____

Date____

Appendix 11. LESSON PLAN of TECMRER- Problem-solving Strategies

Subject: Mechanics-I (Phy-101)

Topic: Newton's laws of motion

Group: Experimental

Class: ____________

Time allowed 50 minute

Age----------years

Sex: Mixed (boys and girls)

Main activity: Studying the Cause, Meaning, Laws, and Application of Newton's laws of motion

Teaching Method: TECMRER-Problem-solving strategies

Teaching Model: TECDRER -MODEL

Materials:

- Worksheets for all students: on Newton's laws of motion
- Copies of study notes to all preservice physics teachers on :
- Meaning of Newton's laws of motion
- Stating each of three Newton's laws of motion
- Application of Newton's laws of motion

- By observing the picture and simple demonstration, the student concludes that when the unbalanced force is applied to the mass of matter, they are set in motion.
- Students associate the effect of force on the state of matter /body.

The objective of the lesson

- to investigate the facts associated with Newton's laws of motion.
- to explore the concept related to Newton's laws of motion.
- to state and list three of Newton's laws of motion.
- to explore the application of Newton's laws of motion in a real-life situation.

Presentation

The teacher presents the lesson through the p following steps

Step one. Posing open-ended questions for the students (5 min)

The instructor introduces the lesson to them, by posing an open-ended question

"What do you think about Newton's laws of motion?"

The students discuss and answer the question based on their prior knowledge, and the teacher evaluates the response of the students and their level of associating new knowledge with old or prior knowledge, to guide students' construction of knowledge about Newton's laws of motion.

Step two. Exploring phase, investigating causes, concepts, laws, and application of Newton's laws of motion, depending on the following images answer the following question (15 min).

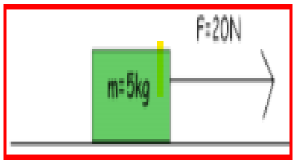


Image one. A force of 20 N was applied to 5 kg of mass and set in motion.

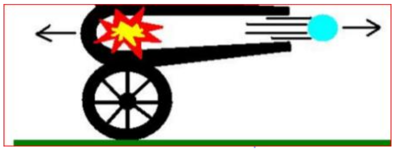


Image two. The bullet fired out of the gun

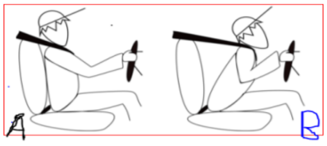


Image three. The state of motion of the man has changed from point A to point B when the force is applied to the seat,

- Can you find out the cause, concepts, law, and application of the law behind image one?
- Would you **explore**, the concept, laws, and application of law behind image two'
- group **explore**, the concept, laws, and application of law behind the image three
- explore the application of Newton's laws of motion in a real-life situation.

Students were given time to explore the main points of their lesson and to rehearse the presentations they made in their class. The teacher goes around facilitating and supporting the students.

Step three choosing strategies and Discussing the steps (2min), Minnesota problem-solving strategies are been selected to solve the problem in mechanics. It has five steps, which are

- a useful description of the problem of the statement
- appropriate physics approach to solving the problem

- specific application of the laws of physics
- mathematical procedure
- logical progression

Step four. Manipulating: applying five steps of Minnesota problem-solving strategies for solving specific applications of Newton’s laws of motion The teacher goes around facilitating and supporting the students.10 min

1. Do you define the cause of the motion of image one?\
2. Can you define Newton’s law motion applied to image two?
3. Do you state Newton’s law of motion applied to image three above?
4. Do you list the application of Newton’s law of motion in a real-life situation?

1.____

2.____

3.____

4.____

Step five, Reflection**:** the preservice physics teacher discussion focused on sharing experiences with his peer. 5 min

Activity : work sheet for each preservice physics teachers

1. Do you define the cause of Newton’s law of motion?
2. What is the meaning of Newton’s laws of motion?
3. Do you state the three Newton’s laws of motion?
4. Do you list the application of Newton’s lows of motion in a real-life situation?

1.____

2.____

3.____
4.____

<u>Step six Evaluation:</u> The researcher evaluates the lesson by giving the students the following quiz to answer individually. (10 min)

- What is the cause of motion?
- Do you explain the meaning of Newton's laws of motion?
- Do you state one of three of Newton's laws of motion?
- Do you list the application of Newton's laws of motion in a real-life situation?

The instructor will collect the answers to the questions, mark them, score them for each student, and return them during the next lesson.

<u>Step seven re-teaching</u>: The instructor concludes the lesson by re-teaching the main idea or missing part of the lesson**. (3 min)**

Full name of Instructor ____

Signature ______________________________________

Date____

Full name of Department head ____

Signature ____

Date____

Full name of School Director ____

Signature ____

Date_______________________

Appendix 12. Lesson plan of Jigsaw-4 Learning Techniques applied in teaching and learning of mechanics for Experimental Group.

Course: Mechanics-I (Phy-101)

Topic: Newton's laws of motion

Group: Experimental

Class: ____________

Time allowed 50 minute

Age----------years

Sex: Mixed (boys and girls)

Main activity: Studying the Cause, Meaning, Laws, and Application of Newton's laws of motion

Teaching Method: Jigsaw-4-Learning Techniques

Materials:

a. Worksheets for all students: on Newton's laws of motion
b. Copies of study notes to all home group students on :
c. Meaning of Newton's laws of motion
d. Stating each of three Newton's laws of motion
e. Application of Newton's laws of motion

Objectives: Cognitive: at the end of the lesson, the students should be able to:

1. Investigate the cause of motion.
2. Write the Meaning of Newton's laws of motion
3. State each of three Newton's laws of motion
4. List the Application, of Newton's laws of motion in a real-life situation.

Affective: the students should be able to work cooperatively in a Jigsaw-4-group

Entry Behavior: Students taught force and Newton's laws of motion in primary and secondary school (7th, 9th, and 11th)

Introduction:

The instructor introduces the lesson by explaining to the student that they are going to learn Newton's laws of motion using the Jigsaw-4 Learning Technique where all of them will work cooperatively together and that the success of the group depends on the success of the individual member of the group.

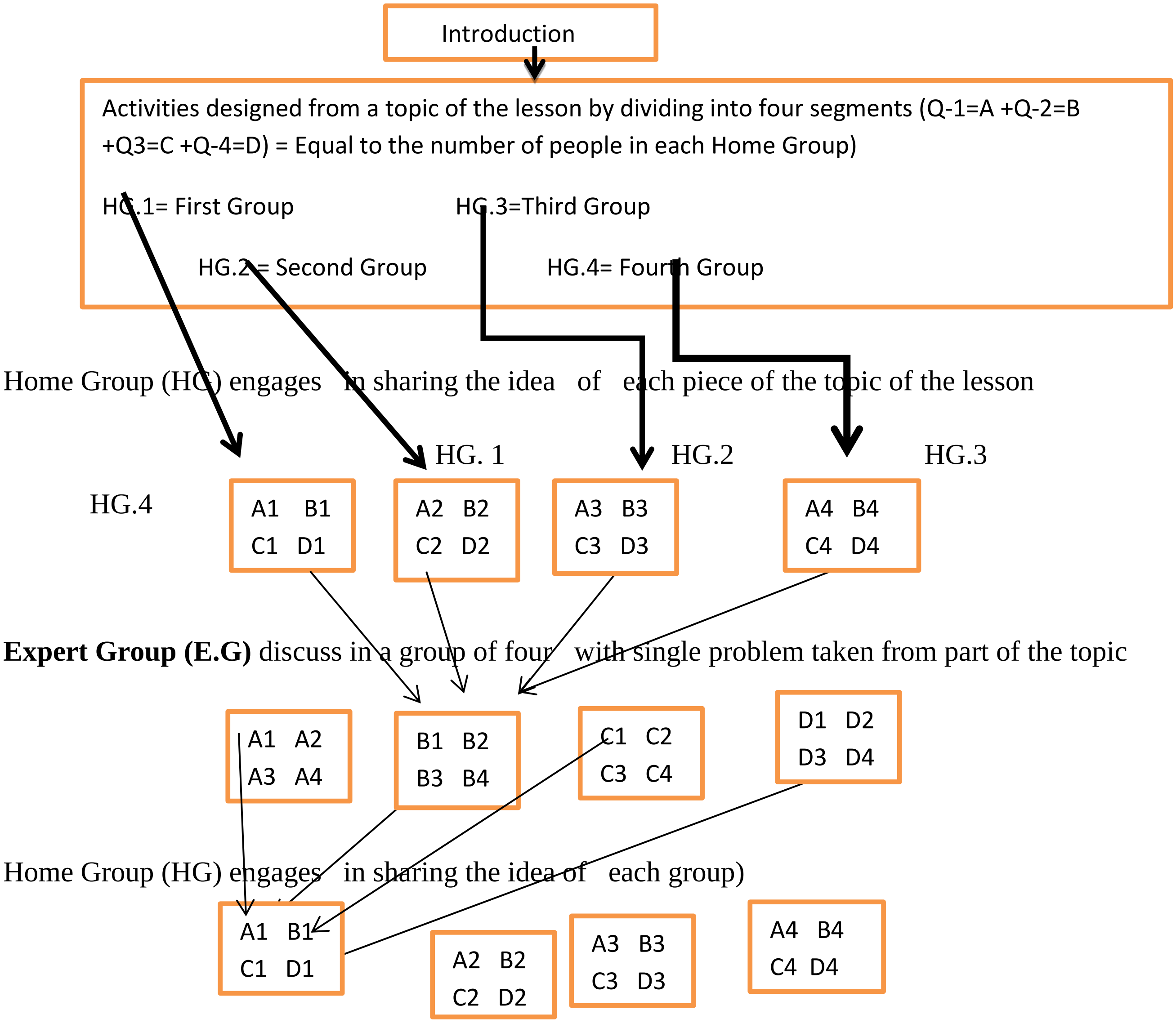
Presentation

The teacher presents the lesson through the following steps

Step 1. Assigning students into Groups

The instructor then groups the students into Jigsaw-4 groups or Homegroup and Expert Group comprising four students per group. Making sure the groups are heterogeneous. Each student in a group is assigned a different task to perform. To begin the lesson, the teacher gives each group of HG specific segments of the lesson presents the results of their activities for the group, and gets some comments.

Each member of the home group did a specific task to work on/study. Each member of the expert was asked to present their investigation of his/her task for some time on a single segment. Students study different tasks in each Expert group. After discussion in EG, each member of the group returns to and reflects on their work for Home groups where they study collectively (Q-1, Q-2, Q-3, and Q-4) the task and record useful information or the worksheet earlier provided for the feedback to his/her Jigsaw-4 group /Home Group.



Expert Group (E.G) Reflection of the idea of each group

Step two. Activity: the activity outlines for expert groups (E G) are as follows; (2 min)

Q- 1 Can you explain the cause of motion?

Q-2 What do you think about the meaning of Newton's laws of motion?

Q -3 Can you discuss and state the three Newton's laws of motion?

Q-4 Can you list the application of Newton's laws of motion in a real-life situation?

Step three Expert Group Discussions (5min)

Expert groups are formed by having one student from each JigsawIV group/ Home Group join other students assigned to the same segment. Students in these expert groups are given time to discuss the main points of their segment and to rehearse the presentations they make in their Jigsaw-4 group. The teacher goes around facilitating and supporting the students.

Step four. Discussion of their learning outcomes (Jigsaw Group/ Home Group Discussion) (20 min)

Members of the expert groups are after some time asked to break and go back to their main group known as jigsaw groups where each expert explains his/her task to the remaining members of his/her group. Other members of the group were encouraged to ask questions and clarification from the expert group where necessary. As the group discussion is on, members of the groups assigned to perform a certain role like the timekeeper, questioner, reader, reminder, and so on do the job.

Activity 1: worksheet

Do you define the cause of motion?

____

____

Activity 2: worksheet

What is the meaning of Newton's laws of motion?

____

Activity 3: worksheet

Do you state the three Newton's laws of motion?

1.____

____

2.____

____

3.____

Activity 4: worksheet

Do you list the application of Newton’s law of motion in a real-life situation?

1.____
2.____
3.____

Evaluation: The researcher evaluates the lesson by giving the students the following quiz to answer individually. (20 min)

- What is the cause of motion?
- Do you explain the meaning of Newton’s laws of motion?
- Do you state each of three Newton’s laws of motion?
- Do you list the application of Newton’s laws of motion in a real-life situation?

The instructor will collect the answers to the questions, mark them, score them for each student, and return them during the next lesson.

Conclusion: The instructor concludes the lesson by re-teaching the main idea or missing part of the lesson**. (3 min)**

Full name of Instructor ____

Signature ____________________________________

Date______________________________________

Full name of Department head ____

Signature ____

Date____

Full name of School Director ____

Signature ____

Date____

Appendix 13. LESSON PLAN of Jigsaw-4 Problem-solving Strategies (J4PSS) conducted on Experimental group.

Subject: Mechanics-I (Phy-101)

Topic: Newton's laws of motion

Group: Experimental

Class: ____________

Time allowed 50 minute

Age----------years

Sex: Mixed (boys and girls)

Main activity: Studying the Cause, Meaning, Laws, and Application of Newton's laws of motion

Teaching Method: Jigsaw-4-Problem-solving strategies (J4PSS)

Teaching Model: TECDRER -MODEL

Materials:

- Worksheets for all students: on Newton's laws of motion
- Copies of study notes to all home group students on :
- Meaning of Newton's laws of motion
- Stating each of three Newton's laws of motion
- Application of Newton's laws of motion

Student's gaining of cognition

The student constructs knowledge (facts, concepts, procedure, laws, and application of laws) related to Newton's laws of motion.

- By observing the picture and simple demonstration, the student concludes that when the unbalanced force is applied to the mass of matter, they are set in motion.
- Students associate the effect of force on the state of matter /body.

Student's gaining of Affective domain:

The students should perceive and be motivated to work cooperatively in a J4PSS.

1) Perception
    - ▪ They listen attentively
    - ▪ They give attention to the activities in their environment
    - ▪ They are willing to learn and understand
    - ▪ They are open-minded
    - ▪ They are not biased
2) Motivation
    - They have intrinsic motivation.
    - They are constantly willing to try.
    - They trust in the democratic process
    - They trust in logic, science, and technology
    - They appreciate the people
    - They try to live clean and health

- They are well-behaved

Student’s, gaining scientific process skill

1. They observe pictures, diagrams, events, and simple demonstrations, using their sense organs.
2. Depending on the observations, the students explore or investigate facts, concepts, laws, and the application of laws for specific tasks behind the problems.
    - They investigate the facts associated with Newton’s laws of motion.
    - They explore the concept related to Newton’s laws of motion.
    - They state and list three of Newton’s laws of motion.
    - They explore the application of Newton’s laws of motion in a real-life situation.

Entry Behavior: Students taught force and Newton’s laws of motion in primary and secondary school (7th, 9th, and 11th)

Introduction:

Assigning students into Groups

The instructor then groups the students into J4PSS groups comprising four students per group. Making sure the groups are heterogeneous. Each student in a group is assigned a different task to perform. To begin the lesson, the teacher gives each group name written on a card. Each member of the group was given a specific task to work on/study. His/her Expert Group is attached to the study note that was given to him/her. Each expert was asked to study his/her task for some time. No student in the same group was allowed to see the task given to his fellow group members. Students studying the same task from each Expert group were asked to form Home groups where they study collectively the task and record useful information or the worksheet earlier provided for feedback to his/her J4PSS group /Home Group.

Presentation

The teacher presents the lesson through the following steps

Step one. Posing open-ended questions for the expert group students (5 min)

The instructor introduces the lesson to the expert group, by posing an open-ended question

> “What do you think about Newton’s laws of motion?”

The students in the expert group going to discuss cooperatively and answer the question based on their prior knowledge, and the successes of the group depend on the success of the individual member of the group. The teacher evaluates the response of the students in the expert group to see their level of associating new knowledge with old or prior knowledge, to guide students' construction of knowledge about Newton’s laws of motion.

Step two. Exploring phase, investigating causes, concepts, laws, and application of Newton’s laws of motion, depending on the following images answer the following question (10 min). The activity outlines for expert groups (E G).

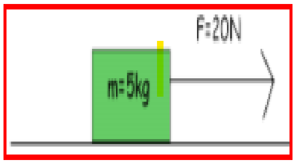


Image one. A force of 20 N was applied to 5 kg of mass and set in motion.

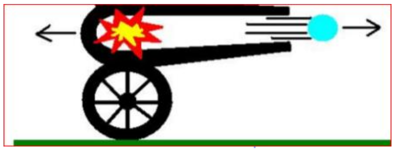


Image two. The bullet fired out of the gun

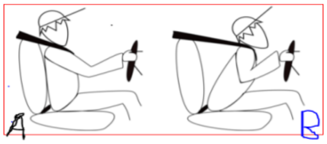


Image three. The state of motion of the man has changed from point A to point B when the force is applied to the seat,

- Can you find out the cause, concepts, law, and application of the law behind image one?

- EG B Members of this group **explore**, the concept, laws, and application of law behind the image two
- EG C Members of this group **explore**, the concept, laws, and application of law behind the image three
- EG D Members of this group explore the application of Newton's laws of motion in a real-life situation.

Expert groups are formed by having one student from each JigsawIV group/ Home Group join other students assigned to the same segment. Students in these expert groups are given time to explore the main points of their segment and to rehearse the presentations they make in their Jigsaw-4 group. The teacher goes around facilitating and supporting the students.

Step three choosing strategies (2min), Minnesota problem-solving strategies are been selected to solve the problem in mechanics. It has five steps, which are

- a useful description of the problem of the statement
- appropriate physics approach to solving the problem
- specific application of the laws of physics
- mathematical procedure
- logical progression

Step four. Manipulating: applying Minnesota problem-solving strategies for solving specific applications of Newton's laws of motion (Expert Group) (10 min)

Expert groups are formed by having one student from each JigsawIV group/ Home Group join other students assigned to the same segment. Students in these expert groups are given time to Manipulate: applying Minnesota problem-solving strategies for solving specific applications of Newton's laws of motion of their segment and to rehearse the presentations they make in their Jigsaw-4 group. The teacher goes around facilitating and supporting the students.

Activity 1: worksheet for EG A

Do you define the cause of the motion of image one?

Do you manipulate the specific application of Newton's laws of motion of image one above?

Useful description______________________________________

Appropriate physics approach____
specific physics approach ____

Mathematical procedure____

Logical progression____

Activity 2: worksheet for EG B

Can you define Newton's law motion applied to image two?

Do you manipulate the specific application of Newton's laws of motion in image two above?

Useful description______________________________________

Appropriate physics approach____
specific physics approach ____

Mathematical procedure____

Logical progression____

Activity 3: worksheet for EG C

Do you state Newton's law of motion applied to image three above?

Do you manipulate the specific application of Newton's laws of motion in image three above?

Useful description____

Appropriate physics approach____
specific physics approach ____

Mathematical procedure____

Logical progression____

Activity 4: worksheet for EG D

Do you list the application of Newton’s law of motion in a real-life situation?

1.____
2.____
3.____
4.____

Step five, Reflection**:** Homegroup discussion focused on sharing of experience from each member of the expert group. Members of the expert groups are after some time asked to break and go back to their main group known as jigsaw groups where each expert explains his/her task to the remaining members of his/her group. Other members of the group were encouraged to ask questions and clarification from the expert group where necessary. As the group discussion is on, members of the groups assigned to perform a certain role like the timekeeper, questioner, reader, reminder, and so on do the job. (10 min)

Activity 1: worksheet for EG A

Do you define the cause of Newton’s law of motion?

____
____
____
____

Activity 2: worksheet for EG B

What is the meaning of Newton’s laws of motion?

____
____
____

Activity 3: worksheet for EG C

Do you state the three Newton's laws of motion?

1.____

2.____

Activity 4: worksheet for EG D

Do you list the application of Newton's law of motion in a real-life situation?

1.____
2.____
3.____

<u>Step six Evaluation:</u> The researcher evaluates the lesson by giving the students the following quiz to answer individually. (10 min)

- What is the cause of motion?
- Do you explain the meaning of Newton's laws of motion?
- Do you state one of three of Newton's laws of motion?
- Do you list the application of Newton's laws of motion in a real-life situation?

The instructor will collect the answers to the questions, mark them, score them for each student, and return them during the next lesson.

<u>Step seven re-teaching</u>: The instructor concludes the lesson by re-teaching the main idea or missing part of the lesson**. (3 min)**

Full name of Instructor ____

Signature ___________________________Date____

Full name of Department head ____

Signature ____

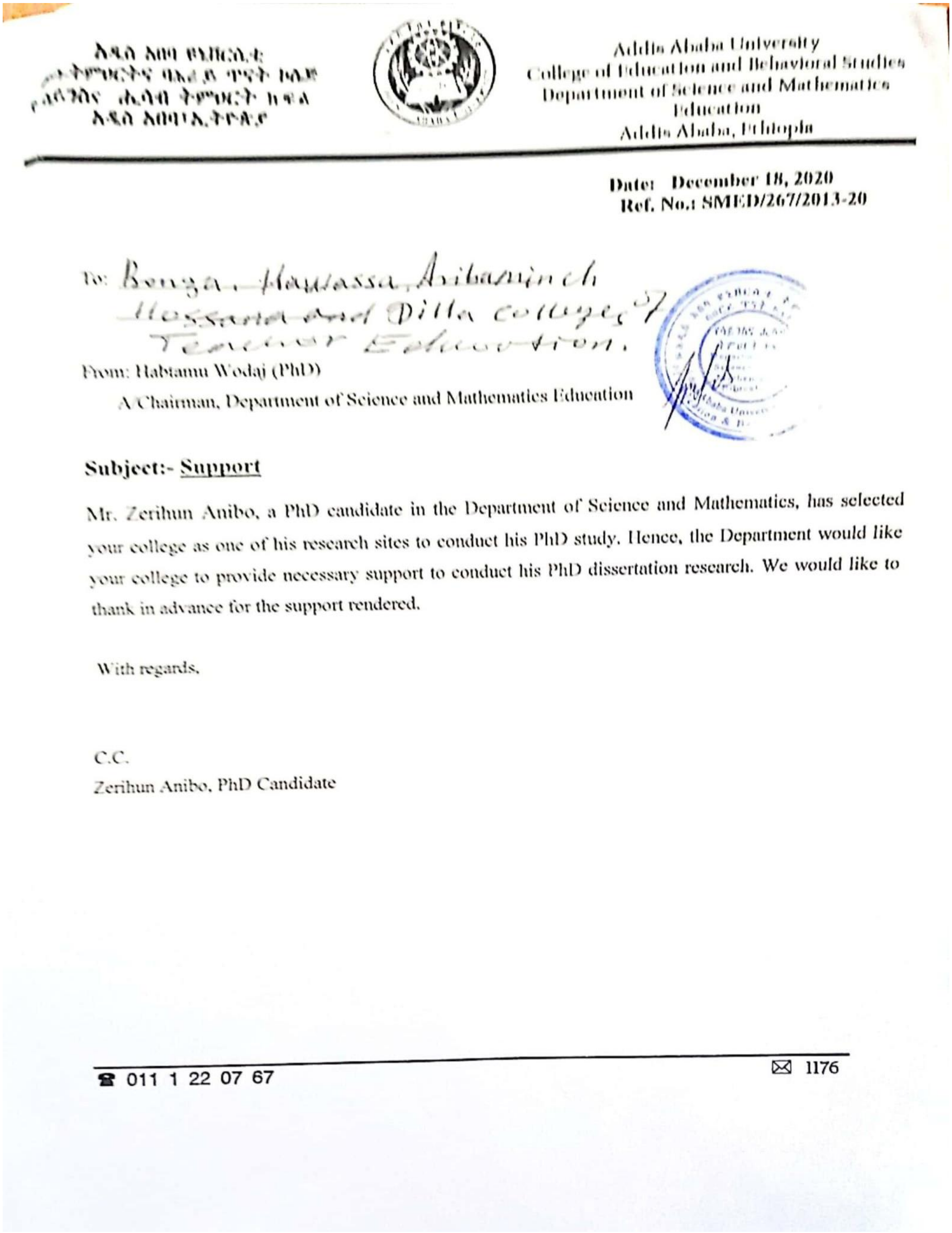
Date____

Full name of School Director ____

Signature ____

Date_________________________

Appendix 14. Permission letters ………………………………………………



አዲስ አበባ ዩኒቨርሲቲ
የትምህርትና ባሕሪይ ጥናት ኮሌጅ
የሳይንስና ሒሳብ ትምህርት ክፍል
አዲስ አበባ፣ ኢትዮጵያ

Addis Ababa University
College of Education and Behavioral Studies
Department of Science and Mathematics Education
Addis Ababa, Ethiopia

Date: December 18, 2020
Ref. No.: SMED/267/2013-20

To: Bonga, Hawassa, Arbaminch Hossana and Dilla colleges of Teacher Education.

From: Habtamu Wodaj (PhD)
A/Chairman, Department of Science and Mathematics Education

Subject:- Support

Mr. Zerihun Anibo, a PhD candidate in the Department of Science and Mathematics, has selected your college as one of his research sites to conduct his PhD study. Hence, the Department would like your college to provide necessary support to conduct his PhD dissertation research. We would like to thank in advance for the support rendered.

With regards,

C.C.
Zerihun Anibo, PhD Candidate

☎ 011 1 22 07 67 ✉ 1176

Appendix 15 participant consent

□□□□ስ መምህር □ቃ□ኛነት ማረጋገጫ (Consent of Teacher)

አ□ስ አበባ ዩኒቨርሲቲ

□ስነት/ትና ባህሪ ጥናት ኮልጅ

የሳይንስና ሂሳብ ት/ት ክፍል

በት/ት ቤት የምርምር ስምምነት ቅፅ

ውት መምህር: እኔ □ትህረ ምረቃ (3ኛ ዲግሪ) መመረቅያ ጥናት ና ምርምር በማካሄት ላ□ እ□ኛለሁ:: □□ህ ጥናት ዋና ዓላማ የኮለጅ 1ኛ ዓመት የፊዚክስ ተማርዎች የፊዚክስ ትምህርትን ውጤት የተለያዩ □□□ችን በመ□ቀም ለማሻሻል ነው:: □ህ ቅፅ በምርምር ለመሳተአ አቃ□ኝነትን ለመ□□ቅ □ተ□□□ ነዉ:: የጥናቱ ርዕስ ***" A Blended Approach of Jigsaw-4 and Problem-Solving Strategies in Preservice Physics Teachers' Understanding of Newton Laws of Motion Concepts and Their Affective Factors"*** :: ጥናቱ በትምህርት ቤቱ የትምህርት ፕሮግራም መሰረት የሚካሄት ነ□ :: ነገር ግን የማስተማሪያ ዘዴን መ□ቀም□አል ነምልከታ ማድረግ፤ ፈተናዎች መፈተን እና መ□□ቆች በመረጃ መሰብሰብ ሂደት ዉስጥ □ኖራሉ:: ጥናቱ በፈቃደኝነት ላይ የተመሰረተነዉ:: በጥናቱ ጊዜም ይሁን ዉጤቱ ሲገለፅ ስም□ አ□□ለፅም፤ በኮት ነዉ የሚሰራዉ:: በዚህ ጥናት የሚሰበሰቡ መረጃዎች ሚስዓራዊነታቸ□ □ተ□በቀ ይሆናል:: ጥናቱ በርስዎ ላይ የሚያስከትለዉ ወጪና ጉዳት የለም:: ነገር ግን ተማሪዎች እንዴት መማር እንዳለባች□ እንዲያዉቁና በፊዚክስ ትምህርት (Physics) ዓሩ ውጤት እንዲያመጡ □ር□ቸዋል ተብሎ ይጠበቃል:: ስለጥናቱ ጥያቄ ካለዎት በማንኛ□ ም □□ መ□□ቅ □ችላሉ::

ስለ ትብብርዎ በቅትሚ□ አመሰግናለሁ

ዘርሁን አንቦ

ከላ□ □ተ□ለፀዉን አንብቤና የጥናቱን ዓላማ ተረድቼ በጥናቱ ለመሳተፍ ተስማምቻልሁ::

ስም ______________________________________

□ርማ ___________________________________

የተማሪዎች ፈቃደኛነት ማረጋገጫ

አ□ስ አበባ ዩኒቨርሲቲ

□ስነት/ትና ባህሪ ጥናት ኮልጅ

የሳይንስና ሂሳብ ት/ት ክፍል

<u>በት/ት ቤት የምርምር ስምምነት ቅፅ</u>

ዉት ተማሪ□ች:

እኔ □ትህረ ምረቃ (3ኛ ዲግሪ) መመረቂያ ጥናትና ምርምር በማካሄት ላ□ እ□ኛለሁ:: የዚህ ጥናት ዋና □ላማ □ኮለ□ 1ኛ ዓመት የፊዚክስ ተማርዎች የፊዚክስ ትምህርትን ውጤት የተለያዩ ዘዴዎችን በመ□ቀም ለማሻሻል ነዉ:: □ህ ቅፅ በምርምር ለመሳተአ አ ቃ□ኝነትን ለመ□□ቅ □ተ□□□ ነዉ:: የጥናቱ ርክስ *“A Blended Approach of Jigsaw-4 and Problem-Solving Strategies in Preservice Physics Teachers’ Understanding of Newton Laws of Motion Concepts and Their Affective Factors”* :**ነዉ።**:: ጥናቱ በትምህርት ቤቱ የትምህርት ፕሮግራም መሰረት የሚካሄት ነ□ :: ነገር ግን የማስተማሪያ ዘዴን መጠቀም፤ ፤□አል ምልከታ ማድረግ፤ ፈተናዎች መፈተን እና መ□□ቆች በመረጃ መሰብሰብ ሂደት ዉስጥ □ኖራሉ:: ጥናቱ በፈቃደኝነት ላይ የተመሰረተ ነዉ:: በጥናቱ ጊዜም ይሁን ዉጤቱ ሲገለፅ ሰማችሁ አ□□ለፅም፤ በኮት ነ□ □ሚሰራ□ :: ከናንተ የሚሰበሰቡ መረጃዎች ሚስዓ ራዊነታቸዉ የተጠበቀ ይሆናል:: ጥናቱ በናንተ ላይ የሚያስከትለዉ ወጪና ጉዳት የለም:: ነገር ግን እንዴት መማር እንዳለባችሁ እንድታቁና በፊዚከስ **ትምህርት** **(Physics)** **ዓ ሩ ውጤት እንድታመ□ □ር□ችኋል** :: ስለጥናቱ ጥያቄ ካላችሁ በማንኛዉም ጊዜ መጠየቅ ትችላላችሁ::□

ስለ ትብብራችሁ በቅትሚ□ አመሰግናለሁ

ዘርሁን አንቦ

ከላ□ □ተ□ለፀዉን አንብቤና የጥናቱን ዓላማ ተረድቼ በጥናቱ ለመሳተፍ ተስማምቻልሁ::

ተ.ቁ	ስም	□ርማ

Appendix 16 supportive instructional material for Module-mechanics-I(Phy-101)