ANALYZING THE EFFECTIVENESS OF THE JIGSAW LEARNING MODEL IN IMPROVING SECONDARY SCHOOL BIOLOGY EDUCATION IN GEDEO ZONE, SOUTH ETHIOPIA

A DEd DISSERTATION

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HAWASSA UNIVERSITY

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ADVISOR APPROVAL SHEEET

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DECLARATION

I, undersigned, hereby declare that this DEd dissertation entitled "ANALYZING THE EFFECTIVENESS OF THE JIGSAW LEARNING MODEL IN IMPROVING SECONDARY SCHOOL BIOLOGY EDUCATION IN GEDEO ZONE, SOUTH ETHIOPIA", submitted impartial fulfillment of the requirements for the degree of Doctor of Education in Biology, Department of Biology, Hawassa University is a record of original work carried out by me and has never been submitted to this or any other institution to get any other degree or certificates. The assistance and help I received during the course of this investigation is have been duly acknowledged.

____________________________ ____________________ __________________

Name of the candidate Date Signature

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ABBREVIATIONS AND ACRONYMS

AGFI = Adjusted Goodness-of-fit Index

AMOS = Analysis of Moment Structures

CFA = Confirmatory Factor Analysis

CFI = Comparative Fit Index

CL = Cooperative Learning

DV = Dependent Variable

D-W = Durbin-Watson Statistic

ES = Effect Size

FDRGE = Federal Democratic Republic Government of Ethiopia

GFI = Goodness-of-Fit Index

IV = Independent Variable

KMO = Kaiser–Meyer–Olkin

MANOVA = Multivariate Analysis of Variance

MOE = Ministry of Education

PCA = Principal Component Analysis

PLCL = Project-Led Cooperative Learning

RMSEA = Root Mean-Square Error of Approximation

SD = Standard Deviation

SPSS = Statistical Package for Social Sciences

SRMR = Standardized Root Mean Square Residual

STAD = Student Teams-Achievement Divisions

TESO = Teacher Education System Overhaul

TLI = Tucker Lewis Index

UNESCO = United Nations Educational, Scientific and Cultural Organization

USA = United States of America

VIF = Variance Inflation Factor

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# ABSTRACT

This study evaluated effects of Jigsaw learning model in improving secondary school biology education in Gedeo Zone, South Ethiopia. A quasi-experimental pretest-posttest design was employed, involving two secondary schools. One school (n = 40 students) was randomly assigned to the intervention group, while the other (n = 41 students) served as the control group. Data were collected using multiple choice biology achievement tests, close ended likert-acle student engagement questionnaires, semi-structured interviews, document analysis, and classroom observations. The quantitative data were analyzed using descriptive statistics, t-tests, MANOVA, correlation, and regression analysis, while the qualitative data were analyzed thematically through coding and categorization of interview transcripts, documents, and observational notes. Analysis of the pretest data revealed that no significant difference in biology achievement score ($t(79) = 1.34$, $P = 0.187$), peer relationship scores ($t(79) = 1.544$, $P = 0.126$), academic support scores ($t(79) = 0.391$, $P = 0.697$), and Overall learning gains scores ($t(79) = 0.556$, $P = 0.58$). After a 16-week intervention, the Jigsaw model resulted in a statistically significant improvement in the experimental group's post-test biology achievement scores ($t(79) = 6.19$, $P < 0.05$), Peer relationships scores ($t(79) = 14.334$, $P < 0.05$), academic supports scores ($t(79) = 8.395$, $P < 0.05$), and overall learning gains scores ($t(79) = 9.463$, $P < 0.05$). However, the intervention showed no notable impact on gender-based post-test achievement scores among experimental group participants (mean difference = 2.2, ES = 0.008, $P > 0.05$). The MANOVA results showed that the jigsaw model had broader impacts on peer relationships, academic support, and overall learning gains revealing moderate to substantial effects (Partial $\eta 2 = 0.471$–0.722). Correlation analysis revealed strong positive associations among peer relationships, academic support and overall learning gains. Multiple regression analysis indicated that peer relationships and academic support together explained 43.2% of the variance in learning gains in biology. The qualitative findings supported these results; the Jigsaw model has positive impact on student engagement and understandings, achievement of course objectives and builds relationships with their peers. However, several challenges were identified, including unfamiliarity with the method, resource constraints, and resistance from some teachers. These findings suggest that the Jigsaw model has the potential to shift biology instruction from content-driven to learner-centered approach. To maximize impact, schools should invest in teacher training, allocate resources for cooperative learning, and integrate Jigsaw into curricula. Future research should explore long-term sustainability and scalability across diverse Ethiopian educational settings.

Key words: Academic achievement; Biology; Cooperative learning; Jigsaw model; Learning gains; peer relationship

CHAPTER ONE: INTRODUCTION

This chapter presents the background of the study, research questions, objectives, research hypotheses, significance, scope, limitations, and definitions of key terms.

1.1 Background of the study

Education is universally recognized as a fundamental driver for maximizing individual potential and fostering meaningful, sustainable national economic growth (Gambari and Olumorin, 2013). In the 21st century, educational systems face the imperative to equip students with essential skills such as communication, problem-solving, cooperation, and critical thinking to navigate the complexities of a knowledge-based economy (Keramati and Gillies, 2022). Science education, in particular, is crucial for developing scientific literacy – the capacity to understand the natural world and engage in scientific reasoning – which is foundational for informed citizenship and further scientific pursuit (Da Silva, 2008). Within the sciences, biology education holds specific importance, providing fundamental knowledge about life processes and the environment. However, achieving deep understanding in biology remains a significant challenge in many educational contexts. This is evident in settings like Ethiopia, where academic performance in biology is often suboptimal; for instance, the national mean achievement score for grade ten biology is reported to be a concerning 40.3% (Wodaj and Belay, 2021). This challenge is not unique to Ethiopia but reflects a broader trend in science education across many developing regions. International assessments, such as the Trends in International Mathematics and Science Study (TIMSS), consistently reveal significant learning gaps. For instance, the TIMSS 2015 science average for 8th-grade students in participating African countries was substantially below the international average of 500 points, highlighting systemic challenges in science achievement (Mullis et al., 2016). Within science disciplines, biology often presents particular difficulties for secondary students, frequently identified as one of the subjects with the lowest performance and highest failure rates in national examinations across Sub-Saharan Africa, suggesting deep-rooted challenges related to both curriculum content and instructional methods (Anderman, 2020).

The imperative to address these learning gaps is further underscored by major global and continental policy frameworks advocating for quality science education. The United Nations Sustainable Development Goal 4 (SDG 4) specifically targets ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all, with a strong emphasis on relevant learning outcomes (United Nations, 2015). The African Union's Continental Education Strategy for Africa (CESA 16-25) prioritizes the revitalization of teaching and learning to improve quality and relevance, particularly in science, technology, engineering, and mathematics (STEM) fields (African Union, 2016). Similarly, UNESCO emphasizes the critical role of innovative science education policies and practices in building scientific literacy and capacity for sustainable development (UNESCO, 2017). At the national level, Ethiopia's Education and Training Policy (FDRE, 2023) and subsequent Education Sector Development Programs (e.g., ESDP V) explicitly advocate for shifting towards learner-centered, active teaching methodologies and strengthening science education to meet national development goals).

Therefore, improving teaching strategies in science, and biology specifically is not merely desirable but a necessity aligned with both urgent empirical evidence of underperformance and compelling national and international policy directives. This underperformance is frequently attributed to the persistent dominance of conventional, teacher-centered teaching methodologies, such as lecture-based instruction and rote memorization (Tabulawa, 2013; Geletu, 2022). Such approaches emphasize passive knowledge transmission rather than active student engagement, often failing to foster meaningful learning experiences or develop the higher-order thinking skills demanded by modern curricula. Indeed, research underscores that the methods of teaching are just as critical as the content being delivered for achieving deep understanding and skill development. A teacher centered culture, characterized by limited student participation, persists notably in Ethiopian classrooms (Tadesse ,2015), highlighting an urgent need for pedagogical shifts.

In response to these challenges, active learning methods, which position students as active participants in knowledge construction, have gained significant attention for their effectiveness in enhancing student engagement and understanding (Prince, 2004).

Among these, cooperative learning strategies represent a major category, proven to improve student motivation, foster better intergroup relations, and enhance critical thinking and problem-solving abilities (Slavin, 1995; Liebech-Lien, 2020). Specific methods include think-pair-share, group investigation, Student Teams-Achievement Divisions (STAD), and the Jigsaw model.

The Jigsaw model, developed by Elliot Aronson in the 1970s, stands out as a particularly structured and student-centered cooperative learning strategy central to this study (Aronson et al., 1978; Aronson, 2002). It is designed explicitly to promote collaboration, reduce competition, and improve learning by making each student responsible for mastering and teaching a unique “piece” of the overall topic, akin to a jigsaw puzzle. The model operates systematically: First, the class is divided into ‘home groups’ of 4-6 students. Each member is assigned a distinct subtopic. Students then form “expert groups” with peers from other home groups who share the same subtopic, collaborating to master their segment. Afterward, they return to their home groups to teach their subtopic. Finally, groups are assessed on the full topic, followed by reflection (Aronson et al., 1978; Slavin, 1995). For instance, in biology lesson on the human digestive system, a home group might cover subtopics like the mouth, esophagus, stomach, small intestine, and large intestine. Each student becomes an expert on one component, teaches peers, and synthesizes knowledge (Aronson, 2002). Key objectives include encouraging active learning, fostering interdependence/accountability, enhancing communication/teaching skills, promoting critical thinking, and reducing social tensions (Aronson et al., 1978; Cohen, 1994).

The choice of the Jigsaw model is grounded in its proven effectiveness across different subjects and academic levels (Garcia, 2021). It prioritizes critical thinking, problem-solving, and decision-making skills aligned with 21st-century needs (Wang *et al.*, 2015). Documented benefits include improved engagement, confidence, peer teaching (reinforcing learning), and support for diverse learners (Doymus, 2008; Blajvaz et al., 2022). However, implementation challenges include the need for meticulous planning, teacher monitoring to ensure equal participation, and potential difficulties arising from uneven student motivation or skills (Aronson *et al.,* 1978; Slavin, 1995). Its emphasis on active student involvement, interdependence, and peer teaching directly supports the development of critical 21st-century skills such as teamwork, communication, and problem-solving (Tadesse and Gillies, 2015). Research has demonstrated its effectiveness in enhancing academic achievement across various subjects, including biology, by fostering deeper understanding of the material and improving retention rate (Doymus, 2008). Moreover, the model fosters higher-order thinking skills and prosocial behaviors, such as tolerance and acceptance among students of different ethnic backgrounds (Cohen, 1994; Sharan, 2010). These aspects address not only academic challenges but also contribute to managing academic heterogeneity and building a more inclusive learning environment.

Despite Ethiopia's policies promoting active and cooperative learning approaches (Habte et al., 2021), implementation remains inconsistent. Barriers include limited resources, inadequate teacher training, resistance to change (Melese et al., 2009; Yimam, 2018), and large class sizes, which exacerbate difficulties in implementing interactive strategies like the Jigsaw model in subjects like biology. The Jigsaw model's specific requirements for careful planning, ongoing monitoring, and balanced group dynamics further compound these challenges (Aronson et al., 1978).

The theoretical foundation of Jigsaw model is deeply rooted in social interdependence theory, which posits that the way interdependence is structured within a learning environment significantly impacts interaction patterns and outcomes (Johnson and Johnson, 2009). This theory suggests that positive interdependence, where individuals perceive that their success is linked to the success of others, promotes higher achievement and more supportive relationships. In the Jigsaw model, each student's contribution is essential for the group's success, creating a sense of responsibility and mutual support among group members. This theoretical focus on interdependence contrasts with Vygotsky's social constructivist theory, which emphasizes the importance of social interactions in cognitive development but does not focus as specifically on the interdependence between students for academic success (Vygotsky, 1978). By engaging in peer teaching and cooperative learning, students can scaffold each other's understanding, leading to deeper comprehension and retention of biological concepts.

In light of these theoretical and practical insights, this study aimed to examine the effectiveness of the Jigsaw model as an instructional strategy in improving secondary school students' academic achievement in biology in Gedeo zone, South Ethiopia regional state. By investigating the impact of this approach, the study seeks to offer empirical evidence on how cooperative learning can address long-standing challenges in biology education, including low academic performance and limited student engagement in the study area.

Besides the academic achievement, this study explored the broader implications of the Jigsaw model on peer relationships, academic support, and overall learning outcomes in secondary school biology. Additionally, it delved into the lived experiences of both teachers and students involved in the intervention, offering insights into the practical application and challenges of implementing the model.

Based on the above comprehensive analysis, the study aimed to contribute the growing body of literature on cooperative learning by presenting interconnected investigations that assess the impact of the Jigsaw model on academic achievement; examine its effectiveness on peer relationships, academic support, and overall learning gains in secondary school biology, and explore the lived experiences of both teachers and students involved in the intervention. These insights reveal the practical application and challenges of implementing the model. By examining both the academic and social dimensions of the Jigsaw model, this study offers valuable perspectives on how such strategies can address persistent challenges in secondary school biology education, ultimately contributing to the development of more effective and inclusive educational practices.

1.2 Statement of the problem

Ethiopian education policies, such as the 1994 Education and Training Policy (FDRE, 1994), the Teacher Education System Overhaul (TESO) (MOE, 2003), and the 2009 Secondary School Curriculum Framework (MOE, 2009), emphasize the importance of inquiry-based and student centered teaching methods. Similarly, the entire Ethiopian Education and Training Policy (FDRE, 2023) and the Ethiopian Education Development Roadmap (MOE, 2018) reinforce this commitment by advocating active learning strategies that foster critical thinking, problem-solving, and collaboration. These policies advocate for a shift from traditional rote learning to more interactive and participatory approaches, ensuring students can acquire essential 21st-century skills. In this context, cooperative learning strategies; such as, the Jigsaw cooperative learning model, have been introduced as effective methods to enhance academic achievement and develop students' problem-solving abilities. Evidence from both local and international studies suggests that cooperative learning positively influences student engagement, critical thinking, and communication skills. For example, international studies, (Haviz, 2019; Soliman Abd El Aliem *et al*., 2019; Darling-Hammond *et al*., 2020) demonstrated the benefits of cooperative learning particularly in biology education. Locally, research conducted in secondary schools, such as in Farta District, South Gondar Zone (Molla and Muche, 2018) and Nekemte Administration town secondary schools (Simesso *et al.*, 2024), obtained student performance improvement in their studies due to cooperative learning approaches. Geletu (2021) also found that the average mean score of cooperative intervening school students performed better than the control school throughout the intervention period due to peer- tutoring among the cooperating group than the control group that did not cooperate to solve problems.

Despite these encouraging findings, significant challenges hinder the effective implementation of cooperative learning in Ethiopia. Teachers often rely on traditional teacher-centered methods, with limited use of cooperative learning strategies. Even when group work is implemented, it frequently lacks key components of cooperative learning, such as positive interdependence and individual accountability (Molla and Muche, 2018). Furthermore, barriers such as large class size (Ahmed, 2017; Mulatu & Bezabih, 2018), inadequate resources (Habtewold & Bezabih, 2018), and insufficient teacher training (Belilew, 2015; Gedamu & Shewangezaw, 2020) exacerbate the problem. Additional challenges include the perception that cooperative learning is politically motivated, which fosters resistance among educators and students (Mulisa and Kassahun, 2018). If these challenges are not addressed, Ethiopian secondary schools may continue to rely on ineffective, passive learning approaches, leading to low student engagement, poor problem-solving skills, and weaker academic performance. The problem to implement cooperative learning effectively could ultimately hinder students' ability to develop their skills necessary for success in higher education and the practices, thereby slowing national educational progress.

Although Ethiopian education policy emphasizes student-centered and cooperative learning methods, their effective implementation in schools remains questionable. While such strategies are integrated into reforms and textbook designs (Geleto, 2019), studies reveal ongoing teacher resistance linked to limited training and unfamiliarity with cooperative learning principles (Belillew, 2015). Even when implemented, key elements like grouping by academic level, gender balance, and student interest are often overlooked (Molla & Muche, 2018).

Theoretical and empirical gaps in previous studies necessitate further investigation. While a substantial body of international research demonstrates the effectiveness of the Jigsaw model in improving science achievement, attitudes, and skills across diverse contexts – including undergraduate laboratories (Karacop, 2017), prospective teacher training (Karacop & Diken, 2017), physics education (Márquez et al., 2017), and secondary science (Tabiolo & Rogayan, 2019; Walad et al., 2019; Kurniawan et al., 2021; Iqbal & Rashid, 2020; Ojekwu & Ogunleye, 2020; Suendarti & Virgana, 2022; Safkolam et al., 2023; Nadrah, 2023) – these findings are often inconsistent and highly context-dependent. Recent reviews highlight this variability; meta-analyses indicate significant benefits for health science students (Shakerian et al., 2020) and broader STEM fields (Møgelvang & Nyléhn, 2023), yet also underscore the critical influence of implementation fidelity, cultural factors, and teacher support (Johnson & Johnson, 2009; Slavin, 2015; Jeppu et al., 2023; Hanapi & Kamal, 2024).

Conceptually, most studies focus narrowly on cognitive gains or isolated skills (e.g., science process skills - Soedimardjono & Pratiwi, 2021), overlooking the holistic impact on peer relationships, academic support systems, classroom inclusivity (Tomlinson & Allan, 2000; Johnson et al., 2014), and the lived experiences of participants within resource-constrained settings like Ethiopia. Methodologically, existing research in comparable contexts often lacks depth: studies may demonstrate achievement gains but fail to explore mediating social factors (Tabiolo & Rogayan, 2019), omit teacher/student perspectives on implementation challenges (Jeppu et al., 2023), or neglect longitudinal assessment of retention (Safkolam et al., 2023). Crucially, research specifically examining the Jigsaw model within Ethiopian secondary biology education, particularly in regions facing acute challenges like Gedeo Zone, remains scarce and fragmented. Existing Ethiopian studies on cooperative learning (e.g., Molla & Muche, 2018; Simesso et al., 2024) provide valuable insights but lack focused examination of Jigsaw's unique peer-teaching structure and its multifaceted impacts within biology classrooms characterized by large classes and resource constraints.

Therefore, a significant gap persists: While international evidence supports Jigsaw's potential, and policy mandates its use, there is a critical absence of comprehensive research in Ethiopian secondary biology that: (1) Rigorously evaluates its impact across academic, social (peer relationships, academic support), and experiential dimensions; (2) Investigates implementation dynamics through the lived experiences of teachers and students; and (3) Provides context-specific insights for zones like Gedeo. This gap hinders the development of evidence-based, locally relevant strategies for effective adoption.

In the Gedeo zone, a region facing unique educational challenges such as resource scarcity and overcrowded classrooms, the adoption of cooperative learning methods remains underexplored. Local studies have highlighted the benefits of cooperative learning on student outcomes, but few have rigorously examined the impact of the Jigsaw model on biology education, particularly in fostering academic achievement, peer relationships, academic support, and overall learning gains in biology. Moreover, the role of inclusive practice, as suggested by Tomlinson and Allan (2000) and Johnson *et al.* (2014), remains unexplored in this context. Despite the widespread recognition of cooperative learning as an effective strategy, the transition from passive to active learning remains a challenge in Ethiopian secondary schools. Recent studies indicate that Ethiopian educators predominantly employ traditional, lecture-based teaching methods, which significantly hinder student engagement and the development of problem-solving skills (Kafale et al., 2024; Faro *et al.,* 2025). As a result, many students face challenges to develop their critical thinking and collaborative skills essential for their academic success.

To address these gaps, this study evaluated the effects of Jigsaw learning model in improving secondary school biology education in Gedeo Zone, South Ethiopia. Specifically, it assessed its impact on academic achievement, peer relationships, academic support, and overall learning gains, while also documenting the lived experiences of teachers and students implementing the model under local constraints. By addressing such challenges of effective implementation and assessing its effect, this study aims to provide evidence-based insights to inform policymakers and support the broader goal of improving educational outcomes in Ethiopian secondary schools.

1.3 Research questions

Based on the stated problem, the following research questions were formulated:

1. To what extent does the Jigsaw cooperative learning model improve students' biology achievement compared to the traditional lecture approach?
2. Is there a statistically significant gender difference in biology achievement among students exposed to the Jigsaw cooperative learning model?
3. To what extent does the Jigsaw cooperative learning model improve students' peer relationships, academic support, and overall learning gains in biology?
4. What is the nature of the relationship among peer relationships, academic support, and overall learning gains in biology for students exposed to the Jigsaw cooperative learning model?
5. To what extent can overall learning gains in biology be predicted by the combined influence of peer relationships and academic support?
6. What are the perceived practices related to the implementation of the Jigsaw cooperative learning model in secondary school classrooms, from the perspectives of students and teachers?

1.4 Research Hypotheses

This study is guided by a set of hypotheses that aim to examine the effect of the Jigsaw cooperative learning model on students' biology achievement, peer relationships, academic support, and learning gains. The hypotheses are formulated based on the research questions, which focus on comparing the Jigsaw model to traditional lecture based instruction, assessing gender based differences in academic performance, and evaluating the relationships between cooperative learning, peer relationships, academic support, and learning gains in biology.

Accordingly, the following alternative directional and null hypotheses were established:

1. **Ha1:** Students exposed to the Jigsaw model perform better in biology achievement than those taught using the traditional lecture approach.
2. **HO2:** There is no a statistically significance gender-wise difference in the average biology achievement scores for students participated in the Jigsaw model intervention in classrooms.
3. **Ha3:** Students exposed to the Jigsaw cooperative learning model will demonstrate significantly greater improvement in peer relationships, perceived academic support, and overall learning gains in biology compared to peers taught using the traditional lecture approach.
4. **Ha4:** There are statistically significant positive correlations between peer relationships, academic support, and overall learning gains among students who participated in the Jigsaw cooperative learning model.
5. **Ha5**: There is a significant relationship between peer relationships and academic support in predicting overall learning gains in biology.

1.5 Objectives of the study

1.5.1 General objective

The general objective of this study was to assess the impact of the effects of Jigsaw learning model on overall learning gains in secondary school biology education and also aimed to identify the challenges and practices of the implementation of the Jigsaw model in secondary schools of Gedeo zone, South Ethiopia.

1.5.2 Specific objectives

The following specific objectives were driven based on the general objective.

1. To analyze the effect of Jigsaw cooperative learning model on students' biology achievement compared to the traditional lecture approach.
2. To find whether there is a statistically significant difference in biology achievement between male and female students exposed to the Jigsaw cooperative learning model.
3. To examine the effect of the Jigsaw cooperative learning model on students' peer relationships, perceived academic support, and overall learning gains in biology.
4. To examine the nature and strength of the relationships between peer relationships, academic support, and overall learning gains among students who participated in the Jigsaw cooperative learning model.
5. To determine the contribution of peer relationships and academic support on students' overall learning gains in biology.
6. To identify the challenges and best practices associated with the implementation of the Jigsaw model in secondary school classrooms, based on the experiences of students and teachers.

1.6 Significance of the study

This study examines the effectiveness of the Jigsaw cooperative learning model in comparison to traditional instructional methods in Ethiopian secondary schools, specifically in the Gedeo zone, South Ethiopia regional state. The findings can make significant contributions in several key areas.

First, it provides valuable insights into how cooperative learning can inform and influence education policy, particularly in the areas of biology curriculum development and student-centered teaching methods. By highlighting the positive impact of cooperative learning on academic achievement and engagement, this study informs towards educational policy reforms that prioritize active, student-centered learning approaches, in line with the growing emphasis on improving teaching and learning outcomes across Ethiopia.

The findings provide evidence-based insights that support the integration of cooperative learning strategies, particularly the Jigsaw model, into national education policy and curriculum guidelines. Policymakers can use this study to advocate for targeted teacher training programs and allocate resources that promote interactive, collaborative learning environments aligned with national goals for quality education and improved student outcomes.

Second, it demonstrates the practicality of implementing the Jigsaw model in the classroom. Through its examination of the model, it provides practical recommendations for teachers, school administrators, and policymakers on how to foster a more interactive and collaborative learning environment, making the approach feasible at local classrooms by depicting the challenges; such as, limited resources and large class sizes. The study also fills a methodological gap by examining the Jigsaw model in the Ethiopian context, where cooperative learning strategies have not been systematically tested or implemented, especially in biology education.

Professionally, the study equips teachers with a student-centered instructional strategy that improves classroom interaction and teaching effectiveness. It encourages reflective teaching practices and continuous improvement, contributing to professional development in pedagogy.

Third, by showing how the Jigsaw model enhances biology students' understanding and retention of key concepts, the research provides evidence of how teaching methods can be optimized to improve students’ academic performance and achievement. Additionally, the study addresses the gap in previous studies the impact of the Jigsaw model on students’ retention and deeper learning, particularly in the biology discipline, had not been thoroughly evaluated.

This study also serves as a foundation for future scholarly inquiry by highlighting the role of Jigsaw cooperative learning in enhancing academic achievement, peer relationships, academic support, and learning gains. It invites further research to explore long-term impacts, cross-disciplinary applications, and comparative effectiveness across different educational levels and regions.

Finally, the study highlights the social significance of the Jigsaw model by focusing on its impact on peer relationships, academic support, and social interactions among students. It emphasizes how the Jigsaw model encourages positive student collaboration, fosters inclusive classroom environments, and strengthens teacher-student relationships, contributing to a more supportive educational atmosphere that enhances overall learning gains. Moreover, this study’s unique approach to exploring the role of peer support and cooperation in fostering inclusive classrooms provides new perspectives on the broader social and educational benefits of the Jigsaw model in the context of Ethiopian secondary schools.

The implementation of the Jigsaw model also supports students' personal development by cultivating communication skills, teamwork, and mutual respect, which are essential for lifelong learning and active citizenship. Furthermore, this study's unique approach to exploring the role of peer support and cooperation in fostering inclusive classrooms provides new perspectives on the broader social and educational benefits of the Jigsaw model in the context of Ethiopian secondary schools.

1.7 Delimitation of the study

This study establishes intentional boundaries in scope, variables, geography, and participants to ensure methodological rigor, contextual relevance, and alignment with research objectives. Geographically, it is confined to two secondary schools in Ethiopia's Gedeo Zone, selected for their representation of rural, resource constrained educational environments where challenges like overcrowded classrooms and limited materials are prevalent. This focus enables findings to inform similar settings while allowing controlled implementation of the Jigsaw model, minimizing logistical complexities (e.g., travel, monitoring), and ensuring comparability through analogous school demographics.

Theoretically and conceptually, the study is delimited to the Jigsaw cooperative learning model, a structured subset of cooperative learning, guided by social interdependence theory. This theory emphasizes positive interdependence and collaborative interaction, aligning with the research questions on academic achievement, peer relationships, and learning gains in biology. Broader cooperative learning models (e.g., STAD) are excluded to maintain analytical precision**.**

Practically, the study examines biology instruction in selected grade levels during the intervention period, analyzing Jigsaw implementation within classroom dynamics. It specifically focuses on the following variables: students' academic achievement in biology (measured via pre/posttests), peer relationships (assessed through surveys and observations), perceived academic support (evaluated via self-reports), learning gains (tracked formatively), and implementation fidelity (monitored through lesson logs). These are included due to their direct relevance to the Jigsaw model's impact on the research questions. Conversely, nonacademic student outcomes (e.g., motivation), teacher practices unrelated to Jigsaw, school level administrative factors (e.g., infrastructure), and parental involvement are excluded to retain focus on classroom based academic and social variables and ensure feasible data collection.

For participants, inclusion criteria required: (1) enrollment in the selected biology classes, (2) active participation in at least 80% of Jigsaw sessions, and (3) completion of key assessments. Exclusions applied to: (1) students newly transferred after the intervention commenced, (2) those absent for over 50% of sessions, or (3) students enrolled in special education programs with individualized curricula. These criteria ensure sample consistency, valid exposure to the intervention, and alignment with the study's biology specific focus.

1.8 Limitations of the study

This study acknowledges limitations inherent to its design and context. First, the findings are context-specific to two secondary schools in Gedeo Zone (n = 81), limiting broader generalizability; however, the mixed-methods approach prioritized depth to capture nuanced dynamics of Jigsaw in resource-constrained settings, aligning with exploratory research goals. Second, while the exclusive focus on the Jigsaw model omits other cooperative strategies, this narrow scope was justified by its proven efficacy in fostering interdependence and suitability for hierarchical biology content (Aronson et al., 1978). Third, potential biases in self-reported data (e.g., social desirability) and observational subjectivity were mitigated through triangulation (pre/post-tests, interviews, document analysis) and structured observation protocols. Finally, unexplored variables (e.g., prior student motivation) were implicitly addressed via baseline equivalence tests ($p > 0.05$) and qualitative contextualization

1.9 Operational Definitions of key terms

Cooperative learning strategy: In this study cooperative learning strategy refers to the implementation of the Jigsaw model in biology classes, where students are organized into heterogeneous groups of 5–6. Groups collaborate for 16 weeks using structured expert/home group activities to achieve shared learning goals.

Jigsaw model: in this study, Jigsaw model refers to a 16-week intervention where grade nine students: (1) Join expert groups to master assigned subtopics, (2) Return to home groups to teach their subtopic, and (3) Complete interdependent tasks requiring peer teaching.

Academic achievement: in this study academic achievement refers to students' biology learning outcomes measured by pre-test/post-test scores on a 35 multiple choice items researcher-constructed test covering grade-level topics. Scores range from 0–100; higher scores indicate greater mastery.

Peer relationship: In this study, peer relationships refer to students' perceived social acceptance in Jigsaw groups, measured by the mean score on a 4-item Likert scale (adapted from Furrer & Skinner, 2003). Responses range from 1 (Strongly Disagree) to 5 (Strongly Agree); higher scores indicate stronger peer belonging.

Academic support: In this study, academic support refers to students' perceptions of peer assistance in learning, measured by the mean score on a 4-item Likert scale (adapted from Tadesse et al., 2018). Responses range from 1 (Strongly Disagree) to 5 (Strongly Agree); higher scores indicate stronger peer academic support.

Overall learning gains: In this study, an overall learning gain refers to students' self-reported growth in academic and personal development skills, measured by the mean score on a 5-item Likert scale (adapted from Tadesse et al., 2018). Responses range from 1 (Very Poor) to 5 (Very Good); higher scores indicate greater perceived gains.

Secondary school: In this study, a secondary school refers to grades 9 to 12 government institutions in Gedeo zone, where subjects such as biology, physics, and chemistry are taught as independent disciplines. This differs from the primary education level (grades 1 to 8), where science subjects are integrated until grades 7 and 8, when they are introduced as separate subjects.

Biology: In this study, biology refers to the 9^{th} grade subject covering Ethiopian curriculum units (e.g., introduction to biology, characteristics and classification of organisms, and cell biology) delivered via the Jigsaw intervention for 16-weeks.

1.10 Organization of the thesis document

The study is organized in to five chapters. Chapter one presents the introduction, including the background of the study, statement of the problem, research questions, objectives of the study, research hypotheses, significance of the study, delimitations of the study and operational definitions of terms. Chapter Two reviews relevant literature, focusing on cooperative learning theories, previous studies on its effectiveness, and the conceptual framework guiding the research. Chapter Three outlines the research methodology, including the research paradigm, design and, method, data collection instruments, methods of data analysis and ethical considerations. Chapter Four presents results and discussion. Chapter five presents summary of the major findings conclusions and recommendations.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

This chapter provides a comprehensive review of theoretical and empirical literatures related to cooperative learning. It begins by defining cooperative learning and identifying its key elements, such as positive interdependence, individual accountability, and group processing. The chapter then delves into the theoretical foundations and educational theories underpinning cooperative learning, highlighting key frameworks like social interdependence theory, constructivism, and Vygotsky's social development theory.

A global perspective on cooperative learning is presented, examining how different educational systems implement and perceive these strategies worldwide. The focus then narrows to the African context, exploring the utilization of cooperative learning strategies within African educational systems, with attention to both successes and challenges.

The chapter further explores the implementation of cooperative learning strategies in Ethiopia, discussing general practices and specific context-related challenges. A detailed examination of the barriers to implementation in Ethiopian secondary schools is provided, addressing issues such as resource constraints, large class sizes, and political factors.

Special attention is given to factors affecting the implementation of cooperative learning in biology lessons in Ethiopia, identifying subject-specific challenges and considerations. The role of teachers in implementing cooperative learning is discussed, emphasizing aspects like training, instructional design, and classroom management.

The chapter also analyzes students' and teachers' perceptions towards cooperative learning, covering attitudes, acceptance, and resistance. Finally, the benefits of implementing cooperative learning are highlighted, showcasing the academic, social, and cognitive advantages for both students and teachers.

2.1 The concept and features of Cooperative Learning

Cooperative learning has emerged as a powerful instructional strategy that fosters both academic achievement and social development. This approach involves small groups of students working collaboratively on common tasks, where each member is accountable for their own learning as well as supporting their peers' success (David W. Johnson and Roger T. Johnson, 2018). By structuring educational activities to enhance both academic and social experiences, cooperative learning enables students to work collectively towards shared goals (Slavin, 2014).

The effectiveness of cooperative learning hinges on five essential features identified by Johnson, Johnson, and Holubec (1994). These features distinguish true cooperative learning from simply placing students in groups:

Positive Interdependence: This replaces the negative interdependence (competition) common in traditional classrooms. Students understand their success is intrinsically linked to the contributions and success of all group members. Teachers foster this by designing tasks requiring collective insights and efforts, potentially linking individual grades to group performance (Johnson et al., 1994). Students learn that everyone's success enhances the learning environment.

Face-to-Face Promotive Interaction: Within small groups, students directly interact, assist each other, share ideas, discuss concepts, build common understanding, and work as a team to ensure each member's success and acceptance. This requires structured discussion time, scaffolded by teacher prompts, opportunities for reporting/sharing, and often assigning specific roles (e.g., facilitator, recorder) to ensure participation and responsibility.

Individual and Group Accountability: Each student is responsible for their own academic progress and task completion, in addition to the group achieving its common goal. This dual accountability ensures all members benefit from the group and contribute meaningfully. It is typically achieved through assessments that evaluate both individual work (e.g., individual tests) and group outcomes (e.g., group project grades).

Interpersonal and Small Group Skills: Cooperative learning provides a vital context for students to develop crucial social skills. These include active listening, inclusive participation, constructive criticism, supportive communication, appreciation of others, effective decision-making, problem-solving, conflict resolution, and compromise. These skills are essential for success beyond the classroom.

Group Processing (Evaluation): Groups need dedicated time to reflect on their effectiveness. They discuss how well they are meeting goals, identify helpful and hindering actions, and resolve internal issues. This can occur through class discussions, written reports, or teacher alerts.

Group processing allows students to improve cooperative skills, address tensions, and practice conflict resolution.

Cooperative learning is implemented through three primary structures, all proven effective in secondary education (Johnson & Johnson, 2009), each fostering cooperation, engagement, and deeper learning by applying the five essential features:

Formal Cooperative Learning: This involves structured group work over a defined period (one class to several weeks) to achieve specific learning goals and complete tasks like problem-solving, experiments, reports, or unit projects. The teacher plays a crucial role by: (a) Planning (objectives, group size/composition, roles, materials, environment); (b) Clarifying tasks and establishing positive interdependence/accountability; (c) Monitoring interactions and intervening for support/skill development; (d) Assessing learning and facilitating group reflection on effectiveness (Johnson et al., 2008, cited in Johnson & Johnson, 2009).

Informal Cooperative Learning: This involves short-term, often spontaneous, pair or small group interactions (typically 2-5 minutes) within a single class session to enhance focus, processing, and comprehension of material. Activities include brief discussions before/after lectures or quick partner exchanges during instruction to respond to questions, explore key ideas, or reflect on content (Smith et al., 2005; Gillies, 2007; Johnson et al., 2008, cited in Johnson & Johnson, 2009).

Cooperative Base Groups: These are long-term, heterogeneous groups (typically 3-4 students) with stable membership (lasting a semester, year, or longer). They meet regularly (e.g., start/end of class or week) to provide consistent academic and social support. Responsibilities include checking homework, completing outline tasks (e.g., attendance), offering personal encouragement, listening to concerns, and giving feedback on work. They foster accountability and sustained peer support (Johnson et al., 2008, cited in Johnson & Johnson, 2009)..

2.2 Models of cooperative learning

Kagan and his colleagues at Kagan Publishing and Professional Development have created a variety of cooperative learning activities. Below are some of the cooperative learning strategies developed by Kagan and his team (n.d.).

2.2.1 Think-Pair-Share

Think-Pair-Share is a four-step discussion strategy that integrates wait time and cooperative learning principles, promoting active participation and deeper thinking. This method is often used within larger lessons and activities. It involves the following steps:

1. **Pose a Question or Problem**: The teacher presents a question or issue to the class.
2. **Think Time**: Students are given time to think individually about their response without raising their hands.
3. **Pair and Discuss**: Students then pair with a partner to discuss their thoughts and ideas.
4. **Share with the Class**: Finally, the teacher calls on a few students to share their responses, including their partner's ideas, with the whole class.

The primary goal of this method is to encourage students to mentally rehearse their responses and articulate their thoughts, which enhances both verbal and cognitive skills. Time limits and transition cues ensure that discussions flow smoothly. This strategy gives all students the opportunity to participate, fostering more engagement in group discussions (Kagan, 1990). The focus is on the preparatory thinking process rather than on completed tasks, and rewards are typically not a central element of this approach (Stahl, 1994).

2.2.2 Numbered Heads Together

Numbered Heads Together is an engaging cooperative learning strategy designed to quickly review objective material while building individual accountability and positive interdependence. In this activity, students are divided into teams, each with four members, who are assigned numbers (1, 2, 3, and 4).

The teacher poses a question to the group, and the students work together to ensure that everyone knows the correct answer. Once the team has "put their heads together," the teacher calls out a number. Only the students with that number are eligible to respond and earn points for their team. This can be done in two forms:

1. **Sequential Form**: Only the student with the called number responds.

2. **Every Pupil Response**: A specific group, such as all students with the number 3, responds using a technique like hand signals.

This strategy promotes positive interdependence, as all team members must collaborate to agree on the answer and ensure everyone is prepared to be called on (Stone and Kagan, 1995, as cited in Bayat, 2004). It also fosters individual accountability since students know they may be called on to contribute.

2.2.3 Team Pair Solo (Kagan)

Team Pair Solo is a cooperative learning strategy that encourages students to approach problems progressively. Initially, students work together as a team to solve a problem. Then, they collaborate with a partner to tackle a similar problem, before finally attempting to solve the problem on their own individually. The goal is to motivate students to take on and succeed with challenges that might initially feel beyond their capabilities.

This approach is rooted in the concept of mediated learning, where students benefit from support at each stage. Working as a team helps them reach a solution, partnering allows them to refine their understanding, and the solo phase fosters independent problem-solving skills. Overall, this strategy boosts student confidence, particularly with more complex material, and encourages them to accomplish tasks with assistance that they might struggle to complete alone.

2.2.4 Three step interview

The Three-Step Interview is a structured group activity where students practice interview and listening techniques. First, one student interviews another about a given topic. After a set amount of time, they switch roles. Next, the pairs join to form groups of four, with each student introducing their partner and sharing the responses from their interview. This approach can be used as a team-building exercise or for activities like discussing opinions, making predictions, evaluating content, or sharing book reports (Olsen and Kagan, 1992, as cited in Bayat, 2004).

2.2.5 Group investigation

Group investigation is a classroom organization strategy where students work in small groups, engaging in cooperative inquiry, group discussions, and collaborative planning on projects. In this method, students form groups of two to six members, select sub-topics from a unit being studied, and break them into individual tasks. Each group carries out activities necessary to prepare their reports, which are later shared with the class through presentations or displays (Slavin, 1995).

2.2.6. Jigsaw

The Jigsaw model is a widely used cooperative learning strategy that has proven effective in enhancing academic achievement, peer relationships, and overall learning outcomes. Originally it was developed by Aronson *et al.* (1978), is a cooperative learning technique where students work together in small groups; each assigned a unique portion of a topic. The main goal of Jigsaw is to foster teamwork and cooperative learning skills, allowing students to gain a deeper understanding of the material than they would by studying independently.

In the Jigsaw model, each student in a six-member team is responsible for mastering a specific part of the lesson. They then meet with students from other teams who are assigned the same portion to discuss and refine their understanding. Afterward, students return to their original teams to teach their section to their peers, promoting interdependence and shared learning. This method not only encourages active participation but also helps develop social and cooperative skills among students (Anderson and Palmer, 1988).

The Jigsaw model has been found to reduce competition in the classroom and encourage cooperation (Cochon Drouet e*t al.,* 2023). It enhances the overall learning experience by engaging students in both content mastery and collaborative teaching. Each student's responsibility for teaching their part of the lesson fosters a sense of ownership and accountability, contributing to a more engaging and effective learning environment (Slavin, 2014).

Research has shown that the Jigsaw model can improve academic performance across various subjects and academic levels. For instance, Karacop and Diken (2017) found that students using the Jigsaw model exhibited improved scientific process skills compared to those who followed traditional methods. Similarly, Atallah *et al.* (2021) noted significant learning improvements in physics courses, particularly in mapping concepts of nuclear therapy and radiation. A study by Garcia et al. (2017) on educational leadership also demonstrated that graduate students learned more effectively through Jigsaw cooperation and smaller, manageable content sections. Furthermore, Garcia (2021) reported significant improvements in self-efficacy and programming skills among novice computer programming students using the Jigsaw approach.

Although the Jigsaw method has shown success in various subjects, its application in biology lessons, particularly in the study area, has not been widely evaluated. This study aims to examine the impact of the Jigsaw model in biology classes, assessing its potential to improve student learning outcomes in this specific context.

In general, despite the variations across different cooperative learning approaches, all strategies aim to encourage students to take significant responsibility for their own learning, rather than viewing learning as something imposed by others.

2.3 Policy Frameworks Promoting Cooperative learning Strategies

In the evolving landscape of Ethiopian education, policy frameworks have increasingly emphasized student-centered learning and cooperative strategies to enhance educational outcomes. The Education and Training Policy of 1994 marked a pivotal shift from traditional rote learning to active learning methodologies, advocating for participatory approaches that engage students in the learning process (FDRE, 1994) . This policy underscores the importance of fostering critical thinking and problem-solving skills among learners.

Building upon this foundation, the Teacher Education System Overhaul (TESO) initiative was introduced to reform teacher education in Ethiopia (MOE, 2003). TESO emphasizes learner-centered teaching methods, aligning with cooperative learning strategies that promote collaboration and active engagement among students. This initiative aims to equip educators with the skills necessary to facilitate interactive learning environments, thereby enhancing student participation and learning outcomes.

Further reinforcing these educational reforms, the 2009 Secondary School Curriculum Framework integrates interactive and participatory teaching methods to boost student engagement (MOE, 2009). This framework encourages the adoption of instructional strategies that foster cooperation among students, aiming to develop both their social and academic competencies. Additionally, the 2023 Ethiopian Education Policy further strengthens the emphasis on cooperative learning by explicitly supporting student-centered pedagogical approaches (FDRE, 2023). This policy underscores the need for creating inclusive and collaborative learning environments where students actively participate in their educational journey, aligning with the broader objectives of enhancing critical thinking, creativity, and teamwork in schools.

At the international level, frameworks such as UNESCO's Four Pillars of learning to know, learning to do, learning to live together, and learning to be advocate for holistic, student-centered educational approaches that align with cooperative learning principles (Delors, 1996). These pillars collectively promote educational strategies that are comprehensive and learner-focused, resonating with the goals of Ethiopian educational policies.

Despite these supportive policies, challenges persist in the effective implementation of student-centered and cooperative learning strategies. A study by Moges (2019) identified several obstacles, including inadequate classroom facilities, large class sizes, insufficient teacher training, and a prevailing focus on teacher-centered approaches. These challenges often result in limited student interest and participation in cooperative learning activities (Moges, 2019).

Moreover, research by Yizengaw (2024) highlighted that both teachers and students frequently express uncertainty regarding the practice of cooperative learning, particularly concerning its fundamental elements and the role of teachers in facilitating the process. This ambivalence underscores the need for targeted interventions to enhance the understanding and implementation of cooperative learning strategies (Yizengaw, 2024).

2.4 Global Perspectives on Cooperative Learning

Globally, cooperative learning has been widely adopted across diverse educational settings, showcasing its versatility and effectiveness. Gillies (2016) provides a comprehensive review of cooperative learning across various educational systems, highlighting its adaptability and positive impact on student outcomes. Hattie (2008) reinforces this by presenting a meta-analysis that positions cooperative learning as one of the most effective instructional strategies, with a significant effect size compared to traditional methods. Studies from Asia (Chen, 2021), Europe (Gillies and Boyle, 2010), and USA (Van Ryzin *et al.,* 2020) further demonstrate how cooperative learning can be tailored to fit different cultural and educational contexts, and it beings improved academic achievement, increased student engagement, and enhanced social cohesion.

2.5 Cooperative Learning in African Contexts

In African educational contexts, cooperative learning has shown both promise and challenges. (Taylor, n.d.) review its adaptation across various African countries, highlighting both successes and obstacles. In South Africa, for example, learner-centered pedagogy has been successfully integrated into the curriculum, leading to a shift from a teacher-oriented approach and enhancing teaching practices in diverse classrooms (Seherrie and Mawela, 2023). On the other hand, Altinyelken and Hoeksma (2021) examines the barriers to implementation of cooperative learning method in in Malawi secondary schools, and identified challenges such as lack of resources, and large class sizes. These issues are also relevant to the Ethiopian context, where similar challenges affect the successful adoption of CL.

2.6 Implementation of cooperative learning strategies in Ethiopia

Currently, the Ministry of Education (MOE) is advocating cooperative learning approach in all schools, colleges and universities. However, the implementation of cooperative learning is not as such in good progress. In the Ethiopian higher education system, teachers most often use teacher-centered pedagogies, which are characterized by a high degree of teacher control, student's minimal engagement (Tadesse *et al.*, 2020) and lack of influence or power (Fisher and Swindells, 1998; Desta, 2004; Zerihun *et al.*, 2012 and Reda and Hagos, 2015). In addition, teachers continue to use instructional practices that are not effective at promoting quality learning. One reason for these shortcomings appears to be with the mismatch between policy intentions to promote student-centered pedagogies while not having a corresponding focus on how to cope with the challenges of implementation (Piper, 2009). A study focusing on the Amhara Region's Universities and Colleges of Teacher Education (CTEs) revealed that the lecture method was employed by 86% of instructors (Tadesse, 2015).

Sirak (2000) cited in Yimam (218) also indicates that about 58% of class activities in Ethiopia teachers' training institutions were inclined to be lecturer-centered while 42% were identified as student-centered.

Moreover, studies have shown that teacher-centered instruction remains predominant in Ethiopian secondary schools. For instance, Zekiros (2020) observed that biology teachers in Hulet Eju Enesie Woreda partially aligned their instructional practices with the First Principle of Instruction model, indicating limited use of student-centered methods. Similarly, Fufa et al., (2023) identified challenges such as large class sizes and traditional seating arrangements hindering the implementation of student-centered strategies in Sebeta town secondary schools. Similarly, Ayele *et al.*, (2019) also reported that in the Amhara Region and Addis Ababa City, only about 30% of teachers frequently implemented active teaching methods such as experimentation, projects, games, competitions, debates, and role play. Similar study conducted in secondary schools of Wolaita zone revealed that the implementation of cooperative learning is below average (Habtewold and Bezabih, 2018). Melese *et al.*, (2009) reported that the practice of learner-centered methods in upper primary schools of Ethiopia was below the expected level due to student, teacher, school environment, policy, resource and equipment related factors.

Collectively, these findings suggest that despite policy efforts to promote cooperative and student centered learning, traditional teacher-centered instructional practices remain wide spread across various educational levels in Ethiopia.

2.7 Students' and Teachers' Perceptions towards Cooperative Learning

According to Lindsey and Norman (1977), perception is the process by which organisms interpret and organize sensation to produce a meaningful experience of the world. Perception on the other hand describes one's ultimate experience of the world and typically involves further processing of sensory input.

Many scholars consider perception as the requisite property of animate practice and they said that without perception practice would be unguided and without practice perception would serve no purpose. Animate practice requires both perception and practice and perception and practice can be described as "two sides of the coin", (http://www.en.wikipedia.org/wiki/perception).

2.7.1 Students' Perception of Cooperative Learning

Attitude plays an important role in teaching learning process. A learner's attitude to the learning will impact the learner outside the classroom. The study done by Burden (2004) showed that a positive attitude would motivate learners to achieve their learning goals. Many research works have been conducted on students' perception and classroom practice of cooperative learning. For instance, Al-Fahad (2009), a study on students' attitude and perceptions towards the effectiveness of mobile learning result indicates that many students believe the importance of cooperative learning (CL) to improve their retention in the teaching and learning process. Also, in his class students were effective in implementing cooperative learning activities. Caroline et al., (2007) as cited in Al-Fahad (2009) also conducted on "perceptions of low ability students on cooperative learning." And they state that low ability students considered cooperative learning as a powerful teaching or learning method to improve their competence in interacting with others even though there are problematic organizational and instructional issues that have to be ironed out before students can profit fully from CL programs. In the actual implementation of CL, except in a few cases, students were effective. In addition to the above finding, Holtfreter (1991), conducted research on “cooperative learning Teams: perception of accounting students.” In the study, majority of students felt that they were part of a team that allowed them to interact well with other students and the instructor. The students accepted their role as active learners whereas the instructor role was relatively passive. The students also accept the principle of cooperative learning as a means to enhance academic achievement, self-esteem, attitudes towards learning and developing positive relationship among others. Furthermore, in the study, students enjoyed working together and showed a strong preference towards cooperation versus working competitively or individualistically and they were effective in the actual implementation of cooperative learning.

2.7.2 Teachers’ Perception of Cooperative Learning

Related to the perception of teachers towards cooperative learning, Thanh (2011) has conducted research on the role of teachers in implementing educational innovation in the case of implementing cooperative learning. The study shows that many teachers have a serious problem in implementing cooperative learning. This was due to their low perception towards cooperative learning. The study argues that many principles of cooperative learning are in serious conflict with the traditional perceptions of Vietnamese teachers regarding the nature of teaching and learning. Veenman (2001) has also assessed teacher’s perception and classroom practice of cooperative learning. In the study, based on pre and post course observations, a significant treatment effect was found for the four of the five basic principles regarded as essential for a lesson activity to be cooperative: except individual accountability. In addition, the course had a positive effect on the engagement rate of students in the treatment condition. The majority of teachers subscribed to cooperative learning to achieve both academic and social goals and also showed readiness to use cooperative learning in their future lessons. The researcher also observed a positive attitude of teachers working in the groups and rated the benefits of cooperative learning relative to competitive or individualistic learning quite positively and in their classroom many teachers were effective in implementing cooperative learning.

Furthermore, Nuntrakun and Nason (2009) have conducted a study on the perception of two Thai teachers towards cooperative learning. The study was conducted based on teachers’ experience of teaching. In the study, the teacher who does not have a long experience of teaching lacks confidence in implementing cooperative learning effectively. However, the teacher who has a better experience of teaching was good in implementing cooperative learning in classroom. Therefore, their finding clearly indicated that experience by itself has its own impact on the implementation of cooperative learning. Nevertheless, both teachers accept the principle of cooperative learning for better academic achievement and interaction. Berkessa *et al.* (2022), finds that even if the majority of students and all teachers had positive and high level of perception for most of cooperative learning tenets, however, the teachers are not giving due attention for cooperative learning activities. This indicates that the awareness of teachers towards 'instructional activities' in implementing cooperative learning was medium. Bain et al. (2009) also found that lack of effective use of cooperative learning by teachers may be due to teachers not having the professional pattern language required to use cooperative learning successfully. Berhanu (2000) findings support that the practice of cooperative language learning is not frequent and many of the elements of the cooperative learning lessons are not well practiced. Also, he concludes that many teachers and students lack the trend of working in cooperation to learn English. Veenman et al., (2001), state that "there is limited information regarding both teachers' and pupils' perceptions of cooperative learning as an effective method of learning". In addition to the above research findings, many project works have already been conducted in abroad on teachers' perception towards cooperative learning. Almost all research works reported many teachers committed to using cooperative learning and they felt positive about the role of the method on the pupil in their classes.

2.8 Benefits of cooperative learning

In addition to what has been said in the concepts of cooperative learning, many potential benefits arise when cooperative learning is used in the classroom instruction at different levels of grades. Researchers also have argued about the superiority & effectiveness of cooperative learning over competitive and individualistic learning on different grounds. This is true for all ages, subject areas, and for tasks involving concepts attainment, verbal problem-solving, categorization, retention and memory, guessing and predicting (Johnson, 1994). Some of the benefits of using CL that have been suggested by different scholars are presented as follows.

A. Enhance student's social skill: In real life, people need to collaborate with others. In their families, on their jobs, and in their social lives, they need to be able to work with others to everyone's mutual benefits. However, schools have not done enough to prepare students to this purpose. Often times, the students are conditioned to compete with others and view others as enemies who obstruct their own success. Other pupils' failure increases one's own chances of success. In cooperative learning groups, the students can exercise their collective skills and practice working with others to achieve mutual benefits for everyone rather than thinking competitively and individualistically (Freeman, 2000).

B. Individualization of instruction: In cooperative learning groups, there is the potential for the students to receive individual assistance from teacher and their peers (Long and Porter, 1985). Help from peer's increases both for the students being helped as well as for those giving the help. In other words, for the students being helped, the assistance from their peers enables them to move away from dependence on teachers and gain more opportunities to enhance their learning. For the students giving help, the cooperative learning groups serve as opportunities to increase their own performance (Webb and Farivar, 1994). Moreover, Brumfit (1984) argues "Placing students in small groups assists individualization for each group, being limited by its own capacities, determines its own appropriate level of working more precisely than can a class working in lockstep, with its larger numbers."

C. Increase students' perception: In cooperative learning students are active learner who needs to construct knowledge by activating their own schemata (Long and Porter, 1985; Brown, 2001). When groups are used, the students receive much more chance to speak. First, there is an increase in the percentage of time when the students are talking instead of the teacher. Second, during the time for the students to talk, many of them are speaking at any one time (Ibid).

D. Decrease anxiety: Students often feel anxious to speak in front of the whole class. In contrast, there is less anxiety connected with speaking in the smaller group. When a student represents the group and reports to the whole class, he/she feels more support because the answer is not just from one student alone, but from the whole group (Long and Porter, 1985). Therefore, Brown (2001) says, "In group activities, the security of the student will be improved and each individual is not entirely on public display."

E. Increase motivation and positive attitude towards class: As cooperative learning groups are interactive; the pace of communication becomes more student-centered than in traditional classroom. In a traditional classroom, a teacher is bound to proceed too slowly for some students and too fast for others. In contrast, students adjust the pace of their communications in cooperative learning groups to the understanding level of their peers. They know if they go too fast, the team will suffer. Over time they develop considerable attention among team members to the understanding level of others (McKernan, 1996). Thus, in cooperative learning groups, the students can encourage and help one another. That is, the cooperative atmosphere of working in a small group may help them develop affective bonds among themselves. This, in turn, greatly increases motivation and positive attitude towards their class.

2.9 Effect of Cooperative learning on achievement of students in biology in Ethiopia

There is a strong relationship between the teaching and learning approach and achievement in science subjects. Studies on teaching and learning approaches in science subjects indicate that cooperative learning approach increases student's academic achievement in science subjects more than traditional teaching and learning approaches (Wachanga and Mwangi, 2004; Kolawole, 2008). Effandi and Zanaton (2007) have noted that teachers should have the knowledge of how students learn science and how best to teach and that effort should be taken now to direct the presentation of science lessons away from the traditional methods to a more student-centered approach. Similarly, Wambugu and Changeiywo (2008) note that the teaching approach that a teacher adopts is one factor that may affect student's achievement and, therefore, use of an appropriate teaching approach is critical to the successful teaching and learning of science.

Researchers have long established that cooperative learning leads to a substantial academic and cognitive benefit. Cooperative learning promotes student learning and achievement (Slavin 1995; Hiltz 1998; Cockrell *et al.*, 2000; Johnson *et al.*, 2000), and increase the development of critical thinking skills (Brandon and Hollingshead 1999; Cockrell *et al.*, 2000). In considering the effects of cooperative learning on academic achievements, researchers have repeatedly examined cooperative versus individual learning experiences by comparing academic achievement of students. Results indicate that cooperative learning experiences promote higher achievement and greater retention than do individual learning experiences for all students (Cohen *et al.***,** 2004). Moreover, research indicates that students engaged in cooperative learning often demonstrate higher academic achievement, enhanced critical thinking skills, increased intrinsic motivation, and improved social interactions. For instance, Tran (2014) found that first-year primary education students who participated in cooperative learning achieved significantly higher scores in both achievement and knowledge retention compared to those who received lecture-based instruction. Similarly, Hsiung (2012) reported that cooperative learning positively impacts academic performance, student attitudes, and retention rates.

In the context of science education, cooperative learning encourages students to solve complex problems cooperatively (Gillies, 2016). One of the key theoretical foundations for cooperative learning is social interdependence theory by Johnson and Johnson (2009),which posits that structuring students' goals to promote positive interdependence enhances both individual accountability and collaborative success. This results in higher academic achievement, especially in science subjects. Slavin (2014) reinforces that cooperative learning creates environments where students share resources, explore diverse perspectives, and scaffold each other's leaning, leading to significant academic gains.

Furthermore, critical thinking; an essential component in science education is also improved through cooperative learning. Topsakal *et al.* (2022) demonstrated that cooperative learning is effective in improving critical thinking skills, which are essential for problem-solving and inquiry-based learning in science.

Empirical studies echo these findings. For instance, Gloria Ibemenji *et al.* (2019) found that cooperative learning significantly improved students' academic performance in biology compared to traditional instructional methods. Similarly, Gillies (2023) reported that students demonstrate higher engagement and achievement in science when they work in cooperative groups, particularly within inquiry-based learning frameworks. These findings are aligned with the broader literature suggesting that CL is particularly suited to complex subjects like science, where peer interaction and discussion can aid in understanding challenging concepts.

A meta-analysis by Yaşar *et al.* (2024) supports the positive effects of cooperative learning (CL) in STEM education, revealing significant improvements in academic performance and student attitudes towards science. The analysis, which included 77 studies, showed a large effect size ($g = 1.070$), indicating that CL not only enhances content knowledge but also fosters critical thinking and collaborative skills. These skills are essential for success in biology and other STEM fields, promoting meaningful learning experiences and positive attitudes toward science education.

The theoretical grounding of cooperative learning also aligns with Vygotsky's (1978) social constructivist theory, particularly the concept of the "zone of proximal development." Through cooperative tasks, students assist each other in learning activities they many not complete alone, thereby advancing cognitive development via social interaction.

Johnson and Johnson (2009) also stipulated that extraordinary achievement comes not from individualistic or competitive efforts of isolated individuals but from cooperative learning that promotes a situation in which students work together in small groups to maximize the learning of all members, sharing their resources, providing mutual support, and celebrating their joint success. It is also stated that if cooperative learning is used in both theoretical and laboratory application, it enables students to actively take part in teaching processes and paves the way for advanced academic and social skills (Carpenter, 2003). By recognizing these benefits, the government of Ethiopia incorporated the concern of active learning in general and CL in particular in policy documents (MoE, 2009).

A local study in Debre Birhan high school also states that the effects of cooperative learning on academic achievement and social skill are better than the usual methods of teaching (Seid, 2012). Molla and Muche (2018) examined cooperative learning versus traditional teaching method on academic achievement of students in biology subject in selected rural schools. The result of their study revealed that there were significant ($P < 0.01$) differences in the posttest scores of the learner academic achievement in which students exposed on cooperative teaching method scored higher than those exposed in traditional teaching method. Dagnew and Sitotaw (2019) also conducted research on effect of practical work on academic achievement of grade nine students' achievement in biology class at Diasopra secondary school, Bahir Dar, Ethiopia and their findings revealed that a significant improvement occurred in the achievement of those students who had been exposed to practical teaching which is one type of cooperative learning strategy. Similarly, Mekonen (2019) conducted research on effect of implementing cooperative learning in improving grade eight students' concept of photosynthesis in primary schools of Ethiopia. The finding of their study revealed that there was a significance difference in mean test score result in which students exposed on cooperative teaching method scored higher than those exposed in traditional teaching method. In addition to increasing academic achievement, cooperative learning has also an impact to increase female students' participation in class. Chimedsa and Wako (2020) conducted action research on improving female students' participation in cooperative learning in biology lesson at Bule-Hora University and reported that cooperative learning increase female students' participation in class room teaching. In general, relative to students taught with the traditional Methods; i.e., with instructor-centered lectures, individual assignments, and competitive grading, growing body of researches is confirming the effectiveness of cooperative learning (Ahmed, 2016).

2.10 Challenges in implementation of cooperative learning and jigsaw model in Ethiopian secondary schools

Implementing cooperative learning in Ethiopian secondary schools presents numerous challenges, which can be categorized into infrastructural, pedagogical, and attitudinal barriers. Although a student-centered teaching approach was introduced in Ethiopian secondary schools decades ago (Wariyo, 2020), the effective implementation of cooperative learning (CL) methods faces significant obstacles. Belilew (2015), and Reda and Hagos (2015) identify several issues, including a lack of student accountability, motivation, and awareness; negative teacher attitudes and negligence; shortages of instructional materials; unclear guidelines, lower-achieving students dependence on higher-achieving peers; insufficient training on cooperative learning implementation; and student reluctance to actively engage in cooperative learning.

Further studies by Habtewold and Bezabih (2018) reveal that student awareness, teacher commitment, classroom facilities, and large class sizes also impact the successful implementation of cooperative learning. Wondimu and Banteamlak (2020) highlight additional factors, such as unequal workload distribution among group members, students' lack of motivation to work in groups, the association of cooperative learning with politics, and challenges related to group organization and structure, particularly at Bonga University. Moreover, Chimdessa and Wako (2020) emphasize that a lack of respect for differing opinions within groups is a major hindrance to successful cooperative learning. Thus, it is vital to examine these challenges independently as follows in order to address the previously raised question.

2.10.1 Infrastructure and Resource Constraints

Inadequate classroom infrastructure and resources are significant barriers. Overcrowded classrooms with fixed seating arrangements limit the flexibility required for group activities (Ahmed, 2017; Molla and Muche, 2018). The lack of essential materials, such as textbooks and visual aids, further hampers cooperative learning processes (Musa Sirajo and Umar Abdullahi, 2023). Without sufficient resources, the potential benefits of cooperative learning are greatly diminished (Nyirenda, 2021).

2.10.2 Pedagogical Challenges and Teacher Training

Time constraints and heavy workloads complicate cooperative learning adoption. Teachers often struggle to allocate sufficient time for planning, implementing, and assessing cooperative learning activities, leading to only superficial engagement (Gedamu and Shewangezaw, 2020; Tamiru *et al.*,2021). Inadequate training exacerbates these issues, with many educators relying on traditional, teacher-centered methods due to a lack of professional development (Totoba, 2021; Geletu, 2022). Therefore, Continuous training initiatives are crucial for effective cooperative learning implementation.

2.10.3 Attitudinal Barriers

Negative attitudes towards cooperative learning from both students and teachers are significant obstacles. Students' reluctance to engage in group work, often preferring competitive approaches, is a key barrier (Belilew, 2015). Teachers' reservations and lack of motivation to employ cooperative learning strategies effectively compound this issue. Additionally, administrative support is frequently insufficient, with school leadership often failing to endorse or facilitate cooperative learning implementation (Ahmed, 2017). Cultural and societal expectations in Ethiopia, which sometimes favor competitive learning environments, further complicate cooperative learning adoption.

2.10.4 Political Perception Barriers

A unique barrier identified in the Ethiopian context is the perception that cooperative learning strategies, particularly Project-Led Cooperative Learning (PLCL), are imposed on schools for hidden political agendas (Mulisa and Kassahun, 2018). This perception fosters resistance among students and affects their motivation to engage in cooperative learning activities, and thus, further complicates its effective implementation.

Table 1 summary of barriers identified in recent reviewed studies

Authors	Design used	Study area	Sample Size	Identified challenges
Yizengaw (2024)	Descriptive survey design	Secondary Schools of Yeka Sub-city, Addis Ababa	n =263	Uncomfortable time schedule; lack of interest and motivation and lack of awareness about the importance of cooperative learning
Tamiru et al., (2021)	Descriptive survey Design	Akesta General Secondary and Preparatory School, Tigray, Ethiopia	n = 33	Lack of interest towards cooperative group work, time constraints to effectively implement
Gedamu and Shewangezaw (2020)	cross-sectional Descriptive survey Design	Arbaminch Secondary School, Karat Secondary School, Sawula Secondary School, Merab-Abaya Secondary School and Konso Secondary School	n = 425	Time constraints and workloads challenges, lack of adequate skills to assess group work

Demie et al., (2019)	mixed methods design	Alamata and Korem Secondary Schools of Tigray, Ethiopia	n = 337	lack of adequate training, lack of classroom facilities, lack of administrative support, lack of time, dependency of slow learners on more able learners, and traditional teaching methods
Molla and Muche (2018)	Quasi-experimental control group interrupted time series design	selected rural secondary schools in Farta District, Northwest Ethiopia.	n = 387	Large class room size, shortage of biological materials and chemicals, lack of providing enthusiastic approaches
Habtewold and Bezabih (2018)	Mixed method design	Secondary Schools of Wolaita zone	n = 337	Awareness among students, teachers' commitment, classroom facilities, and large class sizes
Mulatu and Bezabih (2018)	Descriptive survey design	three selected secondary schools in Genna Bossa Woreda of Dawro zone, SNNPRS	n = 72	Large class size with fixed sitting arrangement, inadequate teacher training, tendency of focusing on teacher-centered method, and time scarcity.
Mulisa and Kassahun (2018)	Mixed method research design	Selected secondary schools of Addis Ababa, Bahir Dar, Gondar, Adama, Dire Dawa, and Hawassa.	n = 991	The students’ firm belief that PLCL (Project-Led Cooperative Learning) is primarily imposed on schools for its hidden political agenda.
Ahmed (2017)	Descriptive survey Design	Secondary Schools of Harari Regional State, Ethiopia	n = 279	Large class size, uncomfortable seating arrangement of students, lack of clear guide line to practice CL and problem of group organization/arrangement, lack of awareness of students about CL, lack of interest in working in group, lack of skills of teachers to manage activities during CL and inclination of interest towards lecture method, inability of School leaders to follow up the implementation of CL, in ability to prepare training to fill gaps.

Lucha and Bongase (2015)	Descriptive research design	Enango Secondary School in West Wollega zone, Lalo District.	n = 30	Lack of conducive class room environment (in appropriate tables), lack of awareness to use different cooperative learning techniques
Belilew (2015)	Mixed method	Selected Secondary Schools in Gedeo, Sidama, and Segen peoples zone, SNNPR	N = 52	Negative attitude of teachers towards CL, lack of training on how to Successfully implement CL, lack of motivation, students' reservation to get actively involved in CL and students' competition to Score Better grades

2.11Theoretical Framework of the study

2.11.1 Theories of cooperative learning

Cooperative learning is encouraged by numerous theories of education. These include motivational theory, social learning theory, developmental theory, and cognitive theory (Slavin, 1995; Tudge, 1996; Leblanc and Skaruppa, 1997).

2.11.1.1. Motivational Theory

Motivational theory focuses on reward that derives students to behave in a certain manner. A cooperative environment creates a context in which students want to help one another. This motivates students to do well for themselves and make sure the other members of the group are also doing so. Students striving to meet their goals are motivated to encourage and support their group members to bring forth their best effort. Cooperative goals create norms that affect students' achievement positively (Slavin, 1995). In return, academic achievement leads to social acceptance (Slavin, 1995). In the traditional classroom, the competitive and/or individualistic goals are not related positively. Actually, an individual's academic achievement is unrelated to the rest of the class or it is against it. Academic achievement is not seen positively by the other students. This discourages students from striving for academic excellence (Slavin, 1995).

2.11.1.2. Social Learning Theory

Like motivational theories, social learning theories focus on the idea of rewards. However, the rewards anticipated in social theories are approval and expectation of group members. In the cooperative learning situation, it is demonstrated by the teachers through praise and peer pressure to encourage students to earn positive feedbacks from their peers. Cooperative learning provides positive social rewards for students to participate in the group. In addition, students build friendship with their group (Leblanc and Skaruppa, 1997).

2.11.1.3. Developmental theory

The basic idea of developmental theories is that individuals' interaction helps in learning. This collaboration brings forth cognitive growth (Leblanc and Skaruppa, 1997). This theory is supported by the learning theories of some educational psychologists, such as Vygotsky and Piaget (Murray, 1994; Slavin, 1995; Vygotsky, 1997). According to (Vygotsky, 1997) learning and our mental development take place in a social space; students learn through interaction with others. In his zone of proximal development, Vygotsky states that next level of development by the student is mainly achieved by adult guidance or during cooperative interaction with peers.

That is, cooperative learning should be increased to optimize learning. In contrast to traditional way of transmitting knowledge, teachers motivate or guide student to achieve learning among them (Murray, 1994; Vygotsky, 1997). Likewise Piagetian psychologists believe that knowledge is learned in interaction with others. Therefore, social interaction promotes cognitive development (Tudge and Ccaruso, 1988). Many Piagetians propose cooperative learning as an effective means. It provides social interaction, resulting in cognitive development and student achievement (Slavin, 1995). The teachers who incorporate Piagetian ideas place students in situations where the students are asked to work with other students who may have different views. Through this interaction, the teacher hopes to bring about academic development (Murray, 1994).

2.11.1.4. Cognitive theory

Scholars from cognitive psychology also advocate the use of cooperative learning. Like the theories mentioned above, they believe that cognitive development is more achieved by the collaborative activity of the group (Wittrock, 1978; Sharan & Shaulov, 1990; Murray, 1994; Slavin, 1995).

For instance, one of the most helpful methods in cognitive learning involves explaining what one knows to another person. Giving and taking explanation is beneficial to student achievement according research done on cooperative learning (Webb, 1994). Students who give the explanations go through cognitive restructuring in order to make the concept more understandable for others (Wittrock, 1978; Sharan & Shaulov, 1990; Slavin, 1995). In the cooperative learning environment, students debate and explain the material to their group members (Johnson & Johnson, 1983; Slavin, 1995).

Another aspect of cognitive learning is, particularly in the process of tutoring, students develop the model of a tutor. By tutoring and receiving help from a tutor, they develop the qualities of an expert. This gives a chance for both parties to exchange position as a tutor and one tutored and develop the cognitive structure by doing so. The teacher guides the students until he/she stands by herself (Murray, 1994).

2.12 Cooperative learning and social interdependence theory

The philosophical roots of the argument for the CL strategy emanates from the epistemological and pedagogical stances as described in the works of scholars, particularly learning as doing (Dewey, 1986), learning as social participation (Lave and Wenger, 1991), learning as environmentally and culturally situated activity (Vygotsky, 1978), and learning as participation with other learners (Rogoff et al., 2001).

Social interdependence theory is the principal theoretical foundation for cooperative learning, as highlighted by Tadesse *et al.* (2021). It serves as the basis for many commonly used cooperative learning approaches in education (Johnson and Johnson, 1999). According to this theory, cooperation in education occurs when there is positive interdependence between learners so that the success of one depends on the activities of the other (Johnson *et al.,* 1998).

Cooperative learning is anchored with the underlying theory of social interdependence adapted to the educational setting (Johnson and Johnson, 2008; Baloche and Brody, 2017). According to this theory, cooperative learning is an umbrella term for a variety of educational approaches that are structured to enable students to learn by working together and to learn to collaborate (Sharan, 2010). The theory of social interdependency predicts that cooperation leads to stronger interpersonal relationships than competition or individual work (Johnson and Johnson, 2009). It further emphasizes that students engaged in cooperative learning work interdependently to achieve shared group goals (Keramati and Gillies, 2022).

Cooperative learning can also provide a mechanism by which learners can have a positive social experience with peers and, over time, develop more positive peer relationships (Roseth *et al.*, 2008). Such positive peer relationships, in turn, can promote greater academic support (Van Ryzin *et al.,* 2020). Positive peer relationships among learners are also associated with higher academic competence, greater participation and effort, and higher learning gains. For instance, a study by Ladd *et al.* (1999) found that peer acceptance and perceived academic competence significantly influence student engagement and achievement. Similarly, Wentzel and Caldwell (1997) demonstrated that positive peer relationships enhance students' motivation and academic performance. Moreover, research by Furrer and Skinner (2003) indicated that students who feel a sense of relatedness with peers exhibit increased engagement and effort in learning activities.

Peer relationships are known to play a crucial role in student success, as positive interactions among students foster a supportive and cooperative learning environment (Van Ryzin et al., 2020; Țepordei *et al.,* 2023). Research suggests that cooperative learning strategies, such as the jigsaw model, can enhance peer interactions and contribute to a more supportive and inclusive classroom climate, particularly in science education (Gillies, 2023). Its effective implementation may enhance the effectiveness of these strategies, making them more adaptable to diverse student needs and learning styles (Tsai *et al.,* 2023). By integrating cooperative learning strategies, teachers can provide more interactive and engaging learning experiences that address different learning styles and abilities.

The practices of cooperative learning, both at school and university levels, are rooted in the social interdependence theory (Johnson and Johnson, 1999). This interconnectedness between theory, research, and practice makes CL distinctive, encouraging many researchers to adopt this theory in their studies (Keramati and Gillies, 2022).

Therefore, this study was guided by social interdependence theory, which aligns with its focus on fostering collaboration and enhancing students' academic achievement through cooperative learning.

2.13 Conceptual Framework of the study

This study's conceptual framework is grounded in Social Interdependence Theory (SIT) (Johnson & Johnson, 2017), which is rigorously adapted to the context of secondary school biology education in Gedeo Zone, Ethiopia. The framework integrates core theoretical principles with critical contextual realities observed within Ethiopian educational settings. Its central proposition posits that the structured interdependence inherent in the Jigsaw cooperative learning model, compared to the traditional lecture method (control group), fosters environments more conducive to enhancing specific outcomes: academic achievement, positive peer relationships, perceived academic support, and learning gains.

Visually represented in Figure 1, this framework serves as the essential analytical lens for investigating the comparative effectiveness of pedagogical approaches, mediating processes, contextual influences, and resultant outcomes. SIT provides the theoretical foundation, as its core tenets, where cooperative goal interdependence drives promotive interaction leading to enhanced productivity and relationships, directly align with the operational mechanisms of the Jigsaw model under investigation. The framework centers on the primary comparison between the intervention (Jigsaw cooperative learning model) and the prevailing practice (Traditional Lecture Method, Control Group).

The framework specifies five critical mediating mechanisms through which Jigsaw is theorized to influence the targeted outcomes:

(1) Positive interdependence, where reliance on peers for shared goal achievement is fundamental for fostering peer relationships and mutual academic support;

(2) Individual accountability, which motivates personal responsibility and is fundamental to gains in academic achievement;

(3) Promotive interaction, where peer encouragement and explanation directly enhance perceived academic support and conceptual learning gains;

(4) Social skills development, strengthening communication and conflict resolution skills essential for improving peer relationships; and

(5) Group processing, where reflective evaluation of teamwork refines cooperative strategies and sustains learning gains.

The framework incorporates key contextual moderators documented within Gedeo Zone secondary schools, anticipated to significantly shape the model's effectiveness: classroom size (large classes potentially impeding monitoring and participation); teacher experience and training (familiarity with cooperative learning strategies is crucial for effective implementation); prior student knowledge and skills (influencing readiness for productive engagement); and resource availability (time constraints and material limitations, common in Ethiopian settings, impacting feasibility). These moderators highlight the necessity for adaptive implementation strategies.

In summary, the conceptual framework demonstrates that the Jigsaw model, operationalized through its mediating elements grounded in SIT, holds potential to enhance targeted academic and social outcomes. However, this potential is critically contingent upon the interplay of specific contextual moderators inherent to the study setting. The framework thus provides essential direction, guiding the systematic investigation of the mediating processes, the influence of local contextual conditions, and the resultant effects on the defined outcomes, ensuring coherence and relevance to the Ethiopian educational context.

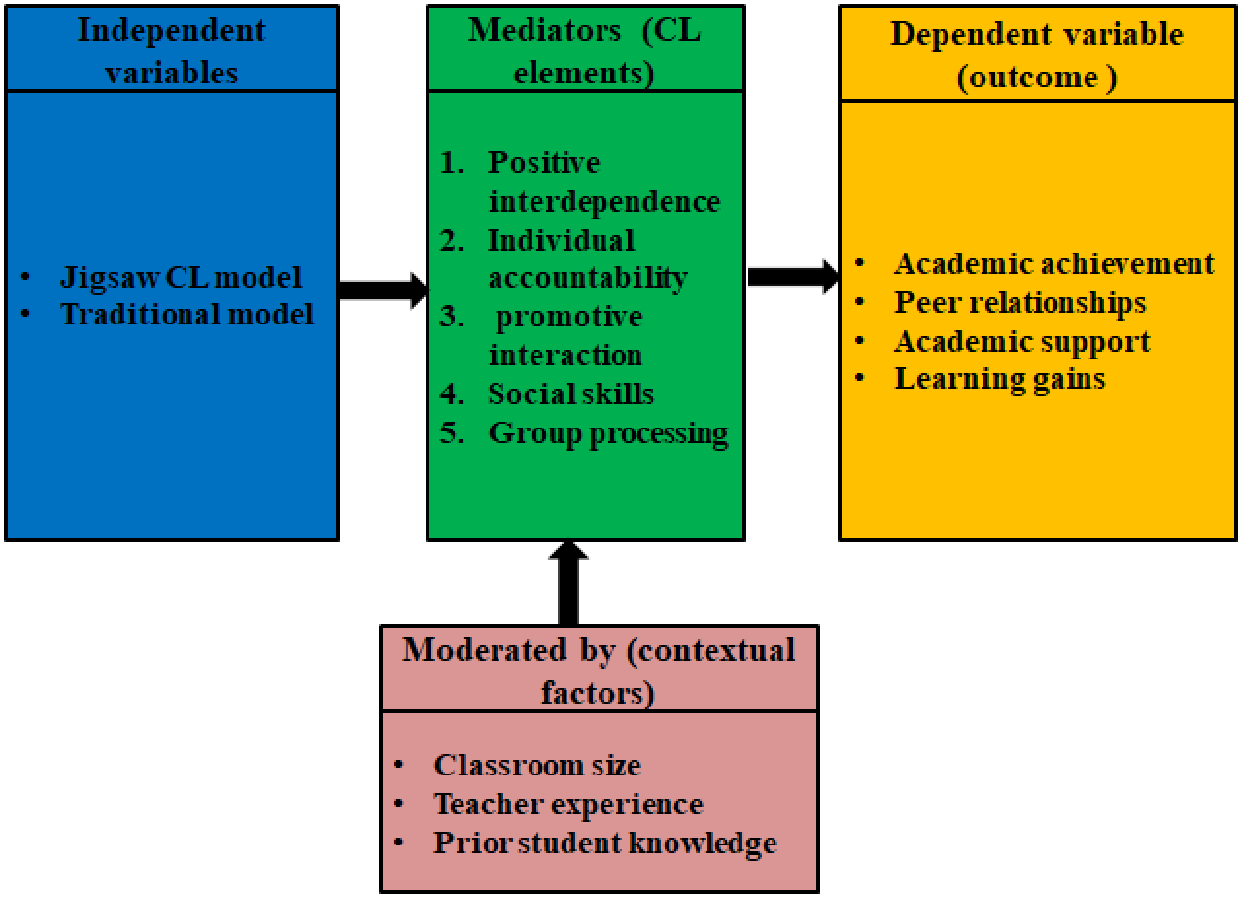

Figure 1 conceptual model of the study

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Description of the study area

The study was conducted from September 7, 2023, to January 7, 2024, in secondary schools located in the Gedeo zone, South Ethiopia regional state. Gedeo zone is known for its rich cultural heritage and agricultural economy, with coffee being a major cash crop. The region encompasses both urban and rural schools, offering a diverse and representative sample of different educational environments. The selected schools represent a mix of these settings, reflecting various student demographics and resource levels, which enhance the generalizability of the findings across the Gedeo zone. The educational system in Gedeo zone faces several challenges, including large class sizes, limited access to teaching materials, and resource constraints. Despite these challenges, the region's schools provide an ideal setting for exploring the effectiveness of innovative teaching methods like the Jigsaw cooperative learning model. Geographically, Gedeo zone is situated north of the equator, between 5°53’N and 6°27’N latitude, and from 38°8’ to 38°30’East longitude, with an altitude ranging from 1500 to 3000 meters above sea level (Degefa, 2016). Administratively, it lies within the South Ethiopia Regional State, one of the twelve self-administering regions of Ethiopia, which have a degree of autonomy in managing their affairs, including education.

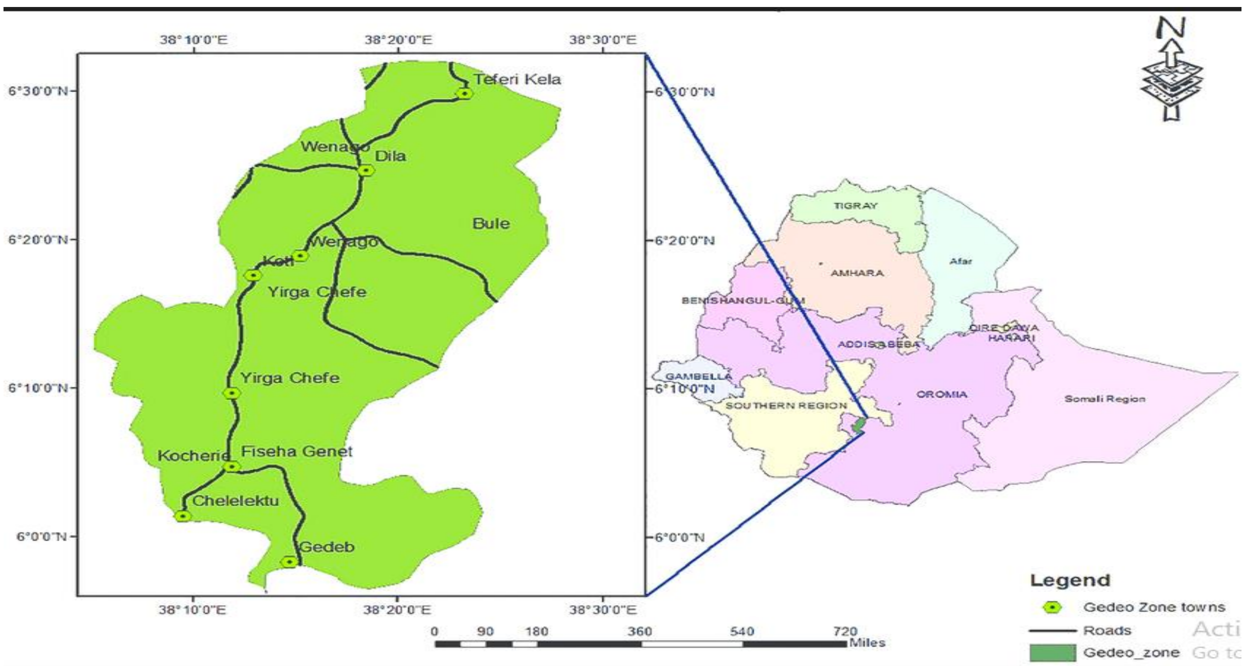

Figure 1: Gedeo Zone location Map (Sileshi Degefa, 2016).

3.2 Research Paradigm

The research paradigm serves as the philosophical foundation guiding the entire study, shaping the researcher's approach to reality (ontology) and knowledge (epistemology). Ontologically, a paradigm addresses whether reality is viewed as a single objective truth or multiple constructed realities. Epistemologically, it determines how knowledge is understood and acquired, spanning from objective measurement to subjective interpretation (Guba & Lincoln, 1994). This study adopts the pragmatist paradigm. This choice aligns with the nature of the research problem, which involves evaluating cooperative learning in resource-constrained educational settings, and reflects the need to generate actionable pedagogical knowledge. Pragmatism resolves the contrast between objective and constructed realities by prioritizing practical consequences and methodological flexibility (Johnson & Onwuegbuzie, 2004). It is therefore positioned as the most suitable framework for investigating complex classroom dynamics.

The selected paradigm directly influences the study's methodological choices through its support for methodological pluralism (Creswell & Plano Clark, 2017). Under pragmatism, mixed methods are strategically integrated. Quantitative data, collected through pre- and post-tests, were analyzed using MANOVA, bivariate correlation, and multiple regression analysis to measure academic achievement, peer relationships, academic support, and learning gains. Qualitative data, gathered through semi-structured interviews, observations, and document analysis, were analyzed thematically to explore the socially constructed dimensions of peer relationships and academic support (Tashakkori & Teddlie, 2010). This dual approach facilitates both hypothesis testing and meaning making, enabling a comprehensive examination of how the Jigsaw model functions within Gedeo Zone classrooms. The paradigm further permits adaptive data collection strategies that are responsive to contextual constraints. For example, structured observations can be used alongside surveys in large-class settings (Morgan, 2014).

The choice of this paradigm is justified by its alignment with three core imperatives of the study. First, it supports research objectives that require both measurable outcomes (that is, what works) and experiential insights (that is, how it works), consistent with pragmatism's problem-centered orientation (Feilzer, 2010). Second, it accommodates Ethiopia's educational constraints by allowing methodological flexibility, which is often lacking in more rigid paradigms (Kivunja & Kuyini, 2017). Third, it fulfills the ethical commitment to socially meaningful research by generating implementable strategies for Ethiopian educators (Biesta & Burbules, 2003). This philosophical and methodological coherence ensures a rigorous examination of pedagogical practices within their context, while enhancing the validity and practical utility of the study's outcomes.

3.3 Research Design and Method

Research design serves as a strategic framework guiding the study from the formulation of research questions to the interpretation of results, ensuring a structured investigation of the chosen phenomenon (Ary et al., 2010; Cohen et al., 2018). This study employed a widely used convergent parallel mixed-methods approach (Creswell & Plano Clark, 2017) to comprehensively examine the research problem. The design afforded equal priority to quantitative and qualitative data, enabling robust comparison between measurable outcomes and participants' lived experiences (Creswell & David, 2018). Specifically, it integrated a quasi-experimental nonequivalent control group pretest-posttest design for the quantitative strand with a phenomenological approach for the qualitative strand, facilitating simultaneous examination of intervention outcomes and contextual learning processes.

Quantitative data collection involved achievement tests and structured questionnaires administered to 81 participants. Qualitative data were gathered through semi-structured interviews with 17 purposively selected informants (16 students and 1 teacher), classroom observations, and document analysis. Both datasets underwent independent analysis: quantitative data using descriptive and inferential statistics, and qualitative data through thematic analysis, followed by integrated interpretation to explore convergence, contradictions, and expansions (Ary et al., 2010; Yin, 2018). This methodological triangulation enhanced the credibility, depth, and validity of findings while leveraging complementary paradigm strengths to mitigate limitations (Creswell, 2014; Teddlie & Tashakkori, 2009).

Methodological alignment with the pragmatic paradigm addressed real-world educational constraints: The quasi-experimental design accommodated contexts where random assignment was impractical (Fraenkel & Wallen, 2012; Rowe & Oltmann, 2016), while all activities were embedded within the regular academic calendar to maintain ecological validity (Hodges et al., 2020). The intervention group received Jigsaw cooperative learning instruction, whereas the control group experienced conventional lecture-based delivery. Temporally phased data collection included: pretest-posttest outcome measures; observation of instructional dynamics; and experiential exploration through interviews and document analysis before, during, and after the intervention. Ethical protocols governing informed consent, confidentiality, and voluntary participation were rigorously maintained throughout.

3.4 Target Population and Sampling

The sample for this study consisted of 81 grade nine students from two government secondary schools in the Gedeo zone. The rationale behind selecting the implementation of cooperative learning at this specific grade level stems from the researcher's belief that introducing a cooperative work culture at this stage has the potential to cultivate teamwork and play a pivotal role in enhancing future performance in national exams.

The Gedeo zone education department documented a total of 27 secondary schools (Gedeo Zone Education Department, 2023). To ensure precision in measurement and control, two schools were chosen through a simple random sampling method, following the recommendation of (Namusoke and Rukundo, 2022). Since random assignment of individual students was not feasible, entire schools were assigned to experimental and control groups to maintain the integrity of existing class structures. Thus, Kofe Secondary School, which had 41 students, was designated as the control group, whereas Dilla Comprehensive Secondary School, which possessed 40 students, was taken as the intervention group. To guarantee a fair and impartial distribution, the schools, rather than individual students, were randomly selected, and then one was designated as the control and the other as the intervention group. This quasi-experimental design ensured that group assignment was systematic, minimizing selection bias while preserving natural classroom settings. By taking a strategic approach, the study's results were more dependable and the impact of cooperative learning in the chosen schools was better understood.

3.5 Experimental intervention

This study employed a quasi-experimental design utilizing the Jigsaw Collaborative Learning (CL) model. The intervention incorporated five key pedagogical elements identified by Tadesse et al. (2021): (1) focusing on students' learning and achievement of diverse outcomes, (2) fostering positive relationships, (3) enhancing students' capacities, (4) maintaining persistence through varied learning activities, and (5) providing consistent implementation support. The learning process was further structured according to CL frameworks defining student cooperation and targeted learning outcomes (Železnik Mežan et al., 2023). To satisfy the core attributes of experimental research, the design featured explicit manipulation of the independent variable (instructional approach: Jigsaw model versus traditional lecture based instruction) to observe its effect on dependent variables (academic support, peer relationships, academic support, and overall learning gains). Participants were randomly assigned to either an experimental group receiving the Jigsaw CL intervention or a control group receiving standard teacher-led instruction on identical biology content. Rigorous controls were implemented to minimize extraneous influences: both groups experienced the same lesson duration (three 40-minute sessions weekly), covered identical curricular material, and underwent identical assessment procedures. This methodological approach was selected to facilitate causal inference regarding the instructional method's impact. Measurement included a pre-test administered prior to the intervention (early September 2023) and a comprehensive post-test following its conclusion (mid-January 2024), utilizing parallel instruments to quantify learning gains. Furthermore, detailed protocols documenting the Jigsaw implementation procedures, group formation criteria, lesson structure, assessment tools, and data collection methods were established to ensure methodological transparency and enable replication under comparable conditions.

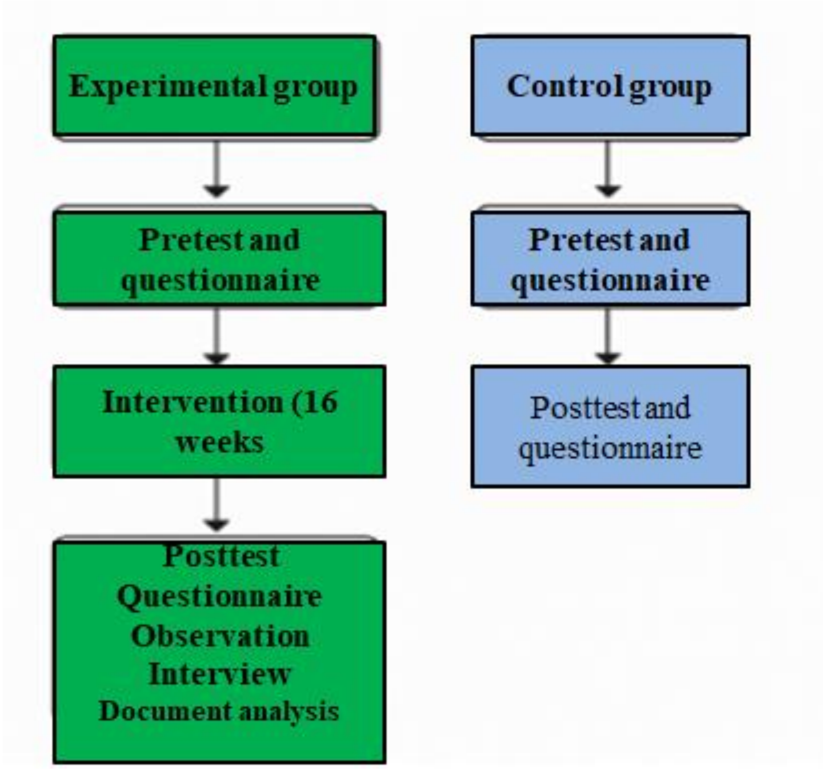

Figure 2 Diagrammatic representation of the experimental design

The intervention spanned 16 weeks, from September 7, 2023, to January 7, 2024, within the Grade 9 biology curriculum. Within the experimental group, students were organized into heterogeneous "home groups" of 5–6 members, with group composition strategically diversified based on prior academic performance and gender to optimize peer learning dynamics. During each session, subject matter was segmented and allocated to home groups, enabling students to develop expertise in their assigned segment. Subsequently, students temporarily reconvened into "expert groups" with peers from other home groups who had mastered the same segment, facilitating in-depth consolidation. Finally, students returned to their original home groups to disseminate their expertise and collectively synthesize all segments. Alongside the primary pre-test/post-test measures, formative evaluations were conducted by the instructor at the conclusion of each lesson to monitor ongoing conceptual understanding (Figure 2).

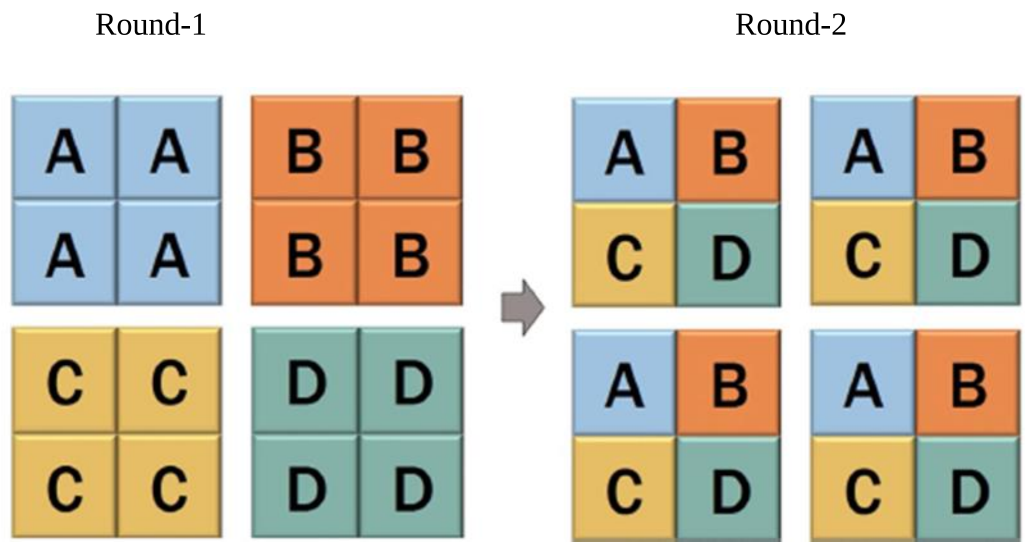

Figure 3 Jigsaw model as a cooperative learning approach, adopted from (Garcia, 2021)

3.5.1 prior to intervention

Before the intervention began, the participating biology teachers attended a three-day training workshop focused on various techniques of the jigsaw CL strategy. During this workshop, the teachers were trained on how to effectively group students, assign tasks, and evaluate students throughout the intervention period.

3.6 Target Population of the study

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3.7 Source of data

In this study, secondary school biology teachers and sampled secondary school students from the selected schools were identified as the primary sources of data. These participants provided first-hand information through achievement tests, questionnaires, interviews, and classroom observations, which were essential for addressing the research questions.

In addition to the primary data, the study also utilized secondary sources of data. These included official documents such as textbooks, annual plan, and daily lesson plan. These secondary sources were instrumental in supplementing the primary data, offering contextual background and supporting the analysis with documented evidence.

3.8 Instruments of data collection

After selecting a research design that aligned with the study's objectives, data were collected using a mixed-methods approach. Ensuring high-quality data collection was crucial, as the reliability of any research study depended significantly on the quality of the data gathered and the methods employed. According to Seliger (1989), studying a phenomenon within its natural context requires multiple data collection methods used simultaneously, with one type of data guiding the next.

To ensure data triangulation, pretest and posttest achievement tests and questionnaires were administered before and after the intervention, respectively. Following this, semi-structured interviews and classroom observations were conducted. Additionally, document analysis was performed on lesson plans, annual plan, and textbook to evaluate the alignment of instructional content with the cooperative learning approach. Biology achievement tests and questionnaires, which assessed students' achievement, peer-relationship, academic support, and overall learning gains, served as quantitative data collection tools while interviews, classroom observations, and document analysis contributed to the qualitative dimension of the study.

3.8.1 Achievement Test

For the intervention, introduction to biology, characteristics and classification of organisms and cell biology topics of grade 9 biology were covered. To assess students' academic performance, multiple choice test from the topics was developed both for a pre-test and post-test. The test consisted of 40 multiple-choice questions. To ensure content validity, two biology professors and one PhD candidate reviewed the tests to confirm whether the questions adequately represented the targeted content. After this review, the final test, now comprising 35 multiple choice items, underwent a pilot phase involving 20 students to assess its reliability. The Kuder-Richardson 20 method was used for this purpose, resulting in a reliability coefficient of 0.93, indicating excellent reliability (Kuder and Richardson, 1937). Consequently, the biology achievement test was chosen as the primary instrument for data collection.

3.8.2 Questionnaire

For this investigation, adapted structured questionnaire with close ended Likert-scale items were employed to gather data. The items covered peer relationships, academic support, and learning gains, and were completed by the students, both before and after the intervention period. A quick synopsis of these items is provided in the section below.

3.8.2.1 Synopsis of questionnaire items

A) Peer Relationship

The relatedness scale questionnaire developed by Furrer and Skinner (2003) and further validated and used by Van Ryzin *et al.* (2020) was used to assess learners' peer relationships. The peer relationship questionnaire had four items. These items were measured using a five-point Likert scale, ranging from strongly disagrees to strongly agree. Sample items included were "When I'm with my group members, I feel accepted"; and "I feel safe when I am with my group members".

B) Academic Support

This was assessed by using adapted version of Tadesse *et al.*(2018) Student Engagement Scale. The academic support scale had four items. The items were measured by a five-point Likert scales, ranging from strongly disagree to strongly agree. The sample items comprised were "Other students in this class want me to do my best schoolwork"; and "In this class, other students like to help me learn".

C) Learning Gain

Learning gains was evaluated by using an adapted version of the Tadesse et al. (2018) Student Engagement Scale. The learning gain scale included five items, measured with a five-point Likert scale, ranging from very poor to very good. The items evaluated the extent to which the topics had contributed to the students various aspects of learning and personal development. Sample items include: “The covered topics have improved my written and communication skills”; and “The course have increased my confidence in tackling unfamiliar problems”.

To ensure linguistic accuracy, the researcher translated the original questionnaire to Amharic, and then consulted language experts for review. The questionnaire was administered to 20 secondary school students for a pilot study to pinpoint any ambiguities or misunderstandings. Participants were given the translated questionnaire and an assessment tool, accompanied by an explanation of the pilot study's objectives. Their task was to assess the clarity of the questionnaire, and recommended necessary improvements. Finally, appropriate improvements were made.

3.8.2.2 Assessing the Psychometric Properties of questionnaire

The face validity of both pre-test and post-test instruments was meticulously evaluated using Principal Component Analysis (PCA) with Varimax Rotation. The results of the Kaiser–Meyer–Olkin (KMO) test for the pre-test indicated a high level of sampling adequacy (KMO = 0.843), affirming its suitability for analysis. Furthermore, Bartlett’s test of sphericity yielded significant correlations between items (χ^2 (78) = 449.669, P = .000), and validated the appropriateness of PCA. The three-component solution extracted during analysis explained a substantial portion of the variance, totaling 63.129%. Component one accounted for 41.723%, component two for 11.65%, and component three for 9.756%. Remarkably, all the three components displayed eigenvalues greater than 1, ranging from 1.268 to 5.424, confirming their significance. Additionally, reliability analysis via Cronbach's alpha coefficients showed robust internal consistency, with an overall alpha coefficient of 0.873. The subscale alphas for peer relationships, academic support, and learning gains were 0.764, 0.799, and 0.851 respectively and these further reinforced the reliability of the instruments.

Similar validation procedures were applied to the post-test instruments, with the KMO test yielding a commendable value of 0.877, indicative of strong sampling adequacy. Bartlett’s test of sphericity again revealed significant correlations between items (χ^2 (78) = 465.18, p = .000), reinforcing the suitability for PCA. In alignment with the pre-test findings, the three-component solution for the post-test elucidated a substantial 64.882% of the variance. Component one contributed 45.075%, component two 10.596%, and component three 9.212%, with all the three components exhibiting eigenvalues surpassing 1, ranging from 1.198 to 5.868. Reliability analysis for the post-test instruments revealed an impressive overall alpha coefficient of 0.896, underscoring the robustness of the instruments. Furthermore, subscale alphas for peer relationships, academic support, and learning gains were 0.813, 0.794, and 0.845 respectively, provided further evidence of reliability.

The instruments' validations were further substantiated through Confirmatory Factor Analysis (CFA) conducted using AMOS 23 software (see below figure 1 and 2). The CFA results for the Pre-test indicated a well-fitting model, with $\chi^2 = 77.582$, df = 62, and $\chi^2/df = 1.251$. Notably, the Goodness-of-fit index (GFI) stood at 0.875, while the Tucker Lewis Index (TLI) and Comparative Fit Index (CFI) demonstrated strong values of 0.951 and 0.961 respectively. Additionally, the Standardized Root mean square residual (SRMR) and Root Mean-Square Error of Approximation (RMSEA) were 0.100 and 0.056 respectively; thus, these affirmed the model's adequacy. The Adjusted Goodness-of-fit index (AGFI) capped off the robust fit indices at 0.817. Similarly, the CFA results for the Post-test unveiled a model with strong fit indices, including $\chi^2 = 74.693$, df = 62, and $\chi^2/df = 1.205$. The Goodness-of-fit index (GFI) at 0.884, along with the Tucker Lewis Index (TLI) and Comparative Fit Index (CFI) values of 0.962 and 0.970 respectively, which bolstered confidence in the model's validity. Importantly, the Standardized Root Mean Square Residual (SRMR) of 0.074, Root Mean Square Error of Approximation (RMSEA) of 0.051, and Adjusted Goodness-of-fit index (AGFI) of 0.830, collectively affirming the adequacy of the proposed model. Most researchers consider these values as indicatives of a good model fit (Brown, 2015; Collier, 2020; Kline, 2023).

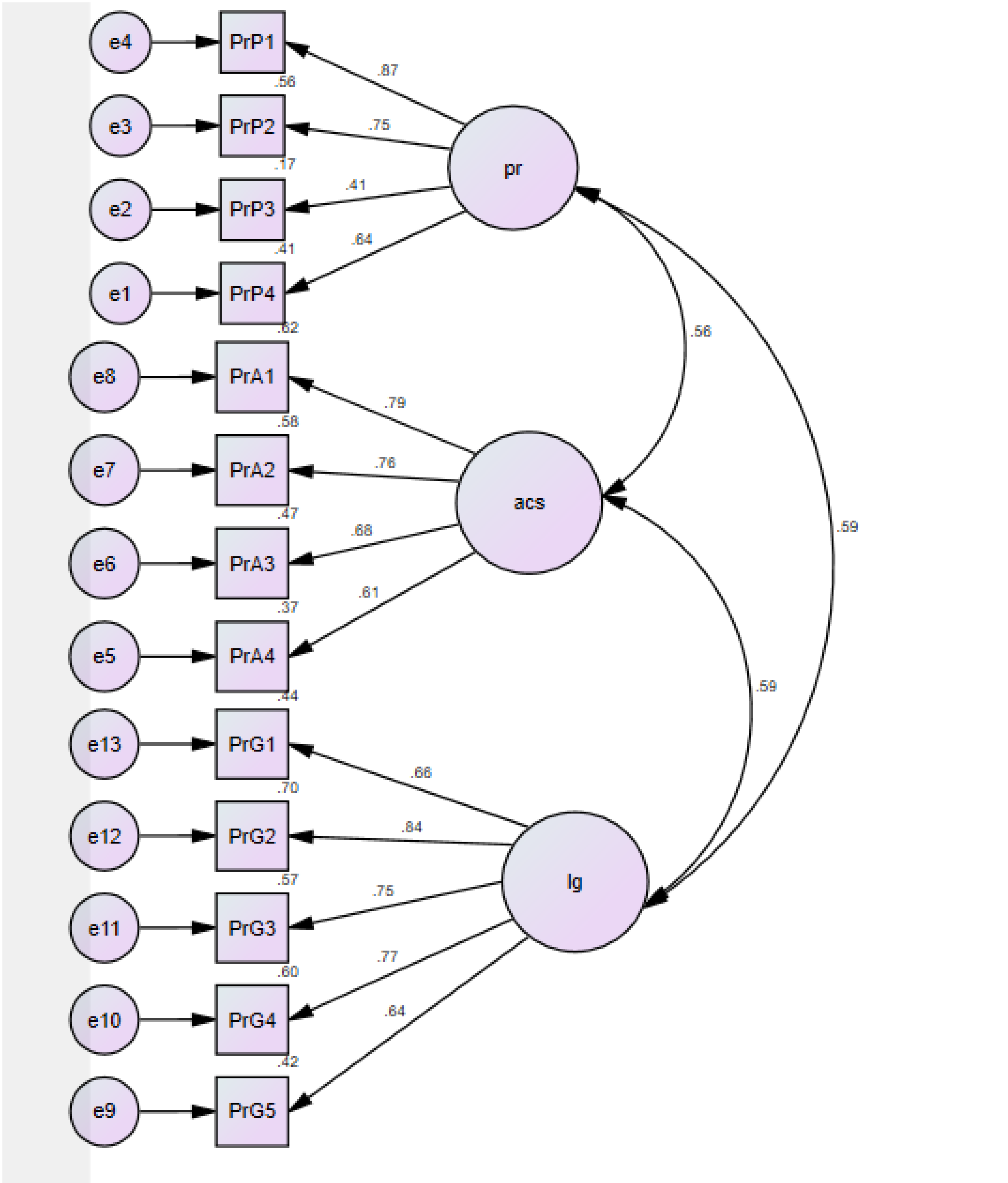

Figure 4 Path diagram illustrating the three factor model for pre-test

Figure 3.2 presents the path diagram illustrating the pre-test relationships between the latent variables: peer relationships (pr), academic support (acs), and learning gains (lg), and their corresponding observed variables. The factor loadings range from 0.41 to 0.87 indicates moderate to high correlations. Error terms (e1-e13) represent the unexplained variance for each observed variable. Additionally, the latent variables 'pr', 'acs', and 'lg' show correlations of 0.56 to 0.59, highlighting significant associations among these constructs in the pre-test results.

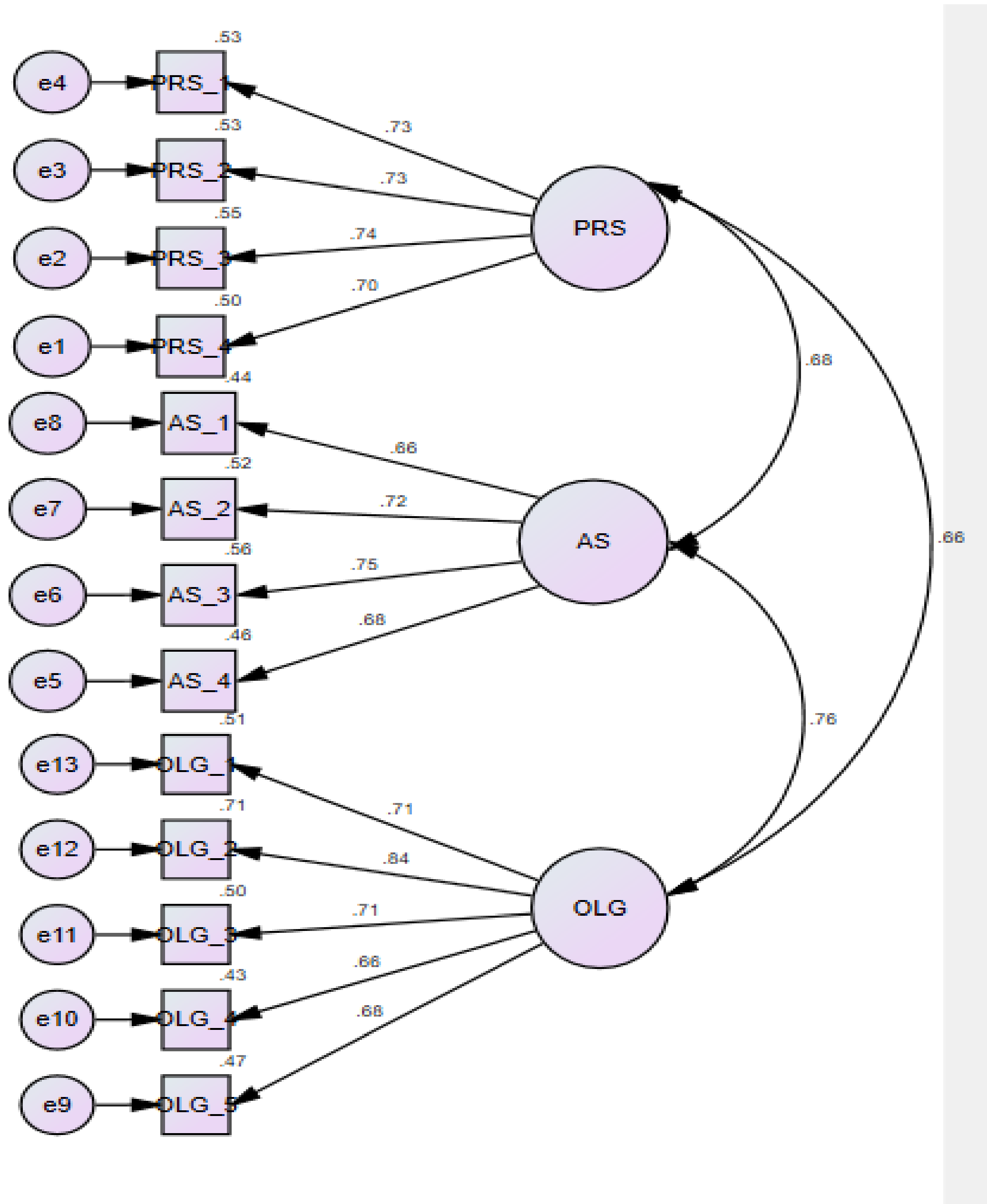

Figure 5 Path Diagram Illustrating the three-factor model for post-test

Figure 3.3 illustrates the path diagram representing the post-test relationships between the latent variables; peer relationships (PRS), academic support (AS), and overall learning gains (OLG), and their respective observed variables. The factor loadings range from 0.66 to 0.86, shows high correlations. Error terms (e1-e13) account for the unexplained variances in the observed variables. The latent variables PRS, AS, and OLG show correlations of 0.66 to 0.76, and reveal significant associations between these constructs in the post-test results.

3.8.3 Interview

At the end of the intervention, semi-structured interviews with open-ended questions were conducted with 17 participants (16 students from the experimental group and one teacher) to explore six key themes: their overall experience with cooperative learning (CL), strengths of the approach, specific examples of these strengths, roles of teachers and students, challenges faced, and feedback on CL lessons. Semi-structured interviews were chosen to allow flexibility in probing responses while systematically addressing core themes across participants. Each face-to-face interview lasted 15–20 minutes and was audio-recorded after obtaining informed consent. Participants were assured of voluntary participation, confidentiality, anonymization of data, and the right to withdraw without consequences. Ethical approval for the study was granted by the College of Natural and Computational Sciences, Hawassa University (Ref: CNCS-REC012/24).

3.8.4 Observation

In addition to interviews, structured classroom observations were conducted to monitor the experimental group's implementation of the Jigsaw model. Over 16 sessions (40 minutes each), the researcher recorded real-time data using a structured observation checklist focused on specific Jigsaw model dynamics, such as group interactions, role adherence, and task engagement. This predefined checklist ensured systematic and objective data collection on targeted behaviors.

To capture contextual nuances, detailed descriptive field notes were maintained concurrently. These notes documented qualitative aspects of CL practices, student-teacher interactions, unexpected events, and researcher reflections. These observations provided firsthand insights into the practical application of the Jigsaw model.

3.8.5 Document analysis

A structured review guided by Bowen's (2009) framework analyzed lesson plans, annual plans, and textbooks to assess their alignment with cooperative learning (CL) principles. This method, which involves systematically reviewing educational documents to extract meaning and support triangulation (Bowen, 2009; Yin, 2018), identified instructional gaps (e.g., group task design, teacher facilitation) through open-ended coding. Lesson plans were evaluated for integration of CL principles, including structured group tasks, student roles, and teacher facilitation (Johnson and Johnson, 2018). Annual plans were reviewed to assess long-term CL implementation consistency, and textbooks were examined for inclusion of collaborative learning guidance. The researcher conducted the analysis to triangulate findings with interviews and observations, providing critical insights into how CL was embedded in instructional materials and whether these resources supported or hindered its effectiveness.

3.9 Procedure of data collection

The data collection procedure followed a structured, phased approach: Pre-intervention, self-administered pre-tests (35 multiple-choice items) and questionnaires were distributed to both experimental and control groups under researcher supervision to establish baseline academic achievement, peer relationships, and academic support. During the 16-week intervention, the experimental group received Jigsaw-based instruction, while the control group continued traditional lectures, with structured classroom observations (16 sessions) and document analysis conducted by the researcher to monitor implementation fidelity and instructional alignment. Post-intervention, self-administered post-tests and follow-up questionnaires were administered to both groups, followed by semi-structured interviews with 16 experimental group students (audio-recorded with consent) to explore their experiences and challenges. Ethical protocols included informed consent, anonymization of data, and secure storage of quantitative and qualitative data. Triangulation of quantitative (tests, questionnaires) and qualitative (interviews, observations, documents) data ensured methodological rigor.

3.10 Data Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 23. Various statistical parametric tests were employed to assess the impact of the jigsaw model on student achievement, peer relationships, and academic support in secondary school biology. Qualitative data (interviews, observations, documents) underwent thematic analysis following

Braun and Clarke's (2006) framework, involving iterative familiarization, open coding, theme development through constant comparison, and refinement. .

Before employing t-test statistics, normality assumptions were thoroughly assessed. The normality of the distribution of the dependent variable, encompassing pre-test and post-test achievement scores for both the experimental and control groups, was confirmed, and no outliers were detected. Histograms were utilized to visually assess the distribution, revealing reasonably normal distributions for the scores. Additionally, the examination of normal Q-Q plots and box plots supported the normality findings. Furthermore, the Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted, indicating no significant evidence to reject the null hypothesis of normality ($P > 0.05$).

Following the fulfillment of these assumptions, an independent sample t-test was conducted to compare the mean scores of pre-test and post-test achievements between the experimental and control groups, evaluating the effectiveness of the cooperative learning approach. Additionally, a paired sample t-test was used within the experimental group to measure performance changes before and after the intervention. Eta squared statistics determined the magnitude of the effect.

To further explore the impact of cooperative learning, a one-way MANOVA (Multivariate Analysis of Variance) was conducted to assess differences across three key constructs: peer relationships, academic support, and overall learning gains in biology. Before applying MANOVA, assumptions such as variance-covariance homogeneity, multivariate normality, and linearity were tested and satisfied.

A bivariate correlation analysis examined relationships between the dependent variables (peer relationships, academic support, and overall learning gains in biology). Furthermore, multiple regression analysis was performed to investigate the extent to which peer relationships and academic support predicted overall learning gains. The appropriateness of the data was verified, ensuring no outliers and confirming a normal distribution of the dependent variable through histograms and Q-Q plot analysis.

Multicollinearity was assessed using correlation analysis, with no concerns as the correlation between independent variables (academic support and peer relationships) was $r = .558$. The tolerance value was 0.689, and the variance inflation factor (VIF) was 1.452, confirming no multicollinearity (VIF < 10, CI < 30). Additionally, the Durbin-Watson statistic (D-W = 1.708) indicated no autocorrelation. The hypotheses were tested at a significance level of .05, ensuring rigorous statistical validation of the findings.

3.11 Ethical Considerations and Clearance

This study was approved by the Ethics Committee of the College of Natural and Computational Sciences, Hawassa University, with the reference number CNCS-REC012/24. Ethical clearance was obtained before conducting the research, and formal permission was secured from the relevant educational institutions.

Participants were fully informed about the purpose and procedures of the study, and informed consent was obtained from all individuals involved. In the case of minor students, consent was also sought from the school administrators. Participation was entirely voluntary, and participants had the right to withdraw from the study at any time without any consequences.

Confidentiality and anonymity were strictly maintained, ensuring that personal information was not disclosed. The collected data were used solely for academic purposes, and all research materials, including survey responses and test results, were securely stored. After a reasonable period, these materials were systematically disposed of in accordance with ethical guidelines.

As this study was an educational intervention using a quasi-experimental design based on the Jigsaw cooperative learning model, all procedures were implemented in a way that did not interfere with the participants' regular learning process or place any undue burden on them.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

Building upon the mixed-methods research design detailed in Chapter 3, this chapter presents empirical findings addressing the effectiveness of the Jigsaw model in secondary biology education. Data from all 81 participants; 40 students in the experimental group receiving the Jigsaw intervention and 41 students in the control group following traditional instruction; were systematically analyzed. Participant retention remained exceptional throughout the study, with 100% completion rates for all quantitative assessments across both groups. This exceeds the 80% validity threshold for educational interventions (Smith & Jones, 2021), eliminating attrition bias concerns.

The analytical approach followed this structured framework:

Table 2 Research Analytical Framework

No	Research Objective	Data source	Analytical Approach
1	Achievement impact	Biology Pre/Post Tests	Independent & Paired t-tests
2	Peer relationship academic support and overall learning gains	Adapted pre/posttest questionnaire	Independent sample t-test, MANOVA, correlation, and regression
3	Implementation Fidelity	Observation Checklists (16 sessions)	Descriptive Statistics
4	Stakeholder Experiences	Interviews (16 students + 1 teacher)	Thematic Analysis (Braun & Clarke, 2006)

The chapter details participant demographics before presenting comparative analyses of pre-test and post-test achievement scores between experimental and control groups, including gender-disaggregated results within the experimental cohort. Subsequent sections examine baseline and post-intervention differences in peer relationships, academic support, and learning gains; between-subjects effects analysis follows these comparisons. Correlation and regression results establish predictive relationships between key constructs. Qualitative insights from interviews and observations provide contextual depth to quantitative findings. Critical discussion integrates throughout each analytical section, facilitating comprehensive interpretation within biology education contexts.

This integrated presentation maintains methodological coherence while delivering robust empirical responses to the study's research questions.

4.2. Demographic Characteristics distribution of Participants

Table 3 Demographic characteristics distribution of participants by gender and age

Demographic Characteristics	Category	Frequency	Percent
Sex	Male	59	72.8
	Female	22	27.2
Total		**81**	**100**
Age (years)	14	1	1.2
	15	25	30.9
	16	48	59.3
	17	7	8.6
Total		81	100

The sex and age distribution of study participant students is presented in Table 3. Regarding gender, large proportion (72.8% or 59) students were male, while the remaining 22 (27.2%) students were female. Regarding the age distribution of the participants, the largest participants of students (48 or 59.3%), were 16 years old, followed by 30.9%, 8.6% and 1.2% participants that were 15, 16 and 17 years old, respectively. The overall average mean age for all participants was 15.75 years.

4.3 Pre-test and post-test scores for experimental and control groups

Table 4 Output of independent sample t-test of participants before treatment

Groups	n	Mean	SD	F	Sig	T	Df	Mean difference	η^2	Sig two tailed
Control	41	52.9	8.03	16.57	0.00	1.34	79	4	0.01	0.187
Experimental	40	56.9	17.02							

SD = Standard deviation; F = F-statistic; Df = Degree of freedom; η^2 = Eta squared; sig. =significance level sig two tailed = Two-tailed significance; T = T-statistic

Table 4 presents the results of an independent sample t-test conducted to compare the mean pretest biology achievement scores of the control and experimental group participants. The analysis found no statistically significant difference in mean pretest scores between the two groups of participants, t(79) = 1.34, $p > 0.05$ (two-tailed), with the experimental group (M = 56.9, SD = 17.02) and the control group (M = 52.9, SD = 8.03) demonstrated comparable baseline achievement levels. The mean difference of 4.0 had a 95% confidence interval ranging from -1.98 to 9.92, suggesting the observed difference was not statistically meaningful. A small effect size ($\eta^2 = 0.01$) further confirmed minimal practical significance in pretest differences. This suggests that the academic status of learners in both groups was highly comparable before exposure to different teaching methods, aligning with the findings that emphasize the importance of establishing baseline equivalence in educational research (Johnson *et al.*, 2014; Gillies, 2016).

Table 5 Output of independent sample t-test of participants after treatment

Groups	n	Mean	SD	F	Sig	T	Df	Mean difference	η^2	Sig two tailed
Control	41	55.7	15.5	1.95	0.167	6.19	79	19.2	0.33	0.000
Experimental	40	74.9	12.1							

SD = Standard deviation; F = F-statistic; Df = Degree of freedom; η^2 = Eta squared; sig. =significance level sig two tailed = Two-tailed significance; T = T-statistic

Table 5 presents the results of an independent sample t-test comparing the post-test biology achievement scores of the experimental and control groups. The analysis revealed a statistically significant difference in mean scores between the two groups after intervention, t(79) = 6.19, $p < 0.05$ (two-tailed. The experimental group (M = 74.9, SD = 12.1) outperformed the control group

(M = 55.7, SD = 15.5), with a mean difference of 19.2. The 95% confidence interval for this difference ranged from 13.01 to 25.37, confirming the magnitude and direction of the effect. A large effect size ($\eta^2 = 0.33$) was observed, aligning with Cohen's (1988) guidelines for substantial practical significance. These findings suggest that the experimental group, exposed to the Jigsaw cooperative learning model, achieved significantly higher post-test scores in biology compared to the control group.

.This supports the notion that cooperative learning strategies enhance student achievement across various contexts (Yaduvanshi and Singh, 2019; Premo *et al.*, 2018). The finding is consistent with (Yaduvanshi and Singh, 2019) who reported superior performance on the Biology Achievement Test (BAT) among low medium and high achiever students using the cooperative learning method at secondary school level. Specifically, low achievers showed a significant mean increase of 27.67% in knowledge ($p < 0.001$); average achievers demonstrated significant improvements ($p < 0.001$) with increases of 15.77% in knowledge, 25.94% in understanding, and 20.25% in total scores. High achievers also displayed significant improvements ($p < 0.01$) with increases of 15% in knowledge, 15% in understanding, and 16.73% in total scores. In an introductory biology course, Premo *et al.*,(2018) further revealed that CL, structured through interdependence-based tasks, increased collaborative engagement at both individual and whole-class levels. However, Premo *et al.*,(2018) also noted that while collaborative engagement improved, it did not directly lead to higher achievement without additional supportive factors. This suggests that cooperative learning, when designed to encourage interdependence, provides students with more opportunities to engage in discussions, solve problems, generate solutions, contribute ideas, and support each other , leading to a positive treatment effect on student outcomes in biology (Geletu, 2022).

The findings are consistent with local studies. For example, Molla and Muche (2018) reported that students instructed using CL strategies performed better on three consecutive biology posttests (Posttest 1: $F = 25.1$, $p < 0.05$; Posttest 2: $F = 44.2$, $p < 0.05$; Posttest 3: $F = 39.9$, $p < 0.05$) compared to those taught conventionally. Similarly, Denbel (2018) found that CL led to improved secondary school mathematics achievement ($t = 2.285$, $p = 0.027$). Geletu (2022) also found that the implementation of cooperative learning method resulted in students' authentic learning engagement and higher academic achievements in science compared to individualistic lecture method where the differences between the baseline ($t(295) = 8.55$, $P<0.05$ (two-tailed) with the experimental group (MD = 10.6) and the control group (MD = 0.64), mid-line(t(295) = 7.54, P<0.05 (two-tailed) with the experimental grup (MD = 6.18) and the control group (MD =0.28) and end-line (t(295) = 7.98, P<0.05 (two tailed) with experimental group (MD = 7.37) and control group (MD = 1.02) showed significant increase. This effect has been confirmed in broader meta-analyses, which demonstrate that CL benefits extend across age groups and educational contexts (Kyndt *et al.*, 2013). Simesso *et al.* (2024) also found that cooperative learning significantly improved achievement (t(126) = 5.544, p < 0.001) and retention (t(126) = 4.167, p < 0.001) in secondary school chemistry.

Regarding the Jigsaw model, Yoruk (2016) found that the Jigsaw model significantly improved academic achievement in elementary school chemistry lessons, with the experimental group scoring an average of 2.39 points higher than the control group, and a statistically significant difference (p = 0.018 < 0.05). Blajvaz *et al.* (2022) also found that the Jigsaw model significantly improved students' physics achievement in the experimental group (Group E), which increased from a pre-test mean of 74.7 to a post-test mean of 82.0 (Z = 2.41, p = 0.016), while the control group (Group C) showed a non-significant decrease from 64.5 to 60.8 (Z = -1.17, p = 0.242). A meta-analysis by Vives *et al.* (2024) reported that, out of 32 studies conducted on STEM achievement using the Jigsaw cooperative learning model, 19 studies demonstrated a positive effect. Among these, three studies focused on biology, seven on chemistry, five on physics, and four on mathematics. The lower number of positive studies in biology may stem from unique implementation challenges posed by the subject's complex conceptual hierarchies; such as interconnected systems like cellular respiration or neural pathways; where fragmented peer-teaching risks compromising knowledge integration without scaffolding. Our study addressed this through sequenced expert materials that maintained conceptual coherence while leveraging Jigsaw's collaborative benefits. Suendarti and Virgana (2022) discovered that the Jigsaw cooperative learning method contributed 19.6% of the variance in natural science learning achievement (P<.000 among junior high school students in Indonesia, while Rahmawati *et al.* (2022) demonstrated that the Jigsaw cooperative learning model significantly enhanced secondary school students’ chemistry achievement, increasing mastery levels from 73.8% to 98.0% over the study period. Ibrahim *et al.* (2023) also reported that the Jigsaw model improved critical thinking skills in secondary school biology, with the experimental group achieving a higher average N-Gain (65.7) compared to the control group (59.15). Doymus (2008) found that the Jigsaw model is particularly effective in enhancing understanding and retention in science subjects by breaking down complex tasks into manageable segments, with students in the Jigsaw group performing significantly better than those in the non-Jigsaw group ($t(66) = 6.149$, $p < 0.05$). Moreover, Baken *et al.* (2022) found that the Jigsaw cooperative learning model improves learning and retention in observation-based undergraduate vertebrate biology laboratory activities in which students in the experimental Jigsaw sections scored 5.336 percentage points higher than the Control sections on quizzes ($Jigsaw_{Mean}$ = 68.597%, $Control_{Mean}$ = 63.261%). Together, these findings affirm the Jigsaw model's potential to positively impact learner performance across various educational levels.

4.4 Comparison of paired sample t-test achievement scores for experimental and control group participants

Table 6 Output of paired sample t-test of experimental group participants before and after treatment

Groups	n	Achievement score	Mean	SD	T	Df	Mean increase	η²	Sig two tailed
Experimental		Pre-test	56.85	17.02	5.45	39	18	0.43	0.000
	40	Post-test	74.85	12.12					

SD = Standard deviation; Df = Degree of freedom; η^2 = Eta squared; sig two tailed = Two-tailed significance; T = T-statistic

Table 6 presents the results of a paired samples t-test comparing the biology achievement scores of the experimental group before and after the intervention. The analysis revealed a statistically significant increase in mean scores from the pre-test (Time 1: $M = 56.85$, $SD = 17.02$) to the post-test (Time 2: $M = 74.85$, $SD = 12.12$), $t(39) = 5.45$, $p < 0.05$ (two-tailed). The mean improvement of 18 points had a 95% confidence interval ranging from 11.32 to 24.68, confirming the intervention's substantial impact. A large practical effect size ($\eta^2 = 0.43$) was observed, aligning with Cohen's (1988) benchmarks for meaningful educational interventions. These results demonstrate that the Jigsaw cooperative learning model significantly enhanced the experimental group's biology achievement, which aligns with prior research indicating cooperative learning fosters deeper understanding and retention of material (Doymus, 2008; Baken et al., 2022). Similarly, Namusoke and Rukundo (2022) also found that after treatment, cooperative learning had a statistically significant effect on the performance of pupils in the experimental group in an English lesson (Mean difference = −5.07, Cohen's d = −1.84, $p < .001$). Additionally, Chen and Lin (2020) reported a significant improvement in college students' learning outcomes in microeconomics in Taiwan. Their Ordinary Least Squares (OLS) results indicated that being in a cooperative learning group (CLG) had a positive effect on course grade ranking, with a coefficient of ($\beta CLG = 2.599*$ ($p < 0.1$).

Table 7 Output of paired sample t-test of control group participants before and after treatment

Groups	n	Achievement score	Mean	SD	T	Df	Mean increase	η^2	Sig two tailed
Control		Pre-test	52.9	8.04	1.01	40	2.8	0.02	.318
	41	Post-test	55.7	15.54					

SD = Standard deviation; Df = Degree of freedom; η^2 = Eta squared; sig two tailed = Two-tailed significance; T = T-statistic

Table 7 presents the results of a paired samples t-test comparing the pre-test and post-test biology achievement scores of the control group. The analysis revealed no statistically significant improvement in mean scores from the pre-test (M = 52.9, SD = 8.04) to the post-test (M = 55.7, SD = 15.54), $t(40) = 1.01$, $p > 0.05$ (two-tailed). The mean increase of 2.8 points had a 95% confidence interval ranging from -3.23 to 8.83, indicating that the observed difference could plausibly reflect random variation. A small effect size ($\eta^2 = 0.02$), aligning with Cohen's (1988) guidelines, further underscores the limited practical significance of the change. These results suggest that the traditional lecture-based approach did not meaningfully enhance biology achievement in the control group, consistent with prior evidence that non-interactive methods may lack the engagement benefits of cooperative strategies (Freeman et al., 2014).

4.5 Gender-wise Comparison of post-test biology achievement scores for experimental group participants

Table 8 Output of Gender wise Mean posttest achievement Score of experimental group participants

Groups	Gender	N	Mean	SD	T	Df	Mean difference	η^2	Sig two tailed
Experimental	Male	26	75.6	11.9	.53	38	2.2	.008	.593
	Female	14	73.4	12.7					

SD = Standard deviation; Df = Degree of freedom; η^2 = Eta squared; sig two tailed = Two-tailed significance; T = T-statistic

Table 8 presents the results of an independent samples t-test comparing post-test biology achievement scores between male and female participants in the experimental group. The analysis revealed no statistically significant gender-based difference in mean scores, $t(38) = 0.53$, $p > 0.05$ (two-tailed). Male students (M = 75.6, SD = 11.9) and female students (M = 73.4, SD = 12.7) demonstrated comparable performance, with a mean difference of 2.2. The 95% confidence interval for this difference ranged from -6.02 to 10.39, indicating that the observed disparity could plausibly result from random variation. A negligible effect size ($\eta^2 = 0.008$) further supports the absence of meaningful gender-based disparities. These findings suggest that gender did not influence academic achievement in biology when taught via the Jigsaw CL model, aligning with research highlighting cooperative learning's potential to reduce gender gaps in education (Kuchynka et al., 2022; Fasasi & Istifanus, 2022).

The findings align with Yoruk (2016) who reported no gender-based difference in academic achievement within the experiment group ($p=0.986 > 0.05$) using Jigsaw model. Similarly, Geletu (2022) found no statistically significant gender differences in natural science achievement scores $t(29) = 11.23$, $P>0.05$ with males (MD = 12.4) and females (MD = 10.26). Fasasi & Istifanus (2022) also observed no significant difference between male and female students' post-test algebra achievement ($F(1, 75) = 0.07$, $p = 0.94$) using the Jigsaw model. Simesso et al. (2024) also found no gender difference in chemistry achievement and retention, with female students (M = 71.97, SD = 11.63) outperforming males (M = 68.73, SD = 8.96) ($t(62) = -1.243$, $p > 0.001$). Kuchynka *et al.* (2022) synthesized evidence suggesting cooperative learning (CL) reduces gender disparities in STEM by fostering equal participation and countering stereotypes. Bećirović *et al.* (2022) similarly found no gender differences in CL outcomes or motivation influencing EFL achievement among Bosnian high school students.

In this study, the small effect size ($\eta^2 = 0.008$) further supports the gender-inclusive efficacy of the Jigsaw CL model. However, this contrasts with earlier research highlighting gender-specific responses to instructional methods (Hyde, 2005).

4.6 Baseline and post intervention Comparison of Peer Relationship, Academic Support, and Learning Gains.

Table 9 t-test results of peer relationship, academic support and learning gains between the experimental and control group participants before intervention

Factor	Experimental Groups (n=40)		Control Groups (n=41)		95% CI				
	M	S.D	M	SD	LL	UL	Df	T	Sig. (2-tailed)
Peer relationship	**3.70**	**0.92**	**3.37**	**0.98**	**-0.09**	**0.75**	**79**	**1.544**	**0.126**
Academic Support	**3.36**	**1.11**	**3.28**	**0.91**	**-0.36**	**0.53**	**79**	**0.391**	**0.697**
Learning gains	**3.55**	**0.98**	**3.43**	**8.89**	**-0.29**	**0.53**	**79**	**0.556**	**0.580**

M= mean; SD = standard deviation; LL = lower limit; UL = upper limit; Df = degree of freedom; CI = confidence interval; sig. two tailed = two-tailed significance

Table 9 shows the result of the independent samples t-tests comparing the experimental and control group participants on peer-relationships, academic support, and learning gains before the intervention. For peer-relationships, the experimental group had a slightly higher mean score (M= 3.7) than the control group (M = 3.37), but the difference was not statistically significant ($t(79) = 1.544$, $p = 0.126$). Similarly, the mean difference in academic support between the experimental (M = 3.36) and control (M = 3.28) groups was small and not significant ($t(79) = 0.391$, $p = 0.697$). In terms of learning gains, no significance difference was observed between the experimental (M = 3.55) and control (M = 3.43) groups ($t(79) = 0.556$, $p = 0.580$). These suggest that, there were no baseline differences in the measured variables between the experimental and control groups before the intervention, reinforcing the importance of establishing comparable starting points for effective educational interventions (Slavin, 1996).

Table 10 t-test results of peer relationship, academic support and learning gains between the experimental and control group participants after intervention

Factor	Experimental Groups (n=40)		Control Groups (n=41)		95% CI				
	M	S.D	M	SD	LL	UL	Df	T	Sig. (2-tailed)
Peer relationship	**4.58**	**0.368**	**3.20**	**0.488**	**1.188**	**1.571**	**79**	**14.334**	**0.000**
Academic Support	**4.35**	**0.476**	**3.06**	**0.844**	**0.978**	**1.587**	**79**	**8.395**	**0.000**
Learning gains	**4.25**	**0.512**	**3.09**	**0.585**	**0.913**	**1.400**	**79**	**9.463**	**0.000**

M= mean; SD = standard deviation; LL = lower limit; UL = upper limit; Df = degree of freedom; CI = confidence interval; sig. two tailed = two-tailed significance

An independent sample t-test was conducted for the total sample (n = 81) as a preliminary analysis. As shown in Table 10, inspection of the two group means indicates that the average peer relationship score for the experimental group learners (4.58) is significantly higher than the control group learners' score of (3.20). The average academic support score for experimental group learners (4.35) is also significantly higher than the control group learners' score of (3.06); and the average learning gain score for experimental group learners (4.25) is significantly higher than the control group learners' score of (3.09).

Specifically, experimental group learners demonstrated a significant statistical difference from control group learners on the peer relationship score ($t(79) = 14.334$, $p < 0.05$), academic support score ($t(79) = 8.395$, $p < 0.05$), and learning gains score ($t(79) = 9.463$, $p < 0.05$) (Table 10). To conclude, learners in the intervention group scored higher than the control group learners on the three measured constructs. This finding aligns with previous research demonstrating the efficacy of interventions, such as cooperative learning environments, in enhancing student outcomes (Springer *et al.*, 1999). Moreover, the results are consistent with Van Ryzin and Roseth (2019) who reported cooperative learning have a direct effect on peer relatedness, academic support, and engagement in learning among students of color in USA. They noted that all outcomes were fit in a single statistical model, which demonstrated adequate fit, X^2 (57) = 116.51, $p < .001$;

CFI .99; TLI .99; RMSEA .024 (90% C.I.: .017-.030). Additionally, Železnik Mežan *et al.*, (2023) found that cooperative learning significantly affects peer relationships among experimental and control group students in athletics training.

4.7 Between-Subjects Effects of Pedagogical Intervention on Peer Relationship, Academic Support, and Learning Gains

Table 11 Summary results of the between subjects effects of the dependent measures between the intervention and control groups for the total sample

IV	DV	Type III sum of squares	Df	Mean square	F	Sig	Partial η2
Design	**Peer relationship**	**38.560**	**(1,79)**	**38.560**	**205.467**	**0.000**	**0.722**
	Academic support	**33.324**	**(1,79)**	**33.324**	**70.48**	**0.000**	**0.471**
	Overall learning gains	**27.124**	**(1,79)**	**27.124**	**89.549**	**0.000**	**0.531**

IV = independent variable; DV = dependent variable; Df =degree of freedom; sig = significance; η2 = eta squared

The MANOVA revealed a significant multivariate main effect for pedagogic condition: Pillai's Trace = 0.838, F(3, 77) = 132.614, P<0.05, partial eta squared = 0.838. Power to detect the effect was 1. Following the significance of the overall MANOVA test, the univariate main effect was examined. The result revealed that the effect is significant for peer relationship, F(1, 79) = 205.467, P<0.05, partial eta square = 0.722, power = 1, academic support, F (1, 79) = 70.408, P<0.05, partial eta square = 0.471, power = 1, and overall learning gains, F(1, 79) = 89.549, P<0.05, partial eta square = 0.531, power = 1 (Table 11). Taken together, the t-tests and MANOVA results suggest that differences in pedagogical conditions influenced instructional processes and learning outcomes. Specifically, the results suggest that learners in the intervention group developed more peer relationships; more academic support, and developed more learning gains in the biology lesson compared to the control group learners, reflecting findings in literature that highlight how different pedagogical approaches can significantly impact student engagement and achievement (Hattie, 2008). This finding is consistent with (Tadesse *et al.*, 2020), who reported that participation in informal cooperative learning pedagogy has a low to medium effect on teaching effectiveness, task orientation, and overall learning satisfaction (0.031≤ partial η2 ≤ .04or 0.36 ≤ Cohen's d ≥ 0.45) in undergraduate classrooms.

4.8 Correlations between Peer Relationship, Academic Support, and Overall Learning Gains

Table 12 Relationships between Peer relationship, academic support and overall learning gain scores

Correlations				
		Peer relationship	Academic Support	Overall learning gains
Peer relationship	**Pearson Correlation**	**1**	**.558****	**.552****
	Sig. (2-tailed)		**.000**	**.000**
	n	**81**	**81**	**81**
Academic Support	**Pearson Correlation**	**.558****	**1**	**.604****
	Sig. (2-tailed)	**.000**		**.000**
	N	**81**	**81**	**81**
Overall learning gain	**Pearson Correlation**	**.552****	**.604****	**1**
	Sig. (2-tailed)	**.000**	**.000**	
	N	**81**	**81**	**81**
**. Correlation is significant at the 0.01 level (2-tailed).				

Sig. (2-tailed = two tailed significance

As shown in the table above, the correlation analysis revealed strong positive associations among peer relationships, academic support, and overall learning gains. Specifically, the correlation coefficients were as follows: Peer relationship and academic support (r = 0.558, P<0.05), Peer relationship and overall learning gain (r = 0.552, P<0.05), academic support and overall learning gain (r = 0.604, P<0.05) (Table 12). These results show that both peer relationships and academic support contributed to learners' overall learning gains in biology positively. This aligns with previous research highlighting the role of peer interaction in fostering academic success (Wentzel, 1998; Tenenbaum *et al.,* 2020). The self-system model of motivational development further underscores the significance of social contexts, such as peer relationships, in shaping students' motivation and engagement in learning activities, demonstrating peer relationships significantly influence learning motivation (β = 0.534, $p < 0.001$) and learning engagement (β = 0.183, $p < 0.001$), both of which mediate the relationship between peer interactions and academic achievement (Shao *et al.*, 2024). Furthermore, Zhu *et al.*, (2025) found that perceived peer support directly affects academic adjustment (β = 0.41, $p < 0.001$) and operates through chain mediating effects of academic hope (β = 0.50, $p < 0.001$) and professional identity (β = 0.29, $p < 0.001$). This evidence suggests that fostering supportive peer relationships not only enhances students' motivation but also improves their engagement in learning.

In summary, the strong correlations observed in this study reflect the integral role of peer relationships and academic support in promoting overall learning gains. These findings advocate for educational strategies that cultivate positive peer interactions and enhance academic support systems to foster student motivation and engagement, ultimately contributing to better educational outcomes.

4.9 Multiple linear Regression Analysis of Peer Relationship and Academic Support on Overall Learning Gains in Biology for Intervention Group

Table 13 multiple linear regression analysis with dependent variable overall learning gains in biology and independent variables peer relationship and academic support for intervention group.

Overall learning gain						
Multiple R = .657					**R^2 = .432**	
ANOVA Table						
	Sum of Squares	Df	Mean Square	F	P	
Regression	22.039	2	11.02	29.625	.000	
Residual	29.014	78	.372			
Total	51.053	80				
Variables in the Equation						
Variables	R	B	Std. Error	β	T	P
Peer relationship	.552	.305	.101	.312	3.032	.003
Academic support	.604	.365	.087	.430	4.179	.000

R^2 = Coefficient of determination; Df = Degree of freedom; F = F-statistics; P = significance level; β = Unstandardized regression coefficient; R = correlation coefficient

As shown in the regression table above, the F value indicates that the multiple correlations R were significant ($P<0.05$). The contribution of both peer relationships, and academic support significantly affected the overall learning gains of learners in biology. The t value also indicates that the contribution of each variables, peer relationship, and academic support, significantly affected the overall learning gains of learners in biology lesson. From the regression table above, since $R^2 = 0.432$ for overall learning gains in biology, the two variables, peer relationship and academic support, had a 43.2% effect or contribution on the overall learning gain in the biology lesson (Table 13). The percentage of effect or contribution of each component, peer relationship, and academic support on overall learning gains in biology can be found by ($R^2 = \beta PRS \times rPRS + \beta AS \times rAS$) X 100 (i.e., 43.2% = 17.22% + 25.97%). Therefore, the contribution of peer relationships enhanced the overall learning gains in biology by 17.22%, and the contribution of academic support enhanced the overall learning gain scores in biology by 25.97%. This finding underscores the importance of peer interaction and support in educational settings, consistent with literature that emphasizes the role of peer relationships in shaping student outcomes (Deci and Ryan, 2008). These findings are consistent with Shen and French (2024), who found that peer selection and influence significantly affect academic achievement among Chinese adolescents. Their study reported that students prefer friendships with similarly achieving peers, which contributes positively to their academic outcomes. Specifically, their results indicated that peer relationships significantly influence learning motivation ($\beta = 0.534$, $p < 0.001$) and learning engagement ($\beta = 0.183$, $p < 0.001$). Additionally, Bankole Adeyemi (2019) highlighted that peer groups significantly influence academic performance among undergraduate students, revealing a significant relationship between peer group interactions and academic success ($r = 0.537$, $p < 0.05$). This emphasizes that students in supportive peer environments tend to perform better academically.

4.10 Students and teacher reflection on cooperative learning: Opportunities challenges and recommendations

Data from interviews, classroom observations, and document analysis were synthesized to provide a comprehensive understanding of the biology teacher's and students' experiences with the jigsaw cooperative learning model. The findings highlight the teacher's and students' lived experiences, as well as the challenges and opportunities encountered. Additionally, adaptive strategies, and observed outcomes are presented, providing a comprehensive understanding of the implementation and impact of cooperative learning in the classroom.

4.10.1 Students reflection on cooperative learning

In this study, the students' interview transcripts were organized into four major themes: 1) general perception of cooperative learning experience, 2) strengths of Jigsaw cooperative learning model recognized by participants, 3) factors affecting effective implementation of the model and 4) overall comments and suggestions regarding Jigsaw cooperative learning lesson.

A) General perception of CL Experience

The majority of participants viewed the Jigsaw cooperative learning model positively. For instance, Participant 2 remarked,

> "At first, I am a bit skeptical about the jigsaw cooperative learning model, but as we progress, I realize how much I benefit from working with my peers. It helps me understand the material better."

Another participant expressed happiness, and stated,

> "I find the Jigsaw cooperative learning experience to be really engaging. It differ from traditional lessons and makes me feel more involved in my learning" (P1).

Another female participant shared her enjoyment, saying,

> "I really enjoy the Jigsaw cooperative learning model. It makes learning feel less intimidating because I have support from my classmates, and I feel more confident in my abilities" (P3).

These statements were supported by classroom observations, which revealed that most students were actively participating in discussions, collaborating with their peers, and demonstrating enthusiasm in their learning. The environment appeared interactive, with students helping each other and engaging more than in traditional lesson. This aligns with existing literature indicating that cooperative learning fosters active participation and social interaction among students, leading to improved academic outcomes (Johnson and Johnson, 1978; Slavin, 2014). Their body language and expressions indicated a sense of involvement and confidence, reinforcing the idea that Jigsaw cooperative learning model positively influenced their engagement and understandings.

B) Strengths of cooperative learning

The majority of the learners recognized various strengths of cooperative learning. For example, Participant 6 mentioned, "What stands out to me is how Jigsaw cooperative learning model helps me build relationships with my peers. I feel like I get to know my classmates better, and it makes the learning experience more enjoyable."

Student 5 highlighted strength by stating,

"One strength I notice is how the Jigsaw cooperative learning model allows us to learn from each other. We all have different perspectives and skills, so we can help each other."

Additionally, Participant 4 noted,

"I think one of the strengths of Jigsaw cooperative learning model is that it promotes cooperation and teamwork. We have to communicate and work together to solve problems, which I believe is an important skill for the future." These insights are consistent with the literature, emphasizing the importance of positive interdependence among students and how cooperative learning enhances both academic and social skills (Slavin, 2014).

C) Factors affecting effective implementation of cooperative learning

The interviewed participants highlighted several key factors that affected the effective implementation of cooperative learning in the classroom.

Participant 9 noted,

"I notice that in some lower classes, the lecture method was still being used extensively. This made it difficult to transition smoothly to the Jigsaw cooperative learning model, as some students were not accustomed to this approach. It created a disconnect in the learning process."

Observations also revealed that students' unfamiliarity with cooperative learning made it difficult to effectively implement it. When students were ordered to discuss in groups, they were playing with each other rather than discussing the issue raised. These challenges echo with findings of Miles and Stipek (2006) who reported students may struggle with collaborative strategies due to this lack of familiarity.

Participant 7 responded that one factor that affected the effectiveness of the Jigsaw cooperative learning model for him was the shortage of textbooks. He added that it was challenging to access the necessary resources, which hindered students' ability to fully engage with the material (P7).

"I felt that the length of the period was a significant factor. Sometimes, there wasn't enough time to complete the Jigsaw cooperative learning activities thoroughly. We ended up feeling rushed, which impacted our learning experience, " expressed participant 8. This aligns with Topping (2005), indicating that inadequate time allocation can hinder the depth of cooperative learning activities.

The observations also confirmed the challenges mentioned by the participants. Sometimes, the period ended before some group reported their feedbacks to the given tasks.

"I believe there is a lack of alignment between the cooperative learning methodology and the political ideologies promotes within the school. This discrepancy creates tension and resistance among some students, affecting the implementation of cooperative learning," remarked participant 10.

Similarly, participant 11 stated,

"I observed a significant barrier to effective implementation of cooperative learning, which was the lack of interest among the majority of teachers. It seemed like many teachers were reluctant to embrace cooperative learning method and preferred traditional teaching approaches. This lack of interest from teachers made it challenging to fully integrate cooperative learning into our lessons and limited our opportunities for collaborative learning experiences."

Furthermore, participant 12 said,

"Another challenge we face in implementing cooperative learning is theunsuitable classroom setup. The arrangement of chairs and desks is not conducive to conducting cooperative learning activities effectively. It is difficult for groups to cooperate comfortably, and the layout often hinders communication among peers. This inconvenience in the classroom setup poses a significant obstacle to the smooth execution of cooperative learning tasks." This observation is consistent with findings by Marzano *et al.* (2001) and Keramati and Gillies (2022), which emphasize how environmental factors influence cooperative learning outcomes.

According to participant 13,

"An issue we encounter during cooperative learning sessions is the insufficient knowledge of the subject matter among some students. This lack of understanding often leads to confusion and wastes our class time as we have to spend extra time explaining concepts to those who are struggling. It disrupts the flow of our cooperative learning activities and hinders our progress. Addressing this gap becomes a significant challenge in effectively implementing cooperative learning in our classroom." The observer witnessed that low knowledge subject matter among some students was a major obstacle to discuss among the groups.

D) Overall Comments and Suggestions Regarding Cooperative Learning Lessons

Participant 16 suggests that students need to be introduced to cooperative learning pedagogies earlier in their educational journey. Providing orientation sessions or workshops on cooperative learning strategies at the beginning of the school year can familiarize students with the concepts and methodologies. This early exposure can better prepare them to actively participate in cooperative learning activities and maximize their learning potential. These suggestions align with recommendations from the literature. For instance, introducing cooperative learning early in students' educational journey has been shown to enhance their readiness and receptiveness to cooperative learning methods (Tadesse and Gillies, 2015).

Another suggestion is to embed cooperative learning activities in textbooks.

"By integrating these activities into the curricula materials, students can easily access and engage with cooperative learning tasks during their regular study sessions. This ensures continuity and consistency in cooperative learning implementation across different subjects and topics (P15)".This suggestion aligns with Johnson *et al.*, (2014) who noted that integrating cooperative learning activities into textbooks can facilitate seamless integration into regular classroom practices.

Furthermore, participant 14 suggests that it is important to provide more opportunities for engagement, especially for medium and low-ability students and silent listeners. Instead of relying solely on teacher-led instruction, incorporating cooperative learning activities allows these students to actively participate and contribute to the learning process. This fosters a more inclusive and cooperative classroom environment. The emphasis on providing inclusive opportunities for engagement resonates with research highlighting the importance of catering to diverse student needs and promoting equitable participation in cooperative learning (Webb, 2009; R. M. Gillies, 2016).

4.10.2 Teacher reflection on cooperative learning

A) Positive impact of the Jigsaw cooperative learning model

i) Student engagement and understandings of the lesson segments

The teacher reported a noticeable increase in student enthusiasm and participation throughout the 16-weeks intervention. Document analysis of 24 lesson plans revealed strong cooperative learning integration, with clear evidence of CL objectives and structured group activities aligning with the Jigsaw model (Appendix-J). Classroom observations over 16 sessions confirmed high levels of active student engagement, discussion, peer explanation, and task completion (Appendix-I).

The teacher noted:

> "My students became more active in the learning process. Some of the quieter students, who normally wouldn't speak up during class discussions, seemed more comfortable sharing their thoughts in smaller group settings." This aligns with social interdependence theory (Johnson & Johnson, 2009), which posits that structured group roles enhance engagement by creating accountability. The findings also corroborate Muraya and Kimamo (2011) and Molla and Muche (2018), who linked cooperative learning (CL) to improved participation in biology. The success of Jigsaw here underscores its utility in democratizing classroom participation, particularly in cultures where hierarchical teacher-student dynamics may suppress student voices.

ii) Achievement of course objectives

The teacher expressed satisfaction… emphasizing that cooperative learning facilitated the integration of key elements... Document analysis indicated that lesson plans explicitly incorporated elements of interdependence and individual accountability (Annex A, Table A.2, Items 1, 3, 6). Classroom observations and performance evaluations further confirmed improved student cooperation and academic performance, reflected in metrics like group reflection, individual accountability, and collective accountability tasks (Annex A, Table A.1).

The teacher stated:

> "The Jigsaw model increased students' motivation to raise questions and engage in discussions without fear, allowing ideas to flow from different directions, unlike the one directional lecture method."

These outcomes reflect Vygotsky's zone of proximal development (1978), where peer cooperation bridges knowledge gaps. The teacher's emphasis on structured tasks aligns with Slavin's (1996) argument that CL efficacy hinges on clear roles and accountability.

iii) Increased preparation and teacher engagement

The teacher acknowledged that implementing Jigsaw cooperative learning model required additional preparation but viewed it as an opportunity for professional growth.

The teacher explained:

> "Preparing Jigsaw lessons took more time than traditional ones. I had to carefully plan each lesson, group students by their abilities, and monitor group work."

Despite the extra effort the teacher found that Jigsaw cooperative learning model significantly enhanced students' leadership, problem-solving, and communication skills, ultimately enriching their learning experiences.

This mirrors Guskey's (2002) findings that pedagogical innovation often demands upfront effort but yields long-term instructional rewards.

B) Challenges in implementing cooperative learning

i) Large class size

A key challenge identified was managing large class sizes with over 40 students per class. The teacher struggled to keep all groups on task and provide individualized attention.

The teacher marked:

> "The large number of students made it hard to move around the classroom and monitor each group." This echoes Keramati & Gillies (2022), who identified class size as a critical barrier in low-resource settings.

ii) Student reluctance and resistance

Some students were hesitant to fully participate in Jigsaw cooperative learning activates, preferring individual work instead. Classroom observations confirmed that certain students disengaged from group discussions.

The teacher noted:

> "There were a few students who weren't as involved in the group discussion. They either didn't want to rely on others or thought they could learn better on their own." This aligns with findings by Gillies (2023), who indicated that student reluctance to engage in CL is a significant barrier that can affect the success of group interactions.

iii) Mismatch between policy and practice

Although Ethiopian education policies emphasize cooperative learning, traditional lecture based methods remain the norm in most classrooms. Biology textbooks are designed to support active learning strategies, yet many teachers continue using conventional teaching approaches.

The teacher observed:

> "While the government clearly outlines the importance of cooperative learning in policy documents and align the text books with these learner centered methods, most teachers still prefer traditional lecture based instruction."

This gap between policy and practice reflects systematic challenges in implementing cooperative learning effectively. This systemic gap reflects Fullan's (2016)theory of implementation failure, where top-down mandates lack grassroots support.

C) Opportunities and benefits of cooperative learning

Despite the initial challenges, the teacher noted that cooperative learning particularly the Jigsaw model provided meaningful opportunities for students to enhance their critical thinking and take ownership of their learning. Classroom observations revealed that students in the "expert groups" developed a strong grasp of their assigned topics and effectively taught their peers, indicating not only comprehension but also the ability synthesize and convey information. Performance evaluations revealed improved outcomes in both group and individual assessments, reflecting the depth of understanding achieved through peer cooperation.

The teacher marked:

> "By the end of the intervention, students were able to teach their peers. They were not only learning the content but also developing teamwork and communication skills."

Document analysis validated these findings, showing that lesson plans integrated structured group teaching sequences, allowing students to function as both learners and teachers, thereby fulfilling key cooperative learning outcomes.

D) Teacher’s recommendations for adaptive strategies in future implementation

i) Modifying group composition and lesson pacing

To effectively implement Jigsaw cooperative learning model in diverse classroom settings the teacher recommended adjusting group compositions based on students’ strengths and weakness in different Jigsaw segments. Additionally, lesson pacing should remain flexible, allowing extra time for students who struggle with certain concepts.

The teacher suggested:

> “Teachers should be flexible in grouping students and pacing lessons to ensure every one participates and learns effectively.” This flexibility in grouping and pacing was critical for the successful implementation of cooperative learning, particularly in resource-limited settings (Slavin R E, 1996).

ii) Integrating traditional teaching methods

For complex topics, the teacher recommended combining traditional instructional methods with cooperative learning to enhance content understanding. Direct instruction should be used before transiting to group activities, particularly for topics requiring foundational knowledge, such as microscopy and cell identification.

The teacher advised:

> “For difficult concepts, it is helpful to explain them through direct instruction before allowing students to work together.” This strategic combination of approaches helped address time constraints and content complexity, reflecting a balanced teaching method (Prince, 2004).

Consequently, this study stands out as the first to conceptually and methodologically examine the effectiveness of Jigsaw cooperative learning model in its specific context. While the findings align and differ from those of other national and international studies, the unique contribution of this research lies in its application to Ethiopian secondary schools, where large class sizes, limited resources, and perceptions of cooperative learning as politically driven present significant challenges. Prior studies such as Slavin (2015) emphasize that cooperative learning models need adaptations to local educational challenges to maximize effectiveness. By adapting the Jigsaw model to these circumstances, the study demonstrates the model's versatility and effectiveness in addressing educational barriers. These insights provide valuable guidance for educators and policymakers in other developing nations, showing how cooperative learning can be successfully implemented in resource-constrained environments.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The major findings of this study are summarized in this chapter in light of the research questions that were raised. This chapter therefore, comprises three sections: (1) summary of major findings, (2) conclusions, (3) recommendations and implications.

5.1 Summary

Despite Ethiopian education policies (FDRE 1994, 2023; MOE 2018) mandating student-centered cooperative learning to develop critical thinking and collaboration skills, its effective implementation in secondary biology education remains limited. Teachers continue to rely primarily on traditional lectures due to resistance to change, insufficient training, large class sizes, and resource constraints; often overlooking core cooperative elements like structured peer interdependence. While international evidence supports models like Jigsaw for improving science outcomes, rigorous research in Ethiopian contexts, particularly resource-constrained zones like Gedeo, is still limoted. Prior local studies lack comprehensive analysis of Jigsaw's impact on academic achievement, peer relationships, academic support, and holistic learning gains, leaving critical gaps in understanding implementation barriers and social-academic linkages. Without addressing this, passive learning approaches persist, hindering biology students' critical skills and academic performance. Consequently, this study aimed to evaluate the effectiveness of the Jigsaw cooperative learning model on overall learning gains in secondary school biology education in Gedeo Zone, South Ethiopia.

It addressed six research questions:

1. To what extent does the Jigsaw cooperative learning model improve students' biology achievement compared to the traditional lecture approach?
2. Is there a statistically significant gender difference in biology achievement among students exposed to the Jigsaw cooperative learning model?
3. To what extent does the Jigsaw cooperative learning model improve students' peer relationships, academic support, and overall learning gains in biology?
4. What is the nature of the relationship among peer relationships, academic support, and overall learning gains in biology for students exposed to the Jigsaw cooperative learning model?

5. To what extent can overall learning gains in biology be predicted by the combined influence of peer relationships and academic support?
6. What are the perceived practices related to the implementation of the Jigsaw cooperative learning model in secondary school classrooms, from the perspectives of students and .teachers?

A convergent parallel mixed-methods approach was employed, using a quasi-experimental, non-equivalent control group pre-test/post-test design. The study involved 81 Grade 9 students from two government secondary schools in Gedeo Zone, selected through simple random sampling of schools (Namusoke & Rukundo, 2022). Schools (not individual students) were randomly assigned: Kofe Secondary School (n=41 control group) and Dilla Comprehensive Secondary School (n=40 experimental group), preserving intact classroom structures while minimizing selection bias. Biology achievement tests, a student engagement questionnaire, interviews, observations, and document analysis were used for data collection. Quantitative data were analyzed using descriptive and inferential statistics, while qualitative data were analyzed thematically. Key findings addressing each research question reveal: (1) The Jigsaw model significantly improved biology achievement compared to traditional lectures, with the experimental group ($M = 74.9$) outperforming the control group ($M = 55.7$) by 19.2 points ($t(79) = 6.19$, $p < 0.05$, $\eta^2 = 0.33$), despite equivalent pretest scores ($p > 0.05$). Within-group gains were substantial for Jigsaw learners (mean difference = 18.0, $t(39) = 5.45$, $p < 0.05$) but negligible for controls (mean difference = 2.8, $p > 0.05$); (2) No statistically significant gender difference emerged among Jigsaw participants, with males ($M = 75.6$) and females ($M = 73.4$) performing comparably ($t(38) = 0.53$, $p > 0.05$); (3) Jigsaw significantly enhanced peer relationships (experimental $M = 4.58$ vs. control $M = 3.20$, $t(79) = 14.33$, $p < 0.05$), academic support (4.35 vs. 3.06, $t(79) = 8.40$, $p < 0.05$), and learning gains (4.25 vs. 3.09, $t(79) = 9.46$, $p < 0.05$), confirmed by MANOVA (Pillai’s Trace = 0.838, $F(3,77) = 132.61$, $p < 0.05$); (4) Strong positive correlations were found among peer relationships, academic support, and learning gains (r = 0.558–0.604, all $p < 0.05$); (5) Peer relationships and academic support jointly predicted 43.2% of the variance in learning gains ($R^2 = 0.432$, $p < 0.05$), with academic support (25.97%) contributing more than peer relationships (17.22%); and (6) Implementation was perceived to enhance engagement and collaboration but faced challenges including student unfamiliarity with cooperative learning, resource limitations, and teacher resistance to departing from traditional methods. These findings confirm Jigsaw's potential to transform biology education in resource-constrained contexts, though addressing contextual barriers is essential for its sustainable adoption.

5.2 Conclusion

This study establishes the Jigsaw cooperative learning model as a transformative pedagogical approach for secondary biology education in Ethiopia's Gedeo Zone. While quantitative results confirm its significant advantage over traditional methods in academic achievement (M = 74.9 vs. 55.7) and gender-equitable outcomes (male M = 75.6; female M = 73.4), the deeper implication lies in its capacity to reconfigure learning dynamics through peer-driven knowledge construction. The robust interdependence between peer relationships, academic support, and learning gains ($R^2 = 0.432$) demonstrates that Jigsaw's efficacy extends beyond test scores. It fosters social scaffolding and collective accountability, which are fundamental shifts in how students engage with biology.

Critically, however, qualitative data reveal that these benefits are contingent upon contextual adaptation. Structured group roles mitigated initial student unfamiliarity, yet persistent barriers such as teacher resistance, resource constraints, and cultural acclimation to student-centered pedagogy threaten scalability. This underscores that Jigsaw's potential as an equitable strategy in resource-limited settings necessitates systemic support, including policy-driven teacher training and infrastructure investment.

Future research should investigate longitudinal impacts on higher-order thinking skills and context-specific scaling models. Ultimately, this work affirms that sustainable pedagogical innovation in underserved regions demands a simultaneous reimagining of teaching practices and educational ecosystems

5.3 Recommendations and implications

The following recommendations are derived directly from the major findings of the study to address identified challenges and leverage opportunities for improving the implementation of the Jigsaw model in Gedeo zone secondary schools:

- District education offices should design targeted training programs for biology teachers, focusing on scaffolding peer interactions (e.g., role assignment, discussion prompts) and addressing resistance through hands-on workshops. Training should emphasize adapting Jigsaw to local resource constraints, such as using low-cost materials for group activities.
- Schools should implement pre-intervention orientation sections to familiarize students with jigsaw roles, cooperation expectations, and conflict resolution strategies. Peer mentoring initiatives could reinforce mutual accountability, aligning with the study's observed link between peer relationships and learning gains.
- School administrators should revise timetables to allocate dedicated time for jigsaw activities and provide materials (e.g., simplified topic guides, role cards) to reduce reliance on textbooks. Regional education bureaus could prioritize funding on classroom tools that support small-group work.
- Curriculum developers at the regional level should integrate jigsaw specific lesson plans in to biology syllabi, particularly for topics where peer explanation enhances conceptual understanding (e.g., complex process like photosynthesis).
- School leaders should establish peer observation networks where teachers cooperatively refine jigsaw implementation. Regular feedback sessions, informed by the study's successful practices (e.g., structured roles, incremental scaffoldings), can build confidence in the model.
- Researchers should partner with local schools to pilot jigsaw in other subjects (e.g., chemistry), while controlling contextual factors like class size and resource availability, ensuring feasibility before broader adoption. .

Synthesizing empirical findings into an integrated Jigsaw Implementation Framework (JIF) to advance pedagogical practices in secondary biology education. Grounded in quantitative and qualitative evidence, the framework comprises four interdependent dimensions. First, pedagogical capacity development addresses teacher resistance through policy-aligned training modules (FDRE 2023), emphasizing cooperative learning principles and positive interdependence techniques. Second, structured student scaffolding counters initial unfamiliarity, evidenced by baseline peer relationship deficits (M = 3.7), through sequenced role-rotation protocols. Third, social-academic enhancement mechanisms leverage the significant mediation of peer relationships ($r = 0.552$) and academic support ($r = 0.604$) in driving learning gains ($R^2 = 0.432$), operationalized through benchmarked assessments aligned with the study's pre-post measurement protocol. Fourth, equity integration embeds gender-inclusive practices validated by statistically comparable achievement outcomes (male M = 75.6 vs. female M = 73.4; $\eta^2 = 0.008$). Implementation progresses through clearly defined phases: preparation (stakeholder orientation), execution (Jigsaw cycles), and consolidation (outcome review) - mirroring the study's pre-post assessment design. The framework's efficacy is validated by multivariate effects (Pillai’s Trace = 0.838, $F(3,77) = 132.61$, $p < 0.05$), with all social and achievement variables measured through pre-intervention and post-intervention instruments: questionnaires for peer relationships, academic support, and learning gains; researcher-developed achievement tests for academic performance (Figure 5)

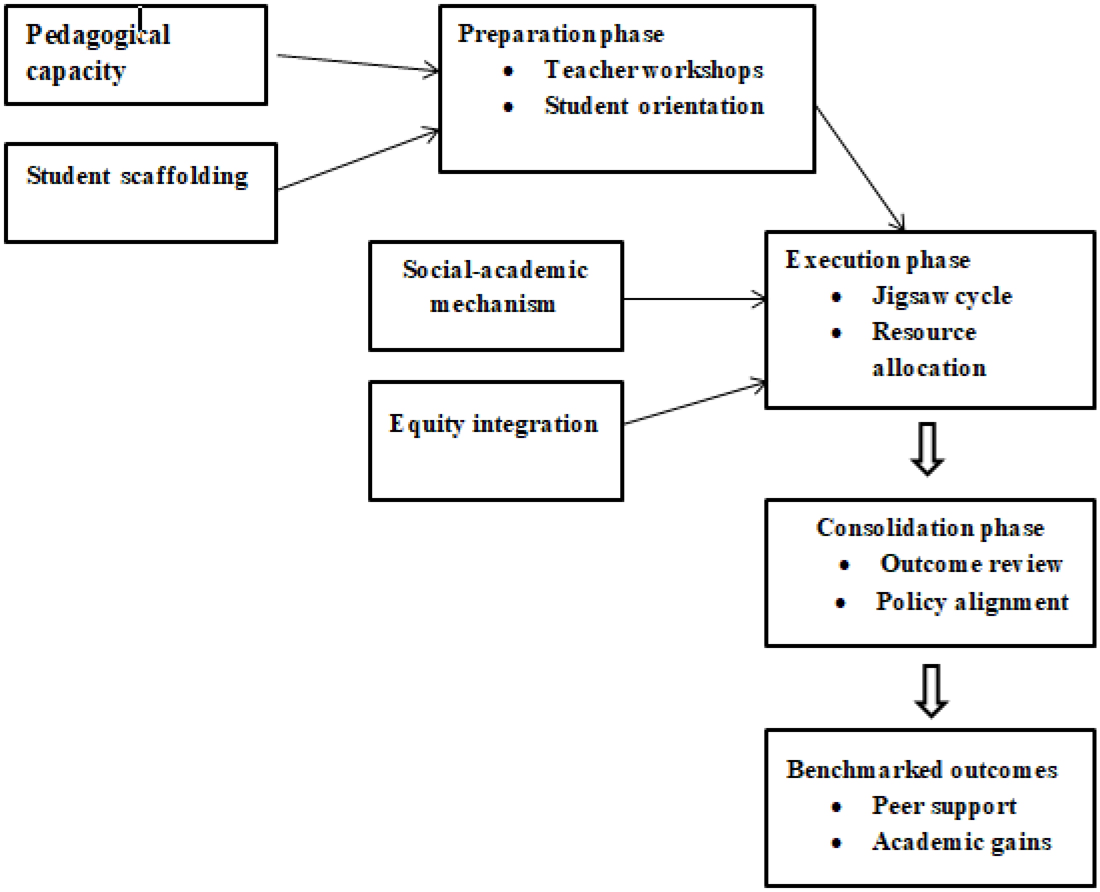

Figure 6 Evidence Informed jigsaw implementation framework

Theoretically, this study is rooted in social interdependence theory, which stresses the significance of positive interdependence in promoting effective learning and improving academic outcomes (Johnson and Johnson, 2009). The Jigsaw model exemplifies these principles by fostering a structured interdependence where each student's contribution is critical to the success of the group (Aronson, 2002). The findings of this study ensured the understanding of how interdependence can drive both academic achievement and social development, particularly within the study context. Specifically, students who experienced cooperative learning showed improved peer relationships and academic support, both of which positively influenced overall learning gains. This reinforces the relevance and applicability of social interdependence theory across diverse educational settings, supporting its role in shaping instructional strategies that can lead to better student outcomes (Kagan, S., and Kagan, 1994).

Practically, this study offers practical insights for Ethiopia's educational system, particularly in addressing challenges in biology education through the Jigsaw cooperative learning model. The findings demonstrate that Jigsaw enhances academic achievement, strengthens peer relationships, and fosters equitable learning outcomes across genders, making it a viable strategy for resource-constrained settings like Gedeo Zone. For policymakers, integrating Jigsaw into national educational frameworks, such as the Education Sector Development Plan, can operationalize learner-centered pedagogy, provided targeted funding is allocated for teacher training and low-cost classroom resources. Teachers can adopt scaffolded peer interactions to address students' initial unfamiliarity with cooperative learning, while peer mentoring programs can reinforce academic support, a key driver of learning gains. Curriculum developers should prioritize redesigning biology units to include Jigsaw activities for complex topics, capitalizing on its success in facilitating peer-led conceptual understanding. School leaders play a critical role in monitoring peer relationships and academic support, ensuring alignment with the study's predictors of success. By grounding strategies in empirical evidence and contextual realities, Ethiopia can advance equitable, cooperative learning reforms that align with global pedagogical innovations while addressing local challenges.

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APPENDIX-A: Instrument for assessing academic achivement

Hawassa University

College of Natural and computational Science

Department of Biology

Biology Achievement test for grade 9 students

The main objective of this test is to gather data with regards to grade 9 students' biology achievement in the school. The items are from Grade 9 introduction to Biology, characteristics and classification of organisms and Cell biology topics. Your correct and complete answer to the following questions will have great value for this study. Therefore, you are kindly requested to answer all the questions after reading thoroughly.

Direction: 1. Don't write your name

2. Make a circle on your response

3. Respond all questions

Section 1: Background information

1.1 Name of school______________

1.2 Student's Code__________________

1.3 Sex____________________

1.4 Grade and Section_______________

Section 2: Test items

Instructions: This test consists of 40 multiple choice questions from grade 9 introduction to Biology, characteristics and classification of organisms and Cell biology topics. Choose the best answer and circle your letter of choice. .

1. Which of the following alternatives is consistent with the accepted sequence of a scientific process?
   A. Data from experiment, hypothesis, theory, law
   B. hypothesis, theory, data from experiment, law
   C. hypothesis, data from experiment, theory, law
   D. theory, law, hypothesis, data from experiment
2. Which of the following structures occupies the center of a mature plant cell?
   A. Cytoplasm C. Central vacuole
   B. Nucleus D. Plastids

3. Which of the following terms refers to all the cellular processes of breaking down and building up of molecules?
   A. Catabolism C. Metabolism
   B. Anabolism D. Hydrolysis
4. Which of the following organelles are absent in higher plant cells?
   A. Plastids C. Ribosomes
   B. Centrioles D. Mitochondria
5. Which cellular structure is responsible for autolysis or self-destruction?
   A. Chromosomes C. Lysosomes
   B. Ribosomes D. Golgi apparatus
6. Which one of the following unicellular organisms is prokaryote?
   A. Amoeba C. Euglena
   B. Bacteria D. Paramecium
7. To which of the following properties of life does the term irritability refer?
   A. Excretion C. Homeostasis
   B. Response to stimulus D. Metabolism
8. From which of the following do scientists usually formulates a hypothesis?
   A. Observation C. Theory
   B. Prediction D. Experiment
9. If the protoplasm shrinks away from the cell wall when a plant cell is bathed in a sugar solution, what is the concentration of the solution relative to the protoplasm the plant cell?
   A. Hypertonic C. Hypotonic
   B. Isotonic D. Isosmotic
10. If letter "d" is observed under a microscope, what would its image look-like?
    A. Letter d itself C. Letter q
    B. Letter b D. Letter p
11. Which of the following structure is missing in a prokaryotic cell?
    A. Cytoplasm C. Nuclear membrane
    B. Plasma membrane D. Nuclear material
12. Which one of the following piece of equipment do biologists use to sterilize objects?

A. Water bath C. Centrifuge

B. Incubator D. Autoclave

13. If an observer moves a microscope slide away from him while looking through a microscope, in which direction would the image of the object on the slide move?

A. Away from the observer C. Towards the left of the observer

B. Towards the observer D. Towards the right of the observer

14. In which of the following types of cellular transportation across the cell membrane, do substances move against their concentration gradient?

A. Osmosis C. Facilitated diffusion

B. Simple diffusion D. Active transport

15. Choose the structure whose typical function is synthesis of proteins?

A. Nucleus C. vacuole

B. Ribosomes D. centriole

16. What is the term used to describe the tentative explanation given to a scientific problem?

A. Data C. Theory

B. Hypothesis D. Principle

17. To which one of the following kingdom would you classify lichen?

A. Plantate C. Monera

B. Protista D. Fungi

18. Which function is carried out by the Golgi apparatus?

A. Protein synthesis C. Digestion of proteins

B. Protein denaturation D. Modification of proteins

19. Which of the following terms best describes a plant cell that is full of water?

A. Flaccid C. Turgid

B. Haemolysed D. Plasmolyzed

20. Among the following, which organelle is not bound by a biological membrane?

A. Nucleus C. Ribosomes

B. Chloroplast D. Mitochondria

21. Which of the following is not found in animal cell?

A. Nucleus C. Ribosome

B. Chloroplast D. Mitochondrion

22. If an object is magnified 500X when viewed under a microscope fitted with 40X objective lens, what is the magnification power of the ocular used?

A. 10X C. 50X

B. 12.5X D. 95X

23. Suppose a student noticed that many plants in a garden died following an excess application of a certain fertilizer, to which step of the scientific method would this correspond?

A. Formulation of hypothesis C. Observation

B. Experimentation D. Collecting information to support hypothesis

24. Which of the following organelles of the cell is involved in the energy release of eukaryotic cell?

A. Chloroplast C. Nucleus

B. Endoplasmic reticulum D. Mitochondrion

25. Which one of the following terms refers to the diffusion of water across a selectively permeable membrane?

A. Dialysis C. Cohesion

B. Osmosis D. Cytoplasmic streaming

26. Select the kingdom of life in which the cellular organelles are without membranes around them?

A. Plantae C. Monera

B. Protista D. Fungi

27. Which of the following organelle is important to regulate the entry and exit of materials into and out of the plant cell?

A. Cell wall C. Nucleus

B. Cell membrane D. Central vacuole

28. All living component of the cell collectively known as what?

A. Legumes C. Vegetables

B. Cereals D. Fruits

29. When trying to view an object under the microscope and after switching to the high power objective, which adjustment knob do you use in order to see a clear picture?

A. The coarse adjustment C. The fine adjustment

B. The middle adjustment D. The arm of the microscope

30. The taxonomic unit 'Phylum' in the classification of animals is equivalent to which hierarchical level in classification of plants

A. Class C. Division

B. Order D. Family

31. Which of these statements is not a reason why biologists classify the living world?

A. To simplify their study

B. To bring order out of chaos or confusion

C. To try to understand how life is originated

D. To make things sound complicated

32. In which of the following plant divisions would you find plants that have no transport tissue?

A. Pteridophyta C. Angiospermae

B. Gymnospermae D. Bryophyta

33. As we go from species to kingdom in a taxonomic hierarchy, the number of common characteristics will:

A. Decrease C. Remains the same

B. Increase D. May increase or decrease

34. Under which of the following groups can the fungi be more conveniently placed?

A. Autotrophs B. Heterotrophs C. Prokaryotes D. Plants

35. Among the following organisms, which one belongs to the prokaryotes?

A. Paramecium B. Streptococcus C. Spirogyra D. Tapeworm

APPENDIX-B :Peer Relationship Academic Support and overall Learning gains questioners

Hawassa University

College of Natural and computational Science

Department of Biology

Hawassa University

College of Natural and computational Science

Department of Biology

Questionnaires prepared to assess learner's peer relatedness, academic support and learning gains towards cooperative learning.

Dear students the main objective of this questionnaire is to collect necessary information about learner's peer relatedness, academic support and learning gains towards cooperative learning pedagogies in Biology lesson. Giving clear and dependable feedback is highly important for the success of this study. The researcher would like to assure you that all the response you give will be confidential and kept safely. Your name is not necessary in this information. Thank you for your cooperation.

Part one:

Background information

Name of institution ……………….

Age ☐

Sex

Male ☐ Female ☐

Part two:

Items related to l**earner's peer relationship, academic support and learning gains towards cooperative learning strategy in biology lesson are** provided below. Please read them carefully and give appropriate response for each item. Your response could vary from "Not at all true" to "Very true" and use a tick **"**√ **"**mark to give your responses.

Key: Strongly agree = 5, Agree =4, Undecided = 3, Disagree = 2, strongly disagree = 1

No	A. Peer relationship subscales	Response				
		5	**4**	3	**2**	**1**
1	When I'm with my group members, I feel accepted					
2	When I'm with my group members, I feel unimportant (reverse Scored)					
3	I feel safe when I am with my group members.					
4	I can achieve many things together with my group members					
	B. Academic Support Scales	**5**	**4**	**3**	**2**	**1**
1	Other students in this class want me to do my best schoolwork.					
2	In this class, other students like to help me learn.					
3	In this class , other students care about how much I learn					
4	Other students in this class want me to come to school every day					
	C. Learning gain Scales To what extent has the learning experience of this course contributed to your learning and personal development in the following ways? Scale: 1: Very poor; 2: Poor; 3: Average; 4: Good, 5: Very Good	**5**	**4**	**3**	**2**	**1**
1	Written communication skills					
2	Problem solving skills					

3	Critically and/or analytically thinking skills.					
4	Working effectively with other individuals.					
5	Feeling confident about tackling unfamiliar problems					

APPENDIX-C Amharic Version questioner

ሐዋሳ ዩኒቨርሲቲ

ተፈጥሮ እና ቀመር ሳይንስ ኮሌጅ

የስነ-ህይወት ትምህርት ክፍል

ህብረታዊ የማስተማር ስነ-ዘዴ በተማሪዎች አቻ ግንኙነት አካዳሚክ ድጋፍ እና አጠቃላይ መማር ማሰተማር ጥቅሞች ላይ ያለውን ሚና ለመፈተሽ የተዘጋጀ መጠይቅ

ክፍል አንድ፡ አጠቃላይ መረጃ

ፆታ ________________

ዕድሜ ____________________

ክፍል ሁለት፡

ህብረታዊ የማስተማር ስነ-ዘዴ በአቻ ግንኑነት በአካዳሚክ ድጋፍ እና በአጠቃላይ መማር ማስማተር ስላለው ጥቅም የሚያጠነጥኑ ጥያቄዎች ከዚህ በታች ቀርበዋል፡፡ እባክዎን በጥንቃቄ ያንብቡ እና ለእያንዳንዱ ጥያቄ በተጠይቁ መሰረት ተገቢውን ምላሽ ይስጡ፡፡

መመዘኛ: 5= **በጣም እስማማለሁ**, 4= **እስማማለሁ**, 3= **አልወሰንኩም**, 2= **አልስማማም**, 1= **በጣም አልስማማም**

ተ.ቁ	**ሀ. በአቻ ግንኙነት ዙሪያ የሚያጠነጥኑ ጥያቄዎች**	**ምላሽ**				
		5	**4**	**3**	**2**	**1**
1	ከቡድን አባሎቼ ጋር ስሆን ተቀባይነት እንዳለኝ ይሰማኛል					
2	ከቡድኔ አባላት ጋር ስሆን አስፈላጊ እንዳልሆንኩ ይሰማኛል።					
3	ከቡድኔ አባላት ጋር ስሆን ደህንነት ይሰማኛል.					
4	ከቡድን አባሎቼ ጋር ብዙ ነገሮችን ማሳካት እችላለሁ					
	ለ. በአካዳሚክ ድጋፍ ዙሪያ የሚያጠነጥኑ ጥያቄዎች	**5**	**4**	**3**	**2**	**1**
1	በክፍል ውስጥ ያሉ ሌሎች ተማሪዎች በትምህርቴ ውጤታማ እንድሆን ይጥራሉ.					
2	የክፍል ውስጥ ጓደኞቼ ትምህርቴን አተኩሬ እንድማር አስፈላጊውን እገዛ ያደርጉልኛል					
3	የክፍል ጓደኞቼ ከተማርናቸው የትምህርት ይዘቶች ውስጥ ምን					

	ያክሉን እንደተረዳሁ በመጠየቅ ባልተረዳኋቸው የትምህርት ይዘቶች ላይ እገዛ ያደርጉልኛል					
4	የክፍል ጓደኞቼ በየቀኑ ትምህርት ቤት መጥቼ ትምህርቴን በአግባቡ እንድከታተል እገዛ ያደርጉልኛል					
	ሐ. በአጠቃላይ መማር ማስተር ጥቅሞች ዙሪያ የሚያጠነጥኑ ጥያቄዎች የዚህ ኮርስ የመማር ማስተማር ሂደት ከሚከተሉት ውስጥ ለወደፊት ለትምህርተዎ እና ለግል እድገትዎ ምን ያህል አስተዋፅዖ አድርጓል? **መመዘኛ: 1= በጣም ዝቅተኛ 2= ዝቅተኛ 3= መካከለኛ 4= ከፍተኛ 5= በጣም ከፍተኛ**	**ምላሽ**				
		1	**2**	**3**	**4**	**5**
1	የጽሁፍ እና የተገባበት ችሎታን ከማሳደግ አንጻር					
2	ችግሮችን ተረድቶ የመፍታት ችሎታን ከማሳደግ አንጻር					
3	በጥልቀት ወይም በሚዛናዊነት የማሰብ ችሎታን ከማሳደግ አንጻር.					
4	ከሌሎች ግለሰቦች ጋር በብቃት መስራትን ከማዳበር አንጻር					
5	በድንገት የሚገጥሙ ችግሮችን ለመፍታት በራስ የመተማመን ስሜትን ከማሳደግ አንጻር					

ስለተባበራችሁን ከልብ እናመሰግናለን !!!!!

APPENDIX-D Lesson observation checklist for intervention Schools

Hawassa University

College of Natural and computational Science

Department of Biology

Lesson observation checklist for intervention Schools to check proper implementation of cooperative learning

No	Observable items	Yes	No
1	Does the teacher develop a clear lesson plan with learning activities aligned with outcomes that are appropriate to cooperative learning models?		
2	Does the teacher define learning objectives for the subject activities and assigns learners to groups?		
3	Does the teacher give group home work/ assignment to learners?		
4	Does the teacher encourage learners to participate in discussions?		
5	Does the teacher allow learners to consult other learners about certain topics or subjects for discussion?		
6	Does the teacher encourage learner's academic groups to reflect on their interactions to identify potential improvements for future group work?		
7	Does the teacher monitor learners' group work and evaluating group and individual performance?		
8	Does the teacher assign learners specific roles, and communicates the criteria for group success?		
9	Does the teacher give individual home work/ assignment to learners?		
10	Does the teacher ensure that each learner is individually accountable for the group's task or tasks?		
11	Does the teacher ensure that the whole group is collectively accountable for the group's task or tasks?		
12	Does the teacher allow learners to question and challenge each other on different learning aspects, share and discuss their ideas, and internalize their learning?		

APPENDIX-E students semi-structured interview Guide

1. What is your name?
2. Would you please share your overall experience with cooperative learning lessons?
3. Would you please share the aspects of cooperative learning that you found most beneficial?
4. Would you please provide an example that reflects the strength of cooperative learning you experienced?
5. Would you please describe the teacher's roles in cooperative learning lessons and how students responded to them?
6. Would you please share one of the challenges you faced during cooperative learning lessons?
7. Would you please share your general comments on cooperative learning lessons?

Appendix-F Teachers semi-structured interview guide

1. Can you describe your overall experience with implementing cooperative learning, specifically the Jigsaw model, in your biology lessons?
2. What challenges did you encounter when using the Jigsaw model, and how did you address them??
3. How has the jigsaw model impacted student engagement, participation, and understanding in your class? Can you provide specific examples??
4. How did you adapt your lesson planning or teaching strategies to successfully implement the Jigsaw model compared to traditional methods?
5. In your opinion, what are the key benefits of cooperative learning, specifically the Jigsaw model, over traditional teaching methods?
6. What advice would you give to other teachers planning to implement cooperative learning in their classrooms

Appendix-G Lesson plan evaluation checklist

No	Checklist items	Yes/no	Comments
1	Are lesson objectives aligned with cooperative learning outcomes, including communication, problem-solving, and teamwork?		
2	Does the plan outline clear steps for group formation, considering student ability levels or learning needs?		
3	Are student roles (e.g., leader, recorder, presenter, and timekeeper) specified for group work?		
4	Is preparation for group activities evident, including necessary materials, time allocation, and group instructions?		
5	Are monitoring strategies for group dynamics and participation (e.g., teacher movement, checkpoints) included?		
6	Is there evidence of assessment methods (peer, group, or individual) to evaluate learning during or after group activities?		
7	Does the lesson include a reflection or review phase for evaluating group performance and lesson effectiveness?		

Appendix –H Textbook evaluation checklist

No	Checklist items	Yes/no	Comments
1	Does the textbook include cooperative learning tasks (e.g., group experiments, discussions, problem-solving)?		
2	Are discussion prompts or guiding questions provided for group-based learning?		
3	Are tasks designed to encourage peer teaching and collaboration among students?		
4	Are activities designed to develop higher-order thinking (e.g., analysis, synthesis, evaluation)?		
5	Are there clear instructions for integrating textbook tasks into cooperative learning sessions?		
6	Do textbook tasks allow flexibility for teachers to adapt them to different group settings?		
7	Are there assessments aligned with group tasks to measure both individual and group learning outcomes?		

Appendix –I Cooperative Learning Implementation: Observation Results

(n=16 sessions; Experimental Group Only)

Key Implementation Indicator	**Sessions Observed**	**Frequency**	**Qualitative Evidence (Field Notes)**
Lesson Plan Alignment	15/16 (94%)		Expert cards focused on organelle functions
Group Formation & Objectives	16/16 (100%)		Heterogeneous groups by ability; assigned protest classification tasks
Group Assignment Design	12/16 (75%)		Cell organelle matching activity required interdependence
Discussion Facilitation	16/16 (100%)	3.2 interventi ons/session	Probing Q: "Why are viruses non-living?"
Peer Consultation	16/16 (100%)	14.7 events/sessio n	Students cross-checked prokaryote vs. eukaryote diagrams
Group Reflection	9/16 (56%)		Group 3 noted: "We confused taxonomy ranks"
Performance Monitoring	14/16 (88%)		Rubric-based feedback on animal vs. plant cell models
Role Assignment & Success Criteria	13/16 (81%)	78% role adherence	Timekeeper ensured classification flowchart completion
Individual Accountability	11/16 (69%)		Randomly selected students defended "characteristics of life" group conclusions
Collective	15/16 (94%		Group grade for "Five

Accountability			Kingdoms of Life" poster project
Critical Dialogue	14/16 (88%)	9.3 debates/session	Argument: "Should mitochondria be called the cell's powerhouse?"

Appendix –J Lesson Plan Evaluation Results - Cooperative Learning Integration (n = 24)

No	Implementation Strength	Presence	Topic-Specific Evidence
1	CL-Aligned Objectives	92%	Explain organelle functions through team collaboration
2	Structured Group Formation	83%	Heterogeneous groups for protist classification
3	Defined Student Roles	75%	Roles for mitosis modeling: Timer, Recorder, Presenter
4	Comprehensive Activity Prep	100%	Pre-labeled slides & timers for microscope labs
5	Proactive Monitoring	88%	Checkpoints during dichotomous key development
6	Diverse Assessments	79%	Peer review + group rubric for cell models
7	Reflection Integration	67%	Group discussion: 'How did roles help our virus debate