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Collaborate to Learn: A Scoping Review of Peer Tutoring Strategies in Secondary Science Education

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Abstract

This scoping review examines peer tutoring strategies in secondary science education from January 2020 to June 2025. As demands for equitable, student-centered instruction increase, peer tutoring has gained attention as a cost-effective and collaborative approach that enhances understanding, engagement, and achievement. Following PRISMA-ScR guidelines, 19 empirical studies were synthesized from Scopus, OpenAlex, PubMed, Crossref, and Google Scholar. Studies were analyzed based on geographical distribution, grade level, science discipline, learning outcomes, tutoring strategies, and duration of implementation. Results show strong representation from the Global South, particularly Nigeria and the Philippines, where peer tutoring helps address large class sizes and limited resources. Chemistry was the most frequently tutored subject, with strategies including Reciprocal Peer Tutoring (RPT), Class-Wide Peer Tutoring (CWPT), Jigsaw, and online models. Most programs lasted 4-6 weeks and demonstrated positive impacts on academic performance, motivation, metacognition, and collaborative learning. Findings affirm peer tutoring's adaptability across disciplines and contexts, highlighting its value as both an instructional tool and a means to foster affective development. Recommendations include structured tutor training, context-sensitive adaptation, and expanded exploration of digital peer-assisted learning. Future research should investigate long-term outcomes, equity considerations, and integration within broader science education reforms.

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Introduction

Science education at the secondary level plays a pivotal role in shaping students' analytical thinking, scientific literacy, and readiness for STEM-related careers. However, across diverse educational contexts, persistent challenges such as large class sizes, limited instructional time, heterogeneous learner profiles, and inequities in resource distribution continue to hinder effective science teaching and learning (Bybee, 2013; Taber, 2014). These constraints are particularly acute in under-resourced settings, where the conventional teacher-led instructional model struggles to meet the individualized learning needs of students, often leading to gaps in engagement, comprehension, and academic performance (Slavin, 2014).

In response to these problems, peer tutoring has gained popularity as a learner-centered teaching technique based on sociocultural and constructivist learning theories. Peer tutoring, which is based on Vygotsky's (1978) work, uses the zone of proximal development to allow students to co-construct knowledge through directed contact with more capable peers. Such interactions promote active involvement, metacognitive reflection, and dialogic learning, which benefits both tutors and tutees intellectually and emotionally (King, 1998; Roscoe and Chi, 2007). According to research, peer tutoring can boost academic accomplishment, create favorable attitudes toward science, and build collaborative abilities, all of which are necessary for success in STEM areas (Maheady et al., 2010; Topping, 2005).

Despite its promise, the organization, aim, and impact of peer tutoring in science classes vary greatly. Some models use formal tactics such as Class-Wide Peer Tutoring (CWPT), Reciprocal Peer Tutoring (RPT), or the Jigsaw approach, but others use more adaptable, context-based arrangements. Moreover, emerging approaches now integrate peer tutoring with digital technologies and flipped classroom models to adapt to evolving educational landscapes (Bergmann & Sams, 2012; Borup et al., 2014). However, effectiveness depends on factors such as the duration of implementation, frequency of interaction, tutor preparation, and alignment with curricular goals (O'Donnell & King, 1999; Slavin, 1996).

Its effectiveness, however, cannot be denied, as its social nature allows learners of the same status (i.e., students) to acquire knowledge collaboratively. This active participation aligns with constructivist learning theory, which emphasizes knowledge construction through social interaction (Qi, 2023). Peers' academic and social support can foster a responsive learning environment and may have unique implications for adolescents' academic motivation, classroom engagement, and sense of school belonging across gender roles (Careemdeen, 2023). Moreover, comparisons between conventional teaching and peer tutoring approaches integrated into the curriculum indicate greater student success when learning is supported through peer collaboration (Grace, 2025).

While numerous empirical studies have examined peer tutoring in science education, the findings remain scattered across contexts, disciplines, and research designs. Much of the existing literature focuses on isolated outcomes or specific strategies, with limited synthesis that captures the diversity, trends, and overall impacts of peer tutoring at the secondary level (Enebechi, 2023; Nwafor et al., 2023). Furthermore, no comprehensive review has systematically mapped the landscape of peer tutoring strategies specifically in secondary science education in light of recent pedagogical innovations and global shifts in instructional delivery.

Therefore, this scoping review addresses this gap by synthesizing and analyzing empirical studies from 2020 to 2025 on peer tutoring in secondary science education. It aims to provide a nuanced understanding of how peer tutoring strategies are implemented, in what contexts, and with what effects—thereby informing educators, researchers, and policymakers seeking equitable and impactful approaches to science teaching. The review was guided by the following research questions:

1. What are the characteristics of the included studies in terms of country, grade level, science discipline, learning outcomes, and program duration?
2. What types of peer tutoring strategies have been employed in secondary science classrooms?
3. What effects of peer tutoring on student learning outcomes have been reported in these studies?
4. What different challenges of implementation have been reported in studies on peer tutoring in secondary science education?

Method

Research Design

This study adopted a scoping review design to systematically map and synthesize existing literature on peer tutoring strategies in secondary science education. Scoping reviews are particularly appropriate for examining broad educational interventions, identifying knowledge gaps, and clarifying concepts, especially when the literature varies in design, scope, and outcomes (Arksey & O'Malley, 2005; Levac et al., 2010). The review follows an enhanced methodological approach developed by Levac et al. (2010) as well as updated Joanna Briggs Institute (JBI) advice for conducting scoping reviews (Peters et al., 2020). To guarantee transparency and rigor, the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) checklist was used as a reporting guide (Tricco et al., 2018).

Study Search Procedure

A multi-stage research article search was conducted to ensure a comprehensive and systematic exploration of relevant studies, guided by the PRISMA-ScR framework to maintain transparency, replicability, and methodological rigor (Tricco et al., 2018). The search focused on empirical, peer-reviewed works published between January 2020 and June 2025, with the goal of capturing current trends and developments in peer tutoring in secondary scientific education. Five major academic databases were thoroughly searched: Scopus, Open Alex, PubMed, Crossref, and Google Scholar. These platforms were chosen because they provide extensive coverage of educational, psychological, and transdisciplinary research. To extend the scope and reduce selection bias that may be presented, a manual search was also conducted. This involved screening several relevant journals and running backward reference searches from included papers, sometimes known as the snowballing strategy (Vassar et al., 2016). This extra procedure ensured that potentially relevant papers, particularly those missed by database-specific indexing, were included in the review.

To retrieve relevant studies, a combination of controlled vocabulary terms and free-text keywords was used, adjusted per database to improve retrieval accuracy. Boolean operators ("AND," "OR") were applied to refine the scope. A sample search string used in Scopus was: ("peer tutoring" OR "peer-assisted learning" OR "peer teaching" OR "reciprocal tutoring") AND ("secondary education" OR "high school" OR "junior high school") AND ("science education" OR "biology" OR "chemistry" OR "physics")Harzing's Publish or Perish (PoP) program made the search process easier by offering streamlined access to many academic databases such as Google Scholar, Crossref, and others. A broad range of various, carefully chosen keywords were used, including peer tutoring, cross-age tutoring, reciprocal peer tutoring, same-age peer tutoring, structured peer-assisted learning, science education, peer learning, and collaborative learning. For reference management and duplicate removal, it was decided that Microsoft Excel was to be utilized extensively due to its organizational and filtering capabilities.

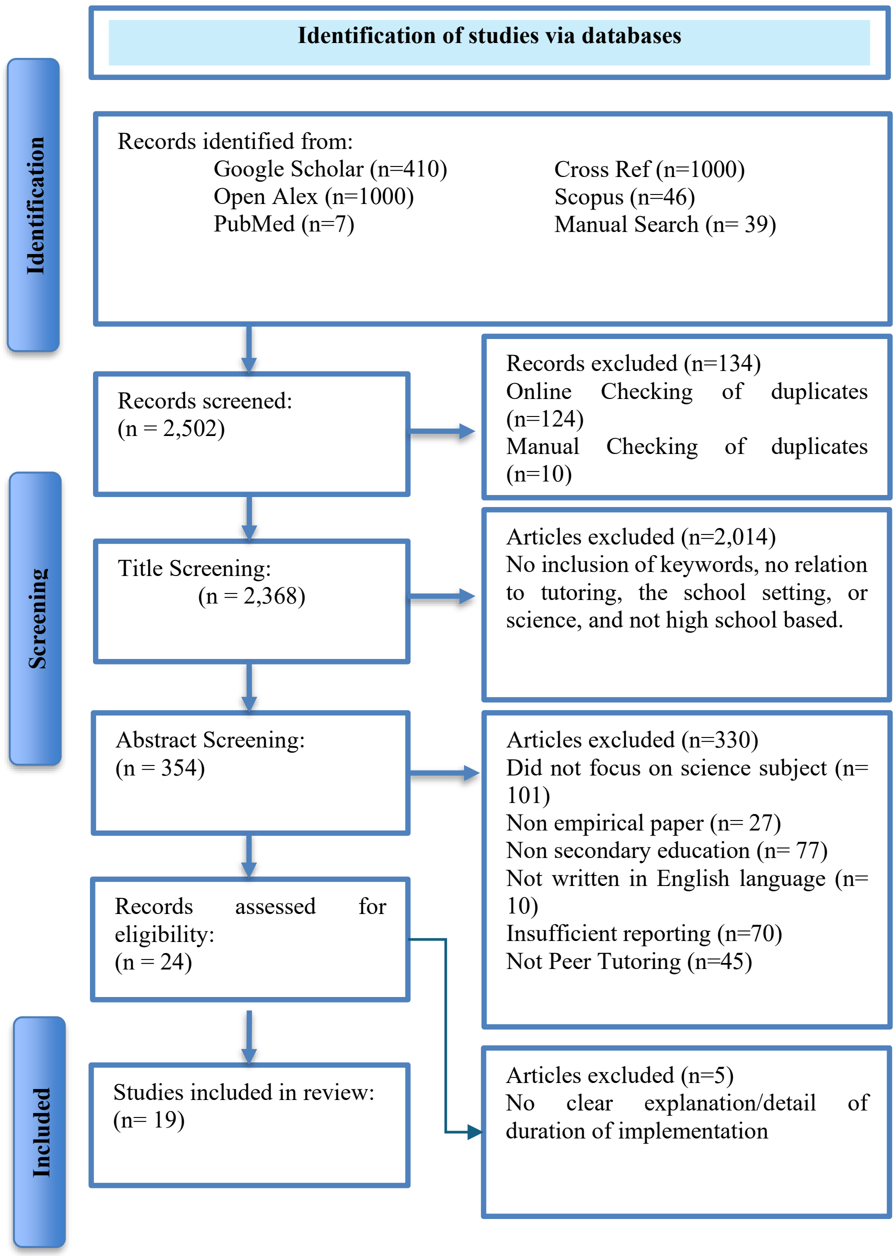

Figure 1. Flow Diagram of the Literature Search Using PRISMA Protocol

A two-stage screening process was employed to ensure the relevance and quality of the studies included in this systematic review. In the first stage, a title and abstract screening was conducted to identify articles that focused on peer tutoring within the context of secondary science education. This initial screening helped filter out studies that were clearly unrelated to the research focus. In the second stage, the full-text screening involved a more thorough evaluation of the remaining studies to determine whether they met the established inclusion and exclusion criteria. This step ensured that only studies with strong methodological alignment and relevant content were selected for the final analysis. To ensure reliability, two independent reviewers conducted each screening phase. Disagreements were resolved through discussion or, when necessary, consultation with a third reviewer.

As illustrated in Figure 1, the initial search across all platforms yielded a total of 2,502 articles. Following the automatic removal of 124 duplicate entries and the manual exclusion of 10 additional duplicates due to formatting inconsistencies, the researcher conducted a thorough screening process. A total of 2,014 studies were excluded during this phase for various reasons, including the absence of relevant keywords in the title, lack of connection to peer tutoring, non-school or non-science contexts, and settings not based in secondary education. Abstract screening further excluded 330 articles due to their focus outside secondary education, lack of relevance to peer tutoring, insufficient reporting, or not being empirical in nature. Ultimately, 24 articles met all preliminary inclusion criteria and were retained for full analysis.

Inclusion and Exclusion Criteria

To ensure that the review captured relevant, high-quality, and contextually appropriate studies, a clearly defined set of inclusion and exclusion criteria was established prior to the screening process. These criteria, aligned with the review's research objectives, were consistently applied across all retrieved articles. Studies were included if they explicitly examined peer tutoring, peer-assisted learning, or reciprocal peer teaching as a central instructional strategy; were implemented within science disciplines such as Biology, Chemistry, Physics, Earth Science, or General Science; and involved participants enrolled in secondary or high school levels (Grades 7–12 or international equivalents). Eligible studies employed quantitative, qualitative, or mixed-methods designs, including case studies, quasi-experiments, randomized trials, or classroom-based evaluations, and were published between January 2020 and June 2025 to reflect recent trends. Only articles written in English, published in peer-reviewed journals or credible academic conference proceedings, and available in full text online were considered. Furthermore, included studies reported at least one type of student learning outcome, such as academic performance, engagement, attitudes, or self-efficacy. Following full-text analysis, five studies out of the 24 initially identified were excluded due to the absence of a clear implementation timeline. Ultimately, 19 studies satisfied all inclusion criteria and were incorporated into the final synthesis. This thorough and methodical process ensured that only empirical, relevant, and easily accessible research relevant to the scope of peer tutoring in formal secondary scientific education were included, resulting in a strong evidence base for the review.

Coding Procedures

The research articles were carefully analyzed and coded to extract essential information, such as the author(s) and year of publication, country of implementation, title, grade or year level of participants, science discipline (e.g., biology, chemistry, physics), targeted learning outcomes (such as academic achievement, critical thinking, or attitudes), and the duration and frequency of peer tutoring implementation. This method ensured an overall grasp of each study's context, focus, and contribution to the field of secondary science education.

Data Analysis

A standardized data extraction form was created to chart major findings from each included study. The following information was extracted: author(s), year of publication, study country or location, study objectives, research design, participant characteristics (grade level, sample size), peer tutoring strategy type, science discipline (e.g., biology, chemistry), duration and frequency of the intervention, outcome measures, and key findings. Descriptive statistics were employed to summarize the studies' features and distributions. Quantitative outcomes (e.g., test scores or performance gains) were tabulated for cross-study comparisons, while qualitative and mixed-methods findings were systematically synthesized to identify recurring insights, challenges, and implementation patterns for peer tutoring in science classrooms.

Findings were reported according to three analytical categories: (1) descriptive mapping of included studies (e.g., context, subject area, duration), (2) types of peer tutoring strategies implemented, and (3) observed effects on learning outcomes. This approach enabled a nuanced understanding of how peer tutoring has been employed in secondary science education and what evidence exists regarding its impact.

Results

General Study Characteristics

Table 1 presents the general characteristics of the included studies, detailing the author(s) and year of publication, country, study title, grade level and number of participants, science discipline targeted learning outcomes, and duration of peer tutoring implementation.

Table 1. Descriptive Features of the Included Studies

No.	Author/s and Year of Publication	Country	Title	Grade Level and Number of Participants	Science Discipline (e.g., biology, chemistry, physics)	Targeted Learning Outcomes	Duration Peer Tutoring Implementation
1	Ruth & Opita (2025)	Nigeria	Effect of Reciprocal-Peer-Tutoring Learning Strategy on Basic Science Students' Interest in Radioactivity in South Senatorial District, Benue State, Nigeria	Junior High School 800 students	Basic Science-Radioactivity	Interest in Radioactivity	6 weeks
2	Kareem & Ewuola	Nigeria	Effectiveness of Peer-Tutoring and Experiential	Senior High School	Biology	Academic Achievement	6 weeks

No.	Author/s and Year of Publication	Country	Title	Grade Level and Number of Participants	Science Discipline (e.g., biology, chemistry, physics)	Targeted Learning Outcomes	Duration Peer Tutoring Implementation
	(2025)		Instructional Strategies in Improving Secondary School Biology Students' Learning Outcomes	95 students			
3	Kwasi & Achor (2025)	Nigeria	Interventions into students' academic performance at HOTS levels in redox reactions using problem-based learning and peer-tutoring strategies	Senior Secondary School II 146 students	Chemistry- Redox Reactions	Conceptual Mastery of Redox Reactions Academic Performance at Higher-Order Thinking Skills (HOTS) Level	5 weeks
4	Potutan & Macagba (2025)	Philippines	Peer tutoring day: Perceptions and its effectiveness on the academic performance of students in learning high school physics	Junior High School 43 students	Physics	Academic Performance in High School Physics	2 weeks
5	Hamidah et al., (2025)	Indonesia	Evaluating Peer Tutoring for Reproductive Health Education: A Study in Palu, Indonesia'	Junior & Senior High School 44 students	Health Education	Knowledge Acquisition in Reproductive Health	2 days
6	Mama et. al., (2024)	South Africa	Assessing the Effectiveness of Peer Tutoring in Improving STEM Education Outcomes'	Senior High School Not explicitly provided	Science, Technology, Engineering, and Mathematics (STEM)	Academic Achievement	2 Academic Years
7	Ozcan et al., (2024)	Turkey	Implementation of Peer Instruction Method on Teaching of Acids and Bases to 12th Grade Students: An Action Research'	Senior High School (12th Grade) 21 students	Chemistry- Acids and Bases	Conceptual Understanding of Acids and Bases Academic Achievement in Chemistry	5 weeks
8	Van Hoe et al., (2024)	Belgium	The implementation of peer assessment as a scaffold during computer-supported collaborative inquiry learning in secondary STEM education'	Junior High School & Senior High School 506 students	Earth Science	Collaborative Learning Skills Critical Thinking and Reflection	2 weeks
9	Verma & Ali (2023)	United States	Impacting Career Choices of Historically Underserved Secondary Students by Designing Near-Peer	Senior High School 126 students	Chemistry- Acids and Bases	Increased Interest in STEM Content Understanding in	6 weeks

No.	Author/s and Year of Publication	Country	Title	Grade Level and Number of Participants	Science Discipline (e.g., biology, chemistry, physics)	Targeted Learning Outcomes	Duration Peer Tutoring Implementation
			Directed Acid-Base Thematic Laboratory Activities to Enhance STEM Interest'			Acid-Base Chemistry	
10	Ovie et al., (2023)	Nigeria	Effects Peer Tutoring, Study Question-Based Instructional Strategies and Lecture Method on Students' Academic Achievement and Attitude Towards Chemistry in Delta and Bayelsa States	Senior Secondary School II 622 students	Chemistry	Academic Achievement in Chemistry	6 weeks
11	Amoo (2022)	Nigeria	Effects of Flipped Learning and Peer Tutoring on Learning Outcome in Biology in Ibadan	Senior High School 114 students	Biology	Academic Achievement in Biology	6 weeks
12	Soriano (2022)	Philippines	Enhancing the Competency of Grade 11 HUMSS Learners Through Online Peer Tutoring (OPT) Program	Senior High School 28 students	Earth Science	Competency Development	1 year
13	Azeez et. al., (2022)	Nigeria	Effect of Jigsaw and Peer-Tutoring Instructional Strategies on Senior Secondary School Students' Academic Achievement and Interest in Periodic Table of Elements in Ankpa Local Government Area of Kogi State	Senior High School 129 students	Chemistry-Periodic Table of Elements	Academic Achievement	8 weeks
14	Akanbi (2022)	Nigeria	Effect of Class-Wide Peer Tutoring on Students' Performance in Physics in Dekina, Nigeria	Senior High School 64 students	Physics	Academic Performance in Physics	4 weeks
15	Thurston et al., (2021)	United Kingdom	Assessing the Differential Effects of Peer Tutoring for Tutors and Tutees'	Junior & Senior High School 295 students	Education Sciences	Academic Achievement for Tutors and Tutees	12 weeks
16	Lamina (2021)	Philippines	Peer-led team learning (PLTL), student achievement and engagement in learning chemistry	Junior High School (Grade 9) 36 students	Chemistry	Student Achievement and Engagement in Chemistry	5 weeks
17	Kalu-Uche & Ogbonna (2021)	Nigeria	Effect of Peer Tutoring Instructional Strategy on Secondary School Slow	Senior High School	Biology	Academic Achievement and Retention of	5 weeks

No.	Author/s and Year of Publication	Country	Title	Grade Level and Number of Participants	Science Discipline (e.g., biology, chemistry, physics)	Targeted Learning Outcomes	Duration Peer Tutoring Implementation
			Learners' Academic Achievement and Retention in Biology	77 students		Biology Concepts	
18	Gongden (2021)	Nigeria	The Effects of Reciprocal Peer Tutoring on Chemistry Students' Achievement and Retention in Chemical Kinetics in Jos Metropolis, Nigeria'	Senior High School 86 students	Chemistry	Academic Achievement in Chemical Kinetics Retention of Chemical Kinetics Knowledge	4 weeks
19	Alemu (2020)	Ethiopia	Improving Secondary School Students Physics Achievement Using Reciprocal Peer Tutoring: A Multi-level Quasi-Experimental Study'	Junior High School (Grade 9) 149 students	Physics	Academic Achievement in Physics	9 weeks

Geographical Location

The majority of studies were conducted in Nigeria (n=9) (e.g., Azeez et al., 2010) followed by the Philippines (n=3) (e.g., Lamina, 2021; Soriano, 2022; Potutan & Macagba, 2025). Individual studies also originated from South Africa (Mama et. al., 2024), Turkey (Ozcan et al., 2024), Belgium (Van Hoe et al., 2024), United States (Verma & Ali, 2023), Ethiopia (Alemu, 2020), United Kingdom (Thurston et al., 2021) and Indonesia (Hamidah et al., 2025).

Educational Level of Participants

The majority of studies focused on secondary education, particularly junior and senior high school. In Nigeria, peer tutoring was widely applied in Grades 7–12 (Akanbi, 2022; Iwanger & Opita, 2025; Kalu-Uche & Ogbonna, 2021). Similar applications were seen in the Philippines (Lamina, 2021; Soriano, 2022). In Belgium and the UK, cross-age tutoring models were implemented (Smith, 2021; Van Hoe et al., 2024).

Science Discipline Focus

Chemistry was the most frequently studied subject, with seven studies emphasizing its use for abstract topics (Azeez et al., 2022; Ephraim, 2021). Physics (Kwasi & Achor, 2025), Biology (Akanbi, 2022), and Earth Science (Soriano, 2022; Van Hoe et al., 2024) were also represented. Broader applications included STEM education (Mama et al., 2024), Basic Science (Iwanger & Opita, 2025), Education Sciences (Verma & Ali, 2023), and Health Education (Hamidah et al., 2025).

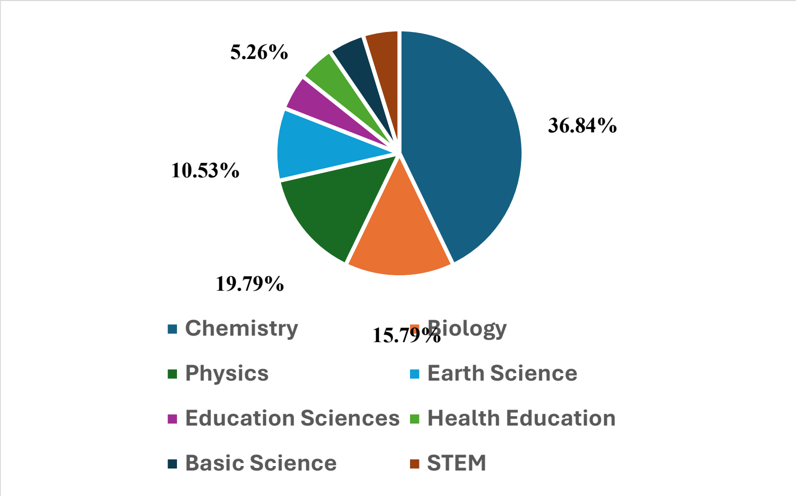

Figure 2. Scientific Disciplines Distribution among Researches Reviewed

Targeted Learning Outcomes

Four primary categories of learning outcomes emerged:

1. Academic achievement and performance – documented in more than half of the studies (e.g., Akanbi, 2022; Azeez et al., 2022; Kalu-Uche & Ogbonna, 2021; Kareem & Ewuola, 2025; Mama et al., 2024).
2. Conceptual understanding – emphasized in five studies, including acids and bases (Ozcan et al., 2024), redox reactions (Kwasi & Achor, 2025), and reproductive health (Hamidah et al., 2025).
3. Engagement and motivation – explored in four studies (Ruth & Opita, 2025; Soriano, 2022).
4. Skills development – highlighted in two studies, focusing on collaboration and critical thinking (Mama et al., 2024; Van Hoe et al., 2024).

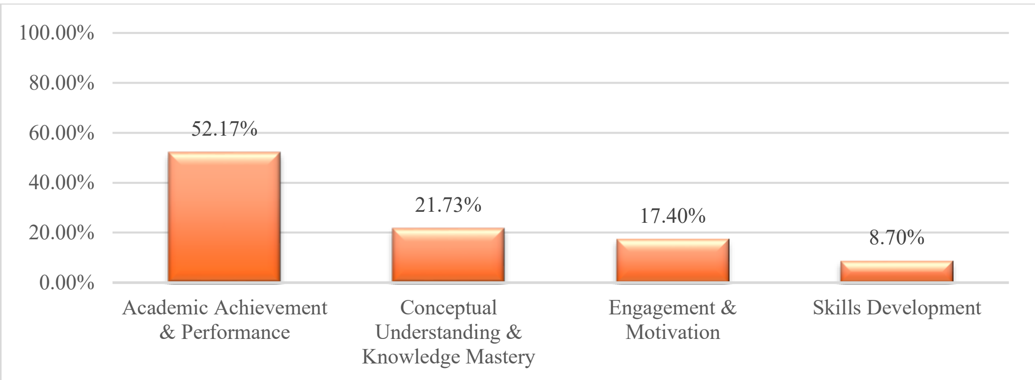

Figure 3. Targeted Learning Outcomes in Science Peer Tutoring

Duration and Frequency of Implementation

Implementation ranged from two days to two years. Six-week interventions were the most common (Amoo, 2022; Kareem & Ewuola, 2025; Ovie et al., 2023; Ruth & Opita, 2025; Verma & Ali, 2023). Shorter implementations of 4–5 weeks also showed positive results (Akanbi, 2022; Kalu-Uche & Ogbonna, 2021; Kwasi & Achor, 2025;

Gongden, 2021; Lamina, 2021; Ozcan et al., 2024). Longer programs of one year (Soriano, 2022) and two years (Mama et al., 2024) demonstrated sustained effects, while very short interventions (Hamidah et al., 2025; Potutan & Macagba, 2025; Van Hoe et al., 2024) provided exploratory insights.

Types of Peer Tutoring Strategies

The review identified a variety of peer tutoring strategies in secondary science education, ranging from informal peer pairings to structured pedagogical models.

- General/Unspecified Peer Tutoring: Over half of the studies (n=11) used general forms of peer tutoring. Students were paired or grouped, with one serving as tutor and the other as tutee, usually under teacher facilitation. Few of these studies described formal training or structured roles.
- Reciprocal Peer Tutoring (RPT): Reported in three studies (Alemu, 2020; Gongden, 2021; Ruth & Opita, 2025). RPT required students to alternate roles as tutor and tutee, emphasizing accountability and active learning.
- Class-Wide Peer Tutoring (CWPT): One study (Akanbi, 2022) implemented CWPT, involving structured class routines, group rotations, and performance monitoring.
- Jigsaw Strategy: Found in one study (Azeez et al., 2022). Students became "experts" on subtopics and then taught peers.
- Flipped Learning with Peer Tutoring: One study (Amoo, 2022) combined flipped classroom methods with peer tutoring, integrating at-home content with in-class peer facilitation.
- Peer Instruction: One study (Ozcan et al., 2024) applied this approach, using conceptual questions followed by peer discussion, often with polling support.
- Other Approaches: Study-Question Based Tutoring (Ovie et al., 2023) emphasized guided questioning, while Online Peer Tutoring (Borup et al., 2014) supported digital or hybrid learning contexts.

Overall, the strategies varied in complexity, structure, and purpose, reflecting the adaptability of peer tutoring in different science education settings.

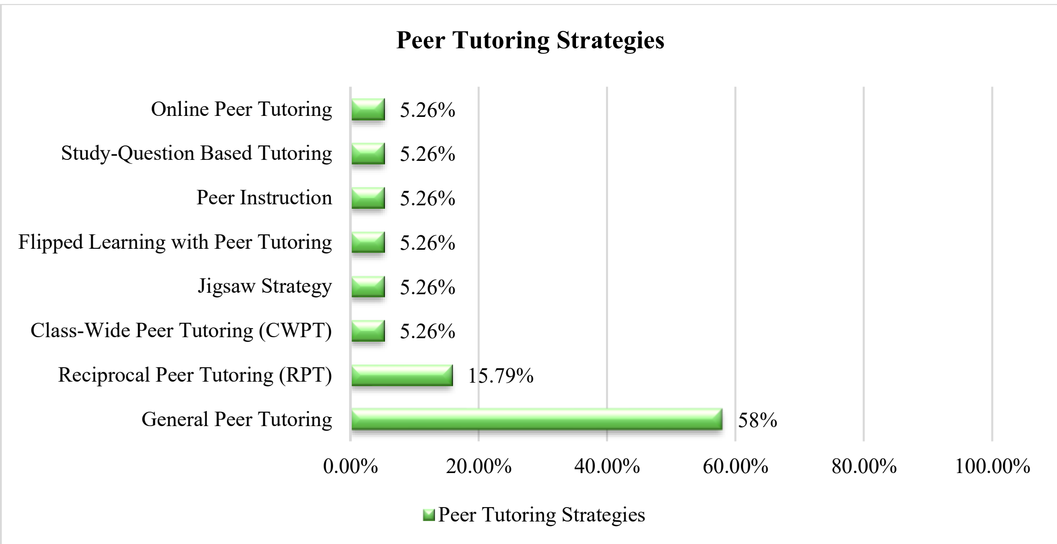

Figure 4. Percentage Distribution of Science Peer Tutoring Strategies

Effects of Peer Tutoring on Secondary Students' Learning Outcomes in Science

The reviewed studies consistently reported that peer tutoring positively influenced multiple learning outcomes among secondary science students. Academic achievement was the most frequently assessed outcome, followed by student engagement, attitudes toward science, and conceptual understanding. Overall, peer tutoring was shown to support both cognitive and affective development in learners. A significant improvement in students' academic performance was observed across studies implementing peer tutoring strategies. For instance, Class-Wide Peer Tutoring (CWPT) resulted in substantially higher post-test scores in physics, with mean gain scores in experimental groups more than doubling those of control groups (Ruth & Opita, 2025). Similarly, Jigsaw and peer tutoring demonstrated significant gains in chemistry learning, particularly in challenging topics like the periodic table (Kareem & Ewuola, 2025).

Reciprocal Peer Tutoring (RPT) was strongly linked to enhanced academic performance and metacognitive abilities. Students engaged in both tutoring and learning roles demonstrated better conceptual engagement and greater self-regulation in their studies. These outcomes align with Roscoe & Chi (2007), who highlighted the dual benefits of teaching and learning roles in peer learning contexts.

Affective outcomes were also widely reported, including improved interest, attitudes toward science, and learner confidence. Flipped Learning with Peer Tutoring, for example, increased student engagement and autonomy, as peer-led sessions allowed learners to clarify misconceptions in low-pressure settings (Ozcan et al., 2024). Such findings demonstrate the motivational advantages of peer-centered instructional strategies (Ryan & Deci, 2000). Finally, most studies found no significant gender differences in the effectiveness of peer tutoring interventions. This suggests that peer tutoring may serve as an inclusive instructional strategy, supporting equity in science education outcomes (Kareem & Ewuola, 2025; Ruth & Opita, 2025). Moreover, programs with longer and more frequent peer tutoring sessions consistently showed stronger and more sustainable learning outcomes.

Table 2. Findings and Effects in Related Studies

No.	Author/s and Year of Publication	Effects of Peer Tutoring on Learning Outcomes
1	Mama et. al., (2024)	Quantitative Findings: Peer tutoring led to marked academic gains, with tutees showing a 15% improvement in math and 12% in science scores. Moreover, 85% reported increased confidence in STEM, and tutors also benefited, improving their own test scores by 10%. Qualitative Findings: Tutees appreciated the approachable and personalized support from peer tutors, which created a comfortable learning atmosphere. Success factors included clear communication, mutual respect, structured sessions, and strong tutor preparation.

No.	Author/s and Year of Publication	Effects of Peer Tutoring on Learning Outcomes
2	Akanbi (2022)	Quantitative Findings: Students in the Class-wide Peer Tutoring (CWPT) group significantly outperformed the conventional group, with higher post-test ($M = 17.48$ vs. 11.73) and gain scores (8.58 vs. 3.64). Statistical analysis confirmed CWPT's effectiveness ($F = 332.457$, $p < 0.05$), with no significant gender differences. Qualitative Findings: Students noted that rotating tutor-tutee roles encouraged active learning, timely feedback, and reduced anxiety. Peer tutors' use of simple language and relatable examples enhanced engagement and comprehension of physics topics.
3	Azeez et. al., (2022)	Quantitative Findings: Both Jigsaw and peer tutoring significantly improved achievement ($M = 49.82$ and 48.72) and interest ($M = 53.05$ and 49.86) in chemistry. Differences between strategies and between male and female students were not statistically significant, highlighting equal effectiveness and inclusivity. Qualitative: Findings: Learner-centered strategies were praised for boosting participation, engagement, and understanding. Students appreciated the interactive nature of both methods, which provided equal opportunities for learning regardless of gender.
4	Kalu-Uche & Ogbonna (2021)	Quantitative Findings: Slow learners taught through CWPT achieved higher post-test ($M = 20.31$) and retention scores ($M = 29.60$) than those in the conventional group ($M = 17.35$ and 24.66). ANCOVA confirmed significant effects on achievement ($F = 9.081$, $p = .004$) and retention ($F = 7.078$, $p = .000$). Qualitative Findings: Peer tutoring fostered collaboration and deeper understanding through simplified, sequential explanations and peer-led Q&A. This approach created a more engaging and supportive environment for struggling learners, especially in biology topics like plant reproduction.
5	Ruth & Opita (2025)	Quantitative Findings: Reciprocal Peer Tutoring (RPT) significantly boosted student interest in radioactivity, with scores rising from 26.25 to 60.55, compared to 15.67 to 24.50 in the control group. ANCOVA confirmed strong effects ($F = 755.960$, $p = .000$; $R^2 = .683$; $\eta^2 = .558$), indicating high impact on engagement.

No.	Author/s and Year of Publication	Effects of Peer Tutoring on Learning Outcomes
		Qualitative Findings: Students expressed greater enthusiasm and accessibility in learning due to the interactive, peer-supported nature of RPT. The method proved equally effective across genders and aligned with research promoting student-centered science instruction.
6	Kareem & Ewuola (2025)	Quantitative Findings Experiential Instructional Strategy (EIS) yielded the highest post-test biology scores and self-efficacy levels, outperforming Peer Tutoring (PTIS) and Conventional Instruction (CIS). Instructional strategy significantly influenced outcomes ($F = 39.65$; $F = 24.778$; $p = .000$), explaining 46.6% of the variance in performance and 35.3% in self-efficacy. Qualitative Findings: EIS was praised for enabling hands-on, meaningful learning (cognitive constructivism), while PTIS supported learning through peer interaction (social constructivism). Both strategies enhanced engagement and understanding, with EIS particularly improving self-efficacy.
7	Amoo (2022)	Quantitative Findings: Flipped learning, peer tutoring, and their combination significantly outperformed traditional lectures in improving biology achievement [$F(3, 105) = 126.497$, $p = .000$]. No gender interaction was found [$F(3, 105) = 0.456$, $p = .714$], showing equal effectiveness for all learners. Qualitative Findings: Students valued flipped learning for its flexibility and individualized support. Peer tutoring deepened understanding through collaborative explanations, enhancing both engagement and performance.
8	Ovie et al., (2023)	Quantitative Findings: Achievement and attitudes toward chemistry significantly differed across instructional methods, with the study question-based strategy scoring highest, followed by peer tutoring, and then the lecture method. Consistent results across two states confirmed the effectiveness of interactive, student-centered approaches. Qualitative Findings: The success of study question-based and peer tutoring methods was linked to active engagement, critical thinking, and peer collaboration. Students noted improved understanding and more positive attitudes toward chemistry

No.	Author/s and Year of Publication	Effects of Peer Tutoring on Learning Outcomes
9	Soriano (2022)	Quantitative Findings: The Online Peer Tutoring (OPT) Program significantly improved student performance, with mean scores rising from 15.46 to 16.86 ($T = 5.000 > 2.052$, $p < 0.05$), confirming its effectiveness for Grade 11 HUMSS students in Earth and Life Science. Qualitative Findings: Students highlighted enhanced peer relationships, accountability, and self-directed learning. OPT was seen as a valuable and innovative approach, recommended for broader implementation.
10	Ozcan et al., (2024)	Quantitative Findings: Peer instruction significantly raised test scores on acids and bases ($M = 10.10$ to 19.52, $p < 0.05$) and reduced misconceptions. However, no significant changes were found in attitudes or argumentation skills despite slight gains. Qualitative Findings: Students reported increased motivation and engagement, attributing success to peer discussions and structured learning through readings and quizzes. The method fostered a collaborative environment that supported conceptual clarity and participation.
11	Kwasi & Achor (2025)	Quantitative Findings: Problem-Based Learning (PBL) and Peer Tutoring significantly enhanced higher-order thinking skills in redox reactions, with mean gains of 53.71 and 53.12, respectively, outperforming the lecture method (27.27). The effect of instructional strategy was significant ($F = 228.119$, $p = .000$), accounting for 76.3% of performance variance. No significant difference was found between PBL and peer tutoring ($p = 0.986$). Qualitative Findings: PBL promoted critical thinking and collaboration, while peer tutoring encouraged active engagement and meaningful interaction. Both strategies supported cognitive development and were effective across genders.
12	Potutan & Macagba (2025)	Quantitative: Peer Tutoring and Discussion (PTD) was rated highly ($M = 3.46$) for helpfulness, empowerment, and motivation, with a significant posttest score improvement ($p = .000$). Though highly effective for conceptual understanding, PTD was slightly less effective in building independent confidence.

No.	Author/s and Year of Publication	Effects of Peer Tutoring on Learning Outcomes
		Qualitative: PTD fostered collaboration and peer support, making mistakes part of the learning process. Students valued the environment but suggested longer tutor preparation and better tutor-learner matching to improve outcomes.
13	Lamina (2021)	Quantitative Findings: Students' chemistry scores improved significantly from 13.83 to 26.06 (p = .000) under the Peer-Led Team Learning (PLTL) approach. Engagement scores also increased from 46.53 to 54.25, showing enhanced cooperation, interest, and participation. Qualitative Findings: Students felt more comfortable learning from peers, leading to better understanding and interaction. High-ability students benefited most, while some low-ability learners struggled slightly, though overall feedback remained positive and supportive of PLTL.
14	Gongden (2021)	Quantitative Findings: Reciprocal Peer Tutoring (RPT) significantly improved both achievement (M = 17.04 vs. 14.80) and retention (M = 16.89 vs. 13.00), with p = .000 for both. No significant gender differences were found in achievement (p = .464) or retention (p = .081). Qualitative Findings: Students viewed RPT as effective for understanding and retaining chemical kinetics. Its structured, inclusive nature promoted collaboration and was well-received across all genders, making it a strong candidate for use in chemistry instruction.
15	Van Hoe et al., (2024)	Quantitative Findings: Peer assessment significantly improved students' knowledge of climate change compared to the control group, regardless of the presence of peer dialogue. Revisions were made in 43.46% of cases, and quality improved significantly when revisions occurred. Qualitative Findings: Students viewed peer assessment as fair and constructive, revising work without strong negative emotions. While dialogue had little effect on emotional response, initial concerns about discomfort were largely unfounded.
16	Verma & Ali (2023)	Quantitative Findings: The project led to significant gains in students' interest in science, with large effect

No.	Author/s and Year of Publication	Effects of Peer Tutoring on Learning Outcomes
		sizes in enjoyment (0.57) and interest in science fiction concepts (0.56). Increases in acid-base knowledge and STEM career interest were also observed, with fewer students reporting disinterest in STEM. Qualitative Findings: Student reflections revealed greater appreciation for science and scientists. Mentorship deepened students' enthusiasm, while mentors also benefited from improved communication skills and satisfaction through meaningful interactions.
17	Alemu (2020)	Quantitative Findings: Consistently implemented Reciprocal Peer Tutoring (3x/week) significantly improved physics achievement (mean diff = 1.96, $p = .002$), especially for low-ability ($p = .001$) and female students ($p = .038$). The intervention accounted for 31.6% of achievement variance ($R^2 = 0.316$). Qualitative Findings: Students favored intensive RPT, particularly among low-achievers and females. Inconsistent application yielded limited impact, and broader implementation was challenged by systemic issues such as poor teaching quality and rigid instructional methods in Ethiopian schools.
18	Thurston et al., (2021)	Quantitative Findings: Tutors, particularly Year 9 students, gained more in reading comprehension (+0.09 effect size) than tutees, who showed a slight, non-significant decline (-0.07). High reliability ($\alpha = 0.93$) and successful error correction (28/29) validated the tutoring process. Qualitative Findings: The program was implemented with high fidelity in structure and content. However, questioning and praise—especially by tutees—were limited. The study emphasized that tutors benefited most, providing early evidence of unequal gains in peer tutoring.
19	Hamidah et al., (2025)	Quantitative Findings: Peer tutoring improved reproductive health knowledge significantly (mean increase from 4.97 to 7.59; $p = .000$), with 97.7% reaching a high-knowledge level post-intervention. However, attitude scores slightly declined and showed no significant change ($p = 0.217$). Qualitative Findings: Though qualitative data was not formally gathered, the discussion suggested that

No.	Author/s and Year of Publication	Effects of Peer Tutoring on Learning Outcomes
		attitudinal change is more complex and was hindered by factors such as program length, lack of emotional content, and limited peer tutor facilitation skills.

Challenges Presented

The review identified four main categories of challenges in implementing peer tutoring: technological barriers, time constraints, pandemic-related disruptions, and contextual challenges. These categories appeared consistently across multiple studies and highlight systemic constraints that affect the success of peer tutoring. Collectively, they demonstrate that both internal and external factors shape the effectiveness of peer tutoring interventions.

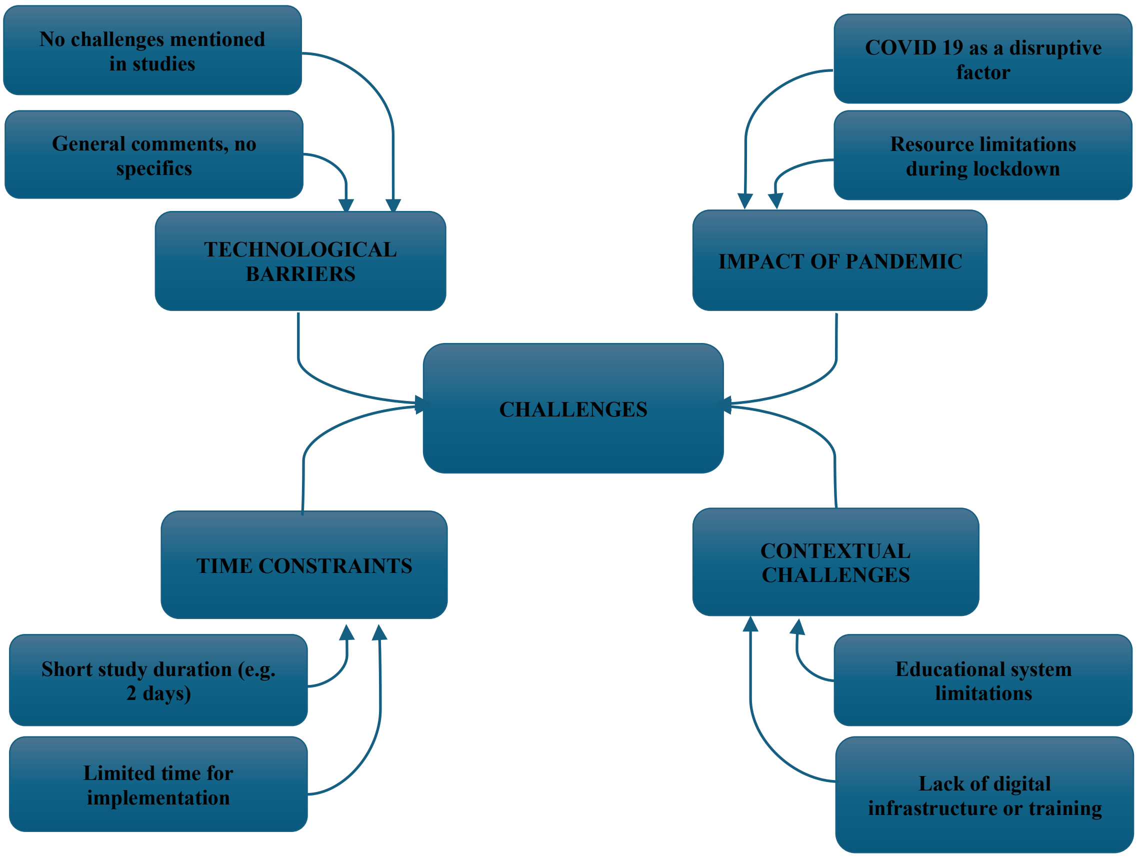

Figure 4. Concept Map of Challenges in Reviewed Studies

Technological barriers were the most frequently reported challenge. Several studies noted that students and peer tutors lacked adequate digital skills, training, and access to resources for online learning (Akanbi, 2022; Azeez et al., 2022; Mama, Owusu, & Wiysonge, 2024). Issues of connectivity, devices, and platform familiarity were cited as obstacles that limited participation (Soriano, 2022).Time constraints also posted significant challenges. Many interventions were short, lasting only a few weeks, which limited their impact on student learning outcomes (Alemu, 2020; Ozcan et al., 2024). In addition, peer tutors often received minimal preparation, reducing the quality of peer-led instruction (Potutan & Macagba, 2025).The COVID-19 pandemic further complicated peer tutoring practices. Lockdowns forced a rapid shift to online and hybrid modalities that disrupted traditional classroom dynamics. Limited access to digital resources and lack of readiness for remote learning created additional barriers (Soriano, 2022). Contextual challenges in schools were also evident. Overcrowded classrooms, shortages of qualified teachers, inadequate laboratory facilities, and weak digital infrastructure hindered effective implementation (Alemu, 2020; Ruth & John, 2025). Institutional barriers such as high teacher turnover and limited school-level support were also reported (Verma & Ali, 2023).

Discussion

Geographical Trends

The dominance of Nigerian studies reflects persistent educational challenges such as overcrowded classrooms, teacher shortages, and limited instructional resources (Akanbi, 2022; Kalu-Uche & Ogbonna, 2021; Gongden, 2020). Peer tutoring in this context consistently produced improvements in achievement, motivation, and engagement (Amoo, 2022; Azeez et al., 2022; Iwanger & Opita, 2025). In the Philippines, similar benefits were observed, with studies emphasizing learner competency and peer-facilitated instruction (Lamina, 2021; Soriano, 2022). Meanwhile, research from Turkey and Belgium highlighted peer tutoring's impact on metacognition and collaborative learning (Ozcan et al., 2024; Van Hoe et al., 2024). The Indonesian study (Hamidah et al., 2025) demonstrated the adaptability of peer tutoring to contextualized science learning, such as reproductive health.

Educational Levels

The prevalence of secondary school participants highlights adolescents' capacity for reciprocal learning and shared accountability (Akanbi, 2022; Iwanger & Opita, 2025; Kalu-Uche & Ogbonna, 2021). In contrast, Belgium and UK studies (Smith, 2021; Van Hoe et al., 2024) expanded its application to cross-age models, showing its potential to develop metacognitive and collaborative skills beyond single-grade classrooms.

Discipline-Specific Applications

Chemistry's prominence (Azeez et al., 2022; Ephraim, 2021) reflects its abstract, concept-heavy nature, where collaborative reinforcement is particularly beneficial. Physics, Biology, and Earth Science studies (Kwasi & Achor, 2025; Soriano, 2022; Van Hoe et al., 2024) confirmed peer tutoring's effectiveness for both theoretical and experimental learning. Broader applications in STEM (Mama et al., 2024) and Health Education (Hamidah et al., 2025) illustrate its interdisciplinary potential.

Learning Outcomes

Academic achievement emerged as the most reported outcome (Akanbi, 2022; Azeez et al., 2022; Mama et al., 2024). However, studies also underscored gains in conceptual understanding (Kwasi & Achor, 2025; Ozcan et al., 2024), motivation (Ruth & Opita, 2025; Soriano, 2022), and skill development (Mama et al., 2024; Van Hoe et al., 2024). These findings affirm that peer tutoring is not merely an academic intervention but also a catalyst for cognitive, affective, and social growth.

Duration of Implementation

The common four-six weeks of implementation window demonstrates a balance between feasibility and effectiveness (Amoo, 2022; Kareem & Ewuola, 2025; Ruth & Opita, 2025).Longer-term programs (Mama et al., 2024; Soriano, 2022) showed sustained effects, particularly in large-scale and online settings, while short-term interventions provided useful exploratory data (Potutan & Macagba, 2025; Van Hoe et al., 2024). These patterns highlight peer tutoring's flexibility in adapting to varying school contexts and research goals. Overall, the synthesis affirms peer tutoring as a multidimensional instructional strategy capable of addressing academic, cognitive, and affective outcomes. Its global application, particularly in resource-constrained settings, positions it as both a practical and transformative approach for advancing science education.

Types of Peer Tutoring Strategies

The diversity of strategies demonstrates that peer tutoring in science education is not monolithic but a flexible, context-driven practice. The prevalence of general peer tutoring models suggests accessibility and adaptability, particularly in classrooms with limited resources or where formalized programs are challenging to implement. However, the lack of detailed methodological description limits replication and evaluation, highlighting the need for clearer reporting (Topping, 2005). Structured approaches such as RPT, CWPT, and Jigsaw highlight peer tutoring's potential to foster deeper engagement, accountability, and collaboration. RPT, in particular, supports both cognitive and metacognitive development (Roscoe & Chi, 2007). CWPT proved valuable for managing large classes (Maheady et al., 2010), while Jigsaw encouraged ownership of learning and communication skills (Aronson, 2002). Innovative hybrids, such as Flipped Learning with Peer Tutoring (Bergmann & Sams, 2012) and Peer Instruction (Mazur, 1997) also illustrate how traditional peer methods are being adapted for modern, interactive classrooms. These strategies promote real-time feedback, inquiry, and conceptual clarity, aligning well with science education's emphasis on active learning. The emergence of online peer tutoring models (Borup et al., 2014) reflects the shift toward digital and hybrid education. These approaches expand participation, flexibility, and collaboration, particularly in post-pandemic learning environments. Altogether, the spectrum of strategies underscores peer tutoring's dual role as a remedial and enrichment tool. Its success across varied contexts confirms its value as a learner-centered practice that enhances both academic mastery and collaborative skill-building in science education.

Effects of Peer Tutoring on Secondary Students' Learning Outcomes in Science

The results affirm that peer tutoring effectively improves both cognitive and affective learning outcomes in secondary science education. Across contexts, peer tutoring enhanced academic achievement, engagement, and conceptual understanding, making it a versatile strategy. Its consistent success demonstrates its adaptability to different science subjects and cultural settings. Structured strategies such as CWPT, Jigsaw, and RPT appear particularly effective in addressing complex science topics. Their reliance on collaboration, explanation, and interdependence encourages deeper understanding and motivation among students. These findings echo Slavin's (1996) emphasis on cooperative learning as a driver of academic and affective growth. The positive outcomes of RPT further highlight the value of role-switching between tutor and learner. As Roscoe & Chi (2007) suggest, students consolidate knowledge more effectively when teaching others, while also reinforcing self-regulation. This aligns with Vygotsky's sociocultural theory (1978), which underscores the importance of scaffolding and social interaction in learning.

Additionally, affective benefits such as motivation and confidence highlight peer tutoring's role beyond academics. Studies like Ozcan et al. (2024) show that peer tutoring within flipped classrooms fosters autonomy and reduces learning anxiety. These results suggest that peer tutoring promotes supportive environments where students feel empowered to participate. Finally, the absence of gender differences points to peer tutoring's inclusivity in promoting equitable science learning outcomes. Extended and frequent implementation was also linked to greater academic gains, supporting Topping's (2005) claim that repetition and feedback loops maximize peer tutoring's effectiveness. These insights underscore the need for structured, sustained, and context-sensitive peer tutoring programs in science education.

Challenges Presented

The results indicate that technological barriers remain a critical limitation in scaling peer tutoring in science education. Without proper training, connectivity, and digital tools, even well-designed tutoring programs struggle to meet their objectives. These findings emphasize the need for targeted investments in digital literacy and infrastructure to ensure equitable learning opportunities. Time-related constraints also suggest that short intervention periods may not provide sufficient depth for meaningful learning. Peer tutors require more structured preparation and ongoing support to be effective facilitators. Extending program durations and embedding them in regular classroom routines may enhance both learning gains and sustainability. The impact of COVID-19 highlights how external disruptions can exacerbate pre-existing educational challenges. While the pandemic forced innovation in online learning, it also revealed systemic inequities in access to technology. Future peer tutoring initiatives must account for flexibility in delivery models and resilience against disruptions. Contextual challenges underscore the broader structural limitations within many educational systems. Large class sizes, limited laboratory facilities, and institutional instability create environments where peer tutoring is both necessary and difficult to sustain. Addressing these systemic issues requires aligning peer tutoring with policy reforms and school-level capacity building.

Conclusion

This systematic review provides compelling evidence that peer tutoring is a powerful and adaptable instructional strategy in the teaching and learning of science at the secondary level. The reviewed studies—spanning diverse educational contexts, particularly in developing countries—consistently report positive effects on students' academic achievement, conceptual understanding, engagement, and attitudes toward science. Models like Class-

Wide Peer Tutoring (CWPT), Reciprocal Peer Tutoring (RPT), and Jigsaw have been effectively applied in a variety of science subjects, including chemistry, physics, and biology. These strategies not only improve cognitive performance but also support metacognitive development, communication skills, and social growth. The findings highlight that the design and delivery of peer tutoring—such as its duration, frequency, and preparation—greatly influence its success. Peer tutoring, when properly implemented, not only strengthens science learning for students but also promotes collaboration, inclusion, and student-centered education. Beyond academic achievement, peer tutoring fosters motivation, confidence, and enthusiasm in science, which are essential for encouraging long-term participation in STEM. This shows that peer tutoring can serve both as a learning intervention and as a tool for shaping students' future academic and career pathways. Overall, peer tutoring emerges as a sustainable and transformative strategy in enhancing science education.

Recommendations

Based on the findings, it is recommended that peer tutoring be formally integrated into science curricula, particularly in subjects and areas where students frequently struggle. Educators should ensure that both tutors and tutees receive systematic guidance to develop communication, feedback, and collaborative learning skills. Schools are encouraged to adopt and adapt various peer tutoring models suited to their specific context, considering factors such as class size, available resources, and student diversity. To maximize impact, peer tutoring programs should be designed with sufficient duration, frequency, and preparation to ensure meaningful learning gains. Institutions should also provide adequate support, including teacher supervision and appropriate training materials, to sustain effective peer learning. Incorporating technology, such as online and hybrid platforms, can further expand peer tutoring opportunities, especially in rural or resource-constrained settings.

Finally, future research should continue to explore peer tutoring in underrepresented contexts and science disciplines, while also investigating its long-term effects on scientific literacy and STEM career aspirations. Policymakers and educators alike are urged to treat peer tutoring not only as an instructional tool but as a strategic investment in equitable and inclusive science education.

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