

Effectiveness and Application of the Jigsaw Instructional Strategy in Mathematics Education for Enhancing Students' Academic Achievement:

A Literature Review

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Abstract

Mathematics plays a central role in education by developing logical reasoning, problem-solving, quantitative literacy, and scientific thinking. However, persistent difficulties in mathematics achievement remain a concern, particularly where instruction is predominantly teacher-centred and procedural. Cooperative learning strategies have therefore gained attention for promoting active participation, peer interaction, conceptual understanding, and improved academic performance. This literature review examines the theoretical foundations, classroom application, effectiveness, implementation requirements, challenges, and prospects of the Jigsaw instructional strategy in mathematics education, with particular attention to Nigerian secondary schools. A structured narrative review was conducted using literature retrieved from Google Scholar, Scopus, Web of Science, ERIC, ScienceDirect, and SpringerLink, supplemented by reference-list screening and citation tracking. The review primarily covered studies published between 2020 and 2026, while relevant seminal works were retained. Studies were included where they examined Jigsaw or clearly defined Jigsaw-based cooperative learning in mathematics education or related learning outcomes. Following screening, duplicate removal, full-text assessment, and application of the inclusion criteria, 15 studies were included. The reviewed evidence generally indicates that well-structured Jigsaw instruction can improve students' mathematics achievement, engagement, communication, and conceptual understanding. However, its effectiveness varies according to content structure, implementation fidelity, group composition, teacher preparation, students' prior knowledge, assessment procedures, and available instructional time. The review therefore concludes that Jigsaw should not replace direct instruction universally but should be strategically combined with teacher explanation, guided practice, formative assessment, and individual evaluation. When appropriately designed and implemented, the strategy offers considerable potential for improving mathematics teaching and learning in Nigeria, particularly for topics that can be divided into meaningful and interdependent learning components.

Keywords: Jigsaw strategy, cooperative learning, mathematics education, academic achievement, peer teaching, secondary school mathematics, Nigeria

1. Introduction

Mathematics is a fundamental component of formal education and plays an important role in developing logical reasoning, quantitative literacy, critical thinking, and problem-solving competence. Its relevance extends beyond the classroom to science, technology, engineering, economics, business, medicine, and everyday decision-making. Consequently, students' ability to understand and apply mathematical knowledge is an important indicator of educational quality and human-capital development.

Despite its importance, mathematics continues to be perceived by many students as difficult, abstract, and anxiety-provoking. Difficulties are often associated not only with the nature of mathematical concepts but also with how mathematics is taught. In classrooms where instruction is dominated by teacher explanation, memorisation of formulas, imitation of worked examples, and individual completion of exercises, students may acquire procedural knowledge without developing sufficient conceptual understanding or mathematical communication skills. Such practices may also restrict opportunities for students to explain their reasoning, compare solution strategies, challenge misconceptions, and construct mathematical meaning collaboratively.

These concerns have stimulated interest in learner-centred and cooperative approaches to mathematics instruction. Cooperative learning involves students working in carefully structured small groups in which members support one another while remaining individually accountable for learning. Research on cooperative learning has generally indicated positive effects on academic and social outcomes when the approach is implemented systematically rather than reduced to unstructured group work (Gillies, 2016; Johnson & Johnson, 2009; Slavin, 2015).

The Jigsaw instructional strategy is one of the most distinctive forms of cooperative learning. Developed by Elliot Aronson and colleagues in the early 1970s, Jigsaw was designed to create positive interdependence by assigning students responsibility for different components of a common learning task. Students initially work in heterogeneous “home groups,” after which members responsible for the same content meet in “expert groups” to study, discuss, and master their assigned material. They subsequently return to their home groups and teach their respective components to their peers. The process transforms students from passive recipients of information into active participants and peer instructors.

The structure of Jigsaw is particularly relevant to mathematics because mathematical knowledge frequently involves related concepts, procedures, representations, and applications that can be organised into coherent sub-components. For example, a lesson on quadrilaterals may be divided into properties of squares, rectangles, parallelograms, rhombi, and trapezia. Similarly, topics such as probability, statistics, algebraic expressions, simultaneous equations, and trigonometry may be organised into complementary subtopics.

Empirical evidence, however, does not justify an unqualified claim that Jigsaw always improves mathematics achievement. Abed et al. (2020), for example, reported higher mathematics

achievement among students taught using Jigsaw than among students receiving conventional instruction. Conversely, Şengül and Katrancı (2014), in a study involving transformation geometry, found no significant difference in students' mathematics self-efficacy following Jigsaw instruction. Such findings suggest that the effectiveness of Jigsaw may depend on the outcome being measured and the conditions under which the strategy is implemented.

This interpretation is reinforced by the systematic review and meta-analysis conducted by Cochon Drouet, Lentillon-Kaestner, and Margas (2023), which examined 69 Jigsaw studies. The review found considerable variability in Jigsaw effects on achievement, motivation, social relations, and self-esteem and identified characteristics such as sample size, student diversity, and content as possible explanatory factors.

Therefore, rather than presenting Jigsaw as inherently superior to conventional instruction, it is more appropriate to examine when, why, for whom, and under what instructional conditions it is effective. This perspective is particularly important in Nigeria, where mathematics classrooms may vary considerably in class size, teacher preparation, instructional resources, students' prior knowledge, and access to digital technologies. Although cooperative learning has received considerable attention internationally, limited empirical evidence exists regarding the effectiveness of the Jigsaw instructional strategy specifically in Nigerian secondary school mathematics classrooms. Much of the available literature on Jigsaw has been generated outside Nigeria, while Nigerian studies on cooperative learning have often examined cooperative learning broadly rather than focusing specifically on Jigsaw and its effects on students' mathematics achievement. Consequently, there remains a need for a focused examination of the theoretical foundations, applications, effectiveness, and contextual factors associated with Jigsaw instruction in Nigerian secondary school mathematics education. Addressing this gap is important for determining whether evidence concerning Jigsaw generated in other educational contexts can reasonably inform mathematics teaching and learning in Nigeria.

Against this background, this literature review examines the theoretical foundations and practical application of the Jigsaw strategy in mathematics education, synthesises evidence concerning its effects on students' academic achievement, identifies conditions that facilitate or constrain its effectiveness, and discusses its relevance to Nigerian secondary school mathematics.

2. Purpose and Scope of the Review

The purpose of this review is to critically examine existing literature on the effectiveness and application of the Jigsaw instructional strategy in mathematics education.

Specifically, the review addresses the following issues:

1. the theoretical foundations of the Jigsaw instructional strategy;
2. the conceptual meaning and structure of Jigsaw;
3. major variants and adaptations of the strategy;
4. applications of Jigsaw to secondary school mathematics;

5. empirical evidence concerning students' mathematics achievement;
6. effects on motivation, engagement, communication, and other learning outcomes;
7. factors influencing successful implementation;
8. challenges associated with the use of Jigsaw; and
9. implications for mathematics teaching in Nigerian secondary schools.

The review is conceptual and integrative rather than a statistical meta-analysis. It therefore synthesises findings across foundational works, empirical studies, and systematic reviews to develop an evidence-informed interpretation of Jigsaw in mathematics education.

3. Methodology of the Literature Review

This literature review adopted a structured narrative review approach to examine the theoretical foundations, application, effectiveness, and educational implications of the Jigsaw instructional strategy, with particular attention to mathematics education. The review was designed to identify relevant theoretical and empirical literature, critically examine reported findings, and synthesise evidence concerning the conditions under which Jigsaw may enhance students' academic achievement and related learning outcomes.

3.1 Databases and Sources Searched

A systematic search of relevant academic literature was conducted using major scholarly databases and academic search platforms. The principal sources searched included Google Scholar, Scopus, Web of Science, ERIC, ScienceDirect, and SpringerLink. Additional relevant publications were identified through the reference lists of selected articles and through citation tracking of key studies. This supplementary searching was used to identify important theoretical works and empirical studies that might not have been retrieved through the initial database searches.

Priority was given to peer-reviewed journal articles, systematic and literature reviews, empirical studies, scholarly books, and authoritative academic publications relevant to cooperative learning, the Jigsaw instructional strategy, mathematics education, and students' academic achievement.

3.2 Search Keywords and Search Strategy

The literature search employed combinations of keywords and Boolean operators to obtain studies directly relevant to the objectives of the review. The principal search terms included:

- “Jigsaw instructional strategy”
- “Jigsaw strategy”
- “Jigsaw cooperative learning”
- “Jigsaw method” AND mathematics
- “cooperative learning” AND mathematics achievement
- “Jigsaw” AND “mathematics education”
- “Jigsaw” AND “academic achievement”

- “Jigsaw” AND “mathematics achievement”
- “Jigsaw” AND “secondary school students”
- “Jigsaw” AND “student achievement”
- “Jigsaw” AND motivation
- “Jigsaw” AND self-efficacy
- “Jigsaw” AND conceptual understanding

The search strategy was deliberately broad at the initial stage and was subsequently narrowed according to the relevance of retrieved studies to the focus of the review. Where appropriate, related terms such as cooperative learning, peer learning, collaborative learning, student achievement, and mathematics learning were combined with Jigsaw-related terms.

3.3 Selection Criteria

Studies were selected according to predetermined inclusion and exclusion criteria. The review primarily emphasised literature published between 2020 and 2026 in order to capture recent developments and empirical evidence concerning Jigsaw instruction and mathematics education. However, seminal theoretical and foundational publications, particularly those associated with Vygotsky’s social constructivist perspective and the development of cooperative learning, were retained irrespective of publication year because of their theoretical significance.

Studies were included when they:

1. examined the Jigsaw instructional strategy or a clearly identifiable Jigsaw-based cooperative-learning approach;
2. addressed mathematics education or provided findings directly relevant to mathematics learning;
3. investigated students’ academic achievement, conceptual understanding, motivation, engagement, self-efficacy, or related educational outcomes;
4. were empirical studies, theoretical papers, scholarly reviews, or authoritative academic publications;
5. provided sufficient information concerning the instructional intervention, participants, outcomes, or theoretical argument; and
6. were published in peer-reviewed or academically credible sources.

Studies were excluded when they:

1. focused exclusively on cooperative-learning approaches unrelated to Jigsaw;
2. had no meaningful connection with mathematics education or the learning outcomes examined in this review;
3. were duplicate publications;
4. were opinion pieces, commercial materials, unpublished web content, or sources lacking sufficient academic credibility; or

5. contained insufficient information to establish their relevance to the objectives of the review.

3.4 Screening and Selection Process

The screening process was conducted in successive stages. First, the titles and abstracts of retrieved records were examined to determine their apparent relevance to the review topic. Duplicate records were removed before further screening. Second, potentially relevant studies were subjected to full-text examination to determine whether they satisfied the established inclusion criteria. Third, the reference lists of particularly relevant studies were examined to identify additional publications that could contribute to the review.

During screening, particular attention was given to the distinction between Jigsaw as a specific cooperative-learning strategy and cooperative learning in general. This distinction was important because evidence concerning cooperative learning as a broad instructional approach cannot automatically be interpreted as evidence for the effectiveness of the Jigsaw strategy.

The final body of literature was therefore selected on the basis of relevance, academic credibility, theoretical contribution, methodological quality where such information was available, and direct connection with the objectives of the review. The selection process was intended to reduce the possibility of including studies merely because they reported positive findings about cooperative learning.

3.5 Approach to Data Extraction and Synthesis

Information from the selected literature was organised thematically rather than statistically aggregated. The review extracted and compared information relating to the theoretical foundation of Jigsaw, characteristics of the instructional procedure, study context, participants, mathematics topics, research design, outcome variables, major findings, and reported limitations.

The synthesis followed a thematic and critical narrative approach. Studies were compared according to areas of convergence, divergence, and gaps in the existing evidence. Particular attention was given to whether reported effects concerned academic achievement, conceptual understanding, motivation, engagement, self-efficacy, or other outcomes. This distinction was considered necessary because improvement in one outcome should not automatically be interpreted as evidence of improvement in another.

The synthesis also considered contextual and implementation factors that may influence the effectiveness of Jigsaw, including group composition, students' prior knowledge, teacher facilitation, quality of instructional materials, task structure, individual accountability, duration of intervention, assessment procedures, and the nature of the mathematics content taught.

Rather than assuming that all studies provide equivalent evidence, greater interpretive attention was given to studies with clear research designs, appropriate comparison groups, adequate descriptions of the intervention, and clearly defined outcome measures. Where findings differed

across studies, possible explanations were considered in relation to methodological and contextual differences.

Overall, the methodology was intended to provide a balanced synthesis of the literature by identifying not only evidence supporting the effectiveness of Jigsaw but also studies reporting limited, mixed, or non-significant effects. This approach provides a more cautious basis for evaluating the potential contribution of Jigsaw instruction to mathematics education.

3.6 Scope and Limitations of the Review

Although the review employed a structured search and screening process, it should be regarded primarily as a structured narrative literature review rather than a fully systematic review or meta-analysis. The inclusion of recent literature from 2020–2026 was prioritised, while seminal theoretical works were retained because they provide the conceptual foundations necessary for understanding the Jigsaw strategy. Differences in research designs, populations, mathematics topics, intervention durations, outcome measures, and educational contexts also limited direct comparison across studies.

Consequently, the conclusions drawn from the literature are interpreted in terms of patterns and consistencies across studies rather than as estimates of a single overall effect size. The methodology nevertheless provides a transparent framework for identifying, selecting, examining, and synthesising relevant evidence on the application and effectiveness of the Jigsaw instructional strategy in mathematics education.

4. Theoretical Foundations of the Jigsaw Strategy

4.1 Social Constructivist Theory

The social constructivist perspective associated particularly with Vygotsky (1978) provides one of the strongest theoretical foundations for Jigsaw instruction. Social constructivism conceptualises learning as an active process through which individuals construct knowledge through interaction with other people and with their learning environment.

The Jigsaw strategy operationalises this principle by creating structured opportunities for students to discuss mathematical ideas, explain procedures, ask questions, challenge interpretations, and negotiate meaning. The expert-group phase enables learners to construct shared understanding of a particular mathematical concept, while the home-group phase requires them to communicate that understanding to peers.

The process also corresponds to Vygotsky's concept of the Zone of Proximal Development, in which learners can accomplish tasks with appropriate assistance that they may not yet be able to perform independently. In mathematics, peer explanation can provide an additional layer of scaffolding through which students encounter alternative ways of interpreting concepts and solving problems.

However, peer interaction does not automatically guarantee correct mathematical understanding. The teacher therefore remains important as a facilitator who monitors discussions, identifies misconceptions, provides corrective explanations, and ensures that students eventually acquire accurate mathematical knowledge.

4.2 Social Interdependence Theory

Social interdependence theory provides another major foundation for cooperative learning. The theory proposes that the outcomes of individuals are affected by their relationships with other members of a group. Positive interdependence exists when individuals perceive that they can achieve their goals only when other group members also achieve theirs (Johnson & Johnson, 2009).

Jigsaw creates positive interdependence by assigning each learner responsibility for a specific component of the lesson. A student studying the properties of a rhombus, for example, must understand the material sufficiently to teach it to other members of the home group. The learning of the group therefore depends partly on the contribution of each individual.

The strategy simultaneously promotes individual accountability. Each learner must master an assigned component rather than allowing stronger group members to complete the entire task. This combination of positive interdependence and individual accountability distinguishes structured cooperative learning from ordinary group work.

4.3 Cognitive Learning Perspective

The Jigsaw strategy also has important cognitive implications. Mathematics learning requires learners to process information, connect concepts, select appropriate procedures, monitor reasoning, and apply knowledge to unfamiliar problems. Jigsaw increases cognitive engagement by requiring students not merely to receive information but to analyse, discuss, explain, organise, and teach it.

The act of explaining mathematical reasoning to peers can encourage students to reorganise their knowledge and identify gaps in their own understanding. Similarly, questions raised by peers may expose misconceptions that might remain hidden during conventional teacher-centred instruction.

Nevertheless, the cognitive benefits of peer teaching depend heavily on the quality of the instructional materials and the level of scaffolding provided. Jigsaw is therefore most effective when expert groups are supplied with carefully designed learning resources, guiding questions, worked examples, and opportunities for corrective feedback.

4.4 Motivation and Engagement

The Jigsaw strategy also has an affective dimension. Students who perceive mathematics as threatening or difficult may become reluctant to participate in whole-class discussions. Small-group interaction can create a less intimidating environment in which students have more opportunities to express their ideas and ask questions.

Furthermore, assigning each learner an important role can increase students' sense of responsibility and belonging. Students may become more engaged because their contribution is necessary for the success of the group.

However, positive perceptions should not be confused automatically with improved achievement. The literature demonstrates that Jigsaw may affect cognitive and affective outcomes differently. The finding by Şengül and Katrancı (2014) that Jigsaw did not significantly improve mathematics self-efficacy illustrates the importance of distinguishing between achievement, motivation, self-efficacy, and other outcomes.

5. Conceptualisation of the Jigsaw Instructional Strategy

The Jigsaw strategy is a structured cooperative-learning procedure in which students learn different components of a common lesson and subsequently teach those components to members of their original groups.

The metaphor of the jigsaw puzzle is central to the strategy: each learner possesses one “piece” of the lesson, and the complete learning experience emerges when the pieces are brought together.

A typical Jigsaw lesson involves the following stages:

Stage 1: Introduction and Preparation.

The teacher introduces the general topic, establishes learning objectives, explains the Jigsaw procedure, and provides appropriate instructional materials.

Stage 2: Formation of Home Groups.

Students are organised into heterogeneous groups, normally consisting of approximately four to six learners. Each member receives a different subtopic or learning responsibility.

Stage 3: Formation of Expert Groups.

Students leave their home groups and join other students who have been assigned the same subtopic. The expert groups examine the content, solve relevant mathematical problems, discuss alternative methods, and clarify misconceptions.

Stage 4: Return to Home Groups.

Students return to their original groups and teach their assigned material to their colleagues. Members listen, ask questions, take notes, and connect the different components.

Stage 5: Synthesis.

The home group integrates the different components into a coherent understanding of the complete lesson.

Stage 6: Teacher Consolidation.

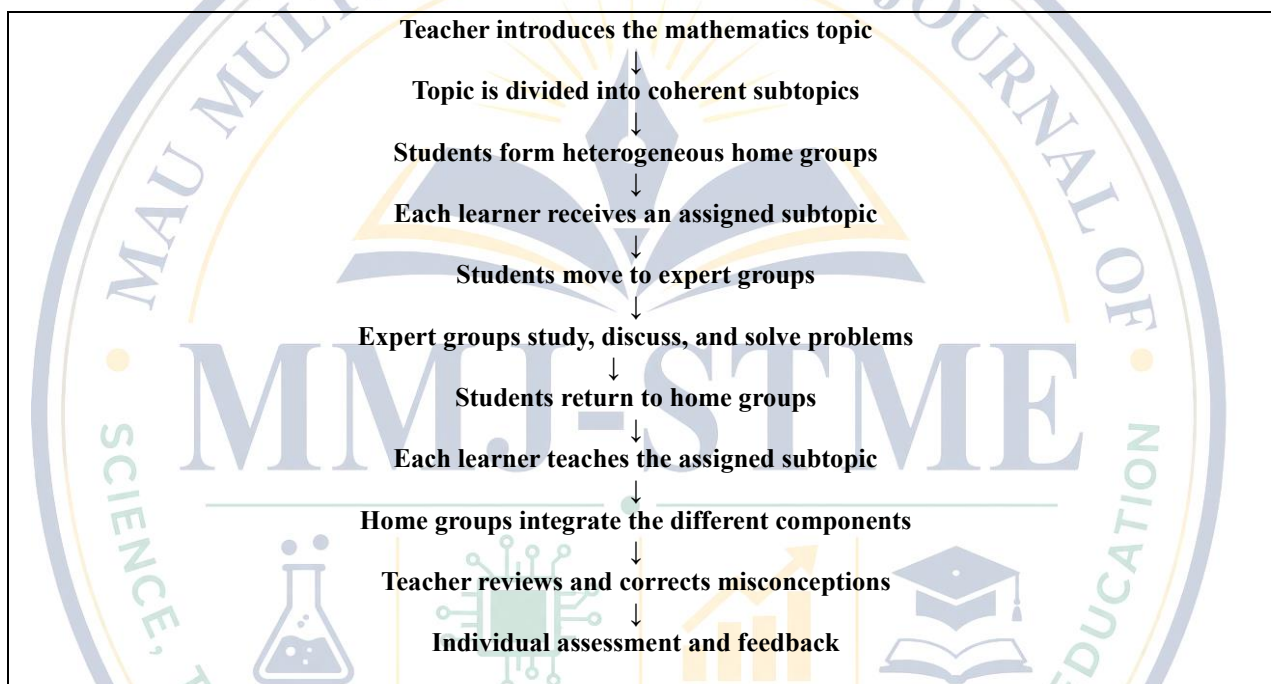
The teacher conducts a whole-class review, corrects misconceptions, highlights essential concepts, and provides additional explanation where necessary.

Stage 7: Individual Assessment.

Students complete an individual task, quiz, or mathematics achievement test to determine whether the intended learning has occurred.

This final stage is particularly important because cooperative learning should not eliminate individual accountability

6. Operational Flow of the Jigsaw Strategy



This sequence demonstrates that Jigsaw is not simply “group work.” Its distinctive features are structured interdependence, expert-group learning, peer teaching, individual accountability, and teacher monitoring.

7. Jigsaw Variants and Their Application to Mathematics

The development of cooperative learning has produced several adaptations of the original Jigsaw model. These variants should be distinguished carefully because they differ in structure and assessment.

7.1 Jigsaw I: The Classic Aronson Model

The original Jigsaw model developed by Aronson and colleagues emphasises positive interdependence. Students study different components of a lesson in expert groups and subsequently teach those components to their home groups.

Application to Mathematics

Jigsaw I is particularly appropriate for topics that contain clearly related components.

For example, an SS1 lesson on properties of quadrilaterals may be divided into: square; rectangle; parallelogram; rhombus; and trapezium.

Each expert group examines definitions, properties, angle relationships, diagonals, area, and perimeter. Students then return to their home groups and explain their assigned quadrilateral.

The principal advantage is that students learn to classify, compare, explain, and communicate mathematical concepts.

7.2 Jigsaw II

Jigsaw II represents a more structured adaptation associated with Slavin. It retains the basic Jigsaw procedure but strengthens accountability through common learning materials, assessment, and recognition of group performance. Jigsaw II is particularly relevant to mathematics because students can be required to complete individual mathematics tasks after the cooperative learning phase.

Example: An SS2 lesson on factorisation may be divided into: common factors; difference of two squares; perfect-square trinomials; factorisation by grouping; and quadratic expressions.

Students study the assigned component in expert groups, teach it in their home groups, and subsequently complete an individual assessment covering the entire topic.

This model is particularly suitable where teachers need to combine cooperative learning with individual accountability and examination preparation.

7.3 Jigsaw III and Jigsaw IV

The development of Jigsaw did not end with Jigsaw II. Later adaptations introduced additional review, assessment, and teacher intervention components.

Holliday's Jigsaw IV was developed specifically to address concerns about whether students had understood the material and whether teachers could identify areas requiring additional explanation. The model incorporates an introductory component, quizzes, and additional teaching where necessary.

This distinction is important because the original paper incorrectly treats Jigsaw III as though it were principally a general “feedback-rich” model and attributes its development to Holliday. The literature indicates that Holliday is more appropriately associated with Jigsaw IV, not Jigsaw III.

Application to Mathematics

These more structured variants are appropriate for topics such as: statistics; probability; functions; trigonometry; coordinate geometry; and data interpretation.

For example, in SS2 Statistics, expert groups may study mean, median, mode, and weighted mean. Following peer teaching, students complete a common assessment. The teacher then identifies misconceptions and reteaches difficult components.

7.4 Online and Blended Jigsaw

Digital technologies have expanded the possible implementation environments for Jigsaw. In an online or blended model, students may collaborate through learning-management systems, video-conferencing platforms, discussion forums, or mobile communication tools.

In mathematics, digital tools such as dynamic geometry software, graphing applications, spreadsheets, and computer-based simulations can support expert-group exploration.

Example: SS3 Trigonometry

Expert groups may examine: trigonometric ratios; complementary angles; solving right-angled triangles; applications of trigonometry; and graphical representations.

Students may use digital mathematical representations to investigate relationships before returning to their home groups to teach their findings. However, digital Jigsaw should not be presented as automatically superior to face-to-face Jigsaw. Its effectiveness depends on access to devices, connectivity, digital competence, instructional design, and students' ability to participate meaningfully in online collaboration.

7.5 Problem-Based Jigsaw in Mathematics

A particularly useful adaptation for mathematics is the integration of Jigsaw with problem-based learning. Instead of dividing a topic into factual subtopics, the teacher presents a complex mathematical problem and divides the solution process into interconnected components.

For example, an SS2 algebraic word problem may require students to: identify relevant information; translate the problem into mathematical expressions; formulate equations; solve the equations; and interpret and verify the solution.

Different students or expert groups work on different components before combining their reasoning in the home groups. This adaptation is especially useful for developing mathematical problem-solving and reasoning because it requires learners to understand not only what procedure to use but also why and when the procedure is appropriate.

8. Application of Jigsaw to Nigerian Secondary School Mathematics

The Nigerian secondary school mathematics curriculum emphasises mathematical concepts, reasoning, problem-solving, communication, and applications. Jigsaw can support these objectives when the content is appropriately selected, and the instructional procedure is carefully structured.

Potential applications include:

S/N	Mathematics area	Possible Jigsaw subtopics
1	Algebra	Factorisation methods
2	Simultaneous equations	Substitution, elimination, graphical method
3	Geometry	Properties of different quadrilaterals
4	Statistics	Mean, median, mode, range, standard deviation
5	Probability	Basic probability, complementary events, combined events
6	Trigonometry	Ratios, angles, applications, graphs
7	Mensuration	Areas, volumes, surface areas, composite figures
8	Coordinate geometry	Gradient, midpoint, distance, equation of a line
9	Functions	Domain, range, representation, transformation
10	Number	Indices, logarithms, surds, number bases

The appropriateness of a topic should nevertheless be determined by the logical interdependence of its components, rather than by the topic title alone. A mathematical topic that cannot be divided without destroying conceptual coherence may be unsuitable for Jigsaw.

9. Evidence on the Effectiveness of Jigsaw in Mathematics Achievement

The empirical literature generally provides support for the potential of Jigsaw to improve academic achievement, but the evidence should be interpreted critically.

Abed et al. (2020) investigated Jigsaw among 80 mathematics students and reported that students taught through the strategy performed better than those taught through a conventional teacher-centred approach. The study also reported more positive attitudes among students in the Jigsaw group.

Broader evidence is also supportive of cooperative learning. A 2022 meta-analysis of cooperative-learning studies involving vocational high-school mathematics found evidence of positive effects on mathematics learning outcomes, although the evidence concerned cooperative learning more broadly rather than Jigsaw alone.

More recently, a 2025 systematic review and meta-analysis of cooperative learning and mathematics achievement among primary-school students reported a pooled Hedges' g of 0.71, although substantial heterogeneity was observed across studies. The review also found relatively strong effects for frequently used cooperative-learning models, including Jigsaw.

These findings provide a reasonable basis for considering cooperative learning as a valuable component of mathematics instruction. Nevertheless, evidence from broader cooperative-learning research should not be presented as direct evidence that Jigsaw itself produces the same effect. The

distinction between Jigsaw-specific evidence and general cooperative-learning evidence is methodologically important.

The strongest caution comes from the systematic review and meta-analysis by Cochon Drouet et al. (2023), which analysed 69 Jigsaw studies and found substantial variability in effects. The authors identified differences in sample size, student diversity, and content as possible moderators.

Therefore, the most defensible conclusion is not that Jigsaw universally improves mathematics achievement, but that well-designed Jigsaw instruction has considerable potential to improve achievement under appropriate instructional conditions.

10. Jigsaw and Mathematics Self-Efficacy

Although achievement is the primary concern of this review, affective outcomes are relevant because students' beliefs about their mathematical capabilities can influence participation and persistence.

Jigsaw theoretically provides several mechanisms through which self-efficacy might develop. Students can observe peers solving mathematical problems, receive assistance, experience successful task completion, and gain confidence from teaching others.

However, empirical evidence is not uniformly supportive. Şengül and Katrancı (2014) examined Jigsaw in transformation geometry among seventh-grade students and found no statistically significant difference between students' pre-test and post-test mathematics self-efficacy scores.

This finding is valuable because it cautions against assuming that an instructional strategy that improves achievement will necessarily produce corresponding improvements in self-efficacy.

11. Jigsaw, Engagement, Communication and Mathematical Reasoning

One of the strongest pedagogical arguments for Jigsaw lies in the opportunities it provides for students to communicate mathematical ideas.

Mathematics learning is not limited to obtaining correct answers. Students must also be able to explain their reasoning, interpret representations, justify procedures, compare solution strategies, and communicate conclusions.

Jigsaw creates repeated opportunities for these activities. Students explain concepts in expert groups and subsequently communicate them to home-group members. This process can promote mathematical language and reasoning.

However, the quality of communication is determined partly by task design. Simply asking students to “teach each other” without guidance may result in superficial explanations or the transmission of misconceptions. Effective Jigsaw therefore requires carefully designed prompts, examples, guiding questions, and teacher monitoring.

12. Factors Influencing the Effectiveness of Jigsaw

The effectiveness of Jigsaw depends on several interacting factors.

12.1 Nature of Mathematical Content: Jigsaw is most appropriate when a lesson can be divided into meaningful and interdependent components. Poorly segmented content may result in fragmented understanding.

12.2 Group Composition: Heterogeneous groups can facilitate peer learning by bringing together students with different levels of prior knowledge. However, group diversity must be managed carefully so that stronger students do not dominate while less confident learners remain passive.

12.3 Teacher Preparation: Jigsaw requires more planning than conventional lecture-based instruction. Teachers must prepare subtopics, instructional materials, expert-group tasks, guiding questions, assessment instruments, and time allocations.

12.4 Students' Prior Knowledge: Students cannot necessarily become effective “experts” simply because they are assigned a subtopic. They require sufficient background knowledge and appropriate scaffolding.

12.5 Time: Jigsaw requires time for movement between groups, expert discussion, peer teaching, synthesis, and assessment. In overcrowded Nigerian classrooms, time management may therefore constitute a significant challenge.

12.6 Assessment: Individual assessment is essential. Without it, students may depend excessively on group members and teachers may be unable to determine whether individual learning has occurred.

12.7 Classroom Climate: Jigsaw requires a classroom culture characterised by respect, cooperation, active listening, and willingness to ask questions. Students unfamiliar with cooperative learning may require explicit training in these behaviours.

12.8 Teacher Monitoring: The teacher should not disappear from the learning process. Effective Jigsaw involves continuous observation, questioning, formative assessment, correction of misconceptions, and strategic intervention.

13. Challenges and Limitations of Jigsaw in Mathematics Education

Despite its potential benefits, Jigsaw has several limitations.

First, implementation complexity can be considerable. Teachers need to prepare suitable materials and coordinate several learning phases within a limited period.

Second, incorrect peer explanations can lead to misconceptions. This is particularly important in mathematics because an incorrect procedure or interpretation can be propagated from an expert student to an entire home group.

Third, unequal participation may occur when some students dominate discussions while others remain passive.

Fourth, large class sizes can make movement between home and expert groups difficult to manage. This challenge may be particularly relevant to Nigerian secondary schools.

Fifth, student readiness varies. Students with weak prior knowledge may require greater scaffolding before they can effectively function as peer teachers.

Sixth, assessment validity may be compromised if the teacher evaluates only group performance. Individual achievement must therefore be assessed separately.

Finally, the evidence itself is heterogeneous. The 2023 systematic review of 69 Jigsaw studies demonstrates that the effects of Jigsaw vary considerably according to context and outcome. Consequently, Jigsaw should be regarded as a pedagogical tool whose effectiveness depends on appropriate instructional design rather than as a universally effective teaching method.

14. Implications for Mathematics Teachers in Nigeria

The literature suggests several implications for Nigerian mathematics teachers.

First, teachers should select Jigsaw topics strategically rather than attempting to use the strategy for every mathematics lesson.

Second, teachers should provide structured expert materials rather than expecting students to discover all mathematical knowledge independently.

Third, peer teaching should be followed by teacher-led consolidation to correct misconceptions and ensure that all students acquire the required mathematical knowledge.

Fourth, teachers should combine cooperative learning with individual assessment.

Fifth, students should receive explicit instruction in collaborative skills, including listening, explaining, questioning, turn-taking, and constructive disagreement.

Sixth, mathematics teachers should exploit low-cost technologies where available, but digital Jigsaw should be adapted to local realities rather than assuming universal access to reliable internet connectivity and digital devices.

Finally, teacher education and professional development programmes should expose mathematics teachers to the principles and practical management of cooperative learning.

15. Implications for Mathematics Teacher Education and Policy

The potential value of Jigsaw extends beyond individual classrooms. Teacher education institutions can incorporate cooperative-learning design into pre-service and in-service mathematics teacher preparation.

Professional development should move beyond theoretical presentations and provide teachers with opportunities to:

- design Jigsaw mathematics lessons;
- develop expert-group worksheets;
- formulate mathematical guiding questions;
- construct individual and group assessments;
- manage heterogeneous groups;
- identify and correct peer-generated misconceptions; and
- evaluate the effectiveness of cooperative-learning interventions.

At policy level, curriculum implementation should recognise that learner-centred approaches require appropriate conditions. Large classes, inadequate instructional materials, insufficient teacher preparation, and limited instructional time can undermine the effectiveness of otherwise sound pedagogical innovations.

16. Research Gaps

The literature reveals several areas requiring further investigation.

16.1 Nigerian Evidence: There is a need for more rigorous empirical research on Jigsaw in Nigerian secondary school mathematics, particularly studies involving diverse geographical regions and school types.

16.2 Longitudinal Evidence: Many existing studies examine short-term achievement. More longitudinal research is required to determine whether Jigsaw produces durable improvements in mathematical understanding and retention.

16.3 Moderating Variables: Future studies should investigate whether factors such as gender, prior achievement, class size, school location, teacher experience, mathematical topic, and students' prior knowledge moderate the effectiveness of Jigsaw.

16.4 Comparison of Jigsaw Variants: There is insufficient evidence comparing Classic Jigsaw, Jigsaw II, Jigsaw III/IV, blended Jigsaw, and problem-based Jigsaw specifically within mathematics education.

16.5 Higher-Order Mathematics Outcomes: Future research should move beyond achievement scores to examine problem-solving, mathematical reasoning, conceptual understanding, mathematical communication, creativity, and transfer.

16.6 Technology-Supported Jigsaw: Further research is needed on how mobile technologies, learning-management systems, GeoGebra, and other digital tools can support Jigsaw in Nigerian schools, particularly in resource-constrained settings.

16.7 Implementation Fidelity: Researchers should report precisely how Jigsaw was implemented rather than merely describing the intervention as “cooperative learning.” This would improve comparability across studies and strengthen the evidence base.

17. Conclusion

The Jigsaw instructional strategy provides a theoretically grounded and pedagogically promising approach to mathematics education. Its distinctive combination of positive interdependence, individual accountability, expert-group interaction, peer teaching, and teacher facilitation creates opportunities for students to participate actively in the construction and communication of mathematical knowledge.

The available evidence generally supports the potential of Jigsaw to improve academic achievement and engagement. However, the literature does not support the conclusion that Jigsaw is universally effective. Evidence from mathematics-specific studies demonstrates positive achievement effects in some contexts but limited effects on some affective outcomes, while broader systematic evidence reveals substantial variation across studies.

Accordingly, the effectiveness of Jigsaw should be understood as conditional rather than automatic. Its success depends on the suitability of the mathematical content, quality of instructional materials, composition and management of groups, students' prior knowledge, teacher preparation, time allocation, assessment procedures, and fidelity of implementation.

For Nigerian secondary school mathematics, Jigsaw is particularly promising for topics that can be logically divided into related components, including geometry, algebra, statistics, probability, trigonometry, functions, and data handling. Nevertheless, it should complement rather than completely replace teacher explanation, guided practice, formative assessment, and individual learning.

The central implication of the literature is therefore not simply that mathematics teachers should “use Jigsaw,” but that they should use Jigsaw strategically, systematically, and evidence-informedly. When carefully integrated into mathematics instruction, the strategy can transform students from passive recipients of mathematical procedures into active participants who explain, question, reason, collaborate, and take responsibility for mathematical learning.

ADVANCING KNOWLEDGE
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