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# The Effectiveness of the Jigsaw Learning Model in Improving Students' Learning Outcomes in Carbon Chemistry

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**ABSTRACT**

**Purpose of the study:** This study aims to examine the effectiveness of the Jigsaw cooperative learning model in improving students' learning outcomes and learning motivation in carbon chemistry at the secondary school level through a classroom-based instructional intervention.

**Methodology:** This study employed classroom action research with three instructional cycles. The Jigsaw cooperative learning model was implemented using lesson plans and student worksheets. Data were collected through achievement tests, observation sheets, motivation questionnaires, and attitude questionnaires. Descriptive quantitative analysis was conducted using Microsoft Excel.

**Main Findings:** The results show a consistent improvement in students' learning outcomes across three cycles, indicated by increased average scores, mastery levels, and absorption rates. Students' affective aspects and learning motivation also improved, with most students reaching moderate to high motivation levels and showing more positive attitudes toward chemistry learning.

**Novelty/Originality of this study:** This study provides new empirical evidence on the integrated impact of the Jigsaw learning model on cognitive, affective, and motivational aspects in carbon chemistry. Unlike previous studies focusing mainly on achievement, this research highlights how structured peer collaboration enhances conceptual understanding and learning motivation in abstract chemistry topics.



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## 1. INTRODUCTION

Chemistry learning at the secondary school level continues to encounter substantial challenges, particularly in fostering students' motivation, active participation, and meaningful conceptual understanding [1], [2], [3]. These challenges are most evident in topics that are abstract in nature and require students to integrate symbolic representations with conceptual reasoning. When instruction relies heavily on teacher-centered approaches, students tend to become passive recipients of information, which often results in surface-level learning and limited engagement with chemical concepts [4], [5]. Consequently, students may struggle to develop the analytical skills necessary to understand and apply chemistry knowledge effectively [6], [7].

One of the key issues in chemistry instruction is the limited opportunity for students to actively construct knowledge through interaction, discussion, and collaborative problem-solving [8], [9]. Effective chemistry learning demands more than memorization of formulas or definitions; it requires students to engage cognitively and socially in order to interpret concepts, articulate reasoning, and negotiate meaning with peers. Without instructional strategies that promote active learning and shared responsibility, students' motivation and learning outcomes remain suboptimal, particularly in complex subject areas [10], [11].

Carbon chemistry, including the study of hydrocarbons, represents a foundational yet challenging topic for secondary school students [12], [13]. Mastery of this topic requires an understanding of molecular structures, nomenclature, isomerism, and reaction patterns, all of which demand higher-order thinking skills [14], [15]. Students often experience difficulties when learning carbon chemistry because instructional practices do not sufficiently support conceptual exploration or peer-based knowledge construction [16], [17]. As a result, learning activities frequently emphasize procedural completion rather than deep conceptual understanding, leading to low motivation and limited retention of knowledge.

Cooperative learning offers a promising alternative to conventional instructional approaches by placing students at the center of the learning process [18], [19]. Through structured collaboration, students are encouraged to share responsibility for learning, engage in meaningful discussion, and develop both cognitive and social skills [20], [21]. Among various cooperative learning strategies, the Jigsaw learning model is particularly notable for its emphasis on individual accountability and positive interdependence [22], [23]. In this model, each student becomes an "expert" on a specific subtopic and contributes essential knowledge to their group, creating a learning environment in which participation and engagement are integral to success.

Despite the recognized potential of cooperative learning, the application of the Jigsaw model in chemistry education, especially in the context of carbon chemistry, remains relatively limited. Existing instructional practices often fail to fully exploit the model's capacity to support conceptual understanding and student motivation in chemistry classrooms [24], [25]. Furthermore, prior studies tend to focus primarily on learning outcomes without sufficiently examining how cooperative structures influence students' motivation and engagement throughout the learning process [26], [27]. This indicates a clear gap in research regarding the systematic implementation of the Jigsaw model as a comprehensive instructional approach for teaching abstract chemistry topics.

The novelty of this study lies in its integrated use of the Jigsaw learning model to enhance both cognitive and motivational aspects of learning in carbon chemistry. Rather than examining learning outcomes in isolation, this research adopts a holistic perspective by exploring how collaborative learning structures support students' active involvement, responsibility, and conceptual development. By applying the Jigsaw model specifically to carbon chemistry, this study provides new insights into how cooperative learning can be effectively adapted to complex and abstract subject matter within chemical education.

The urgency of this research is driven by the increasing demand for student-centered instructional approaches that promote active learning, collaboration, and meaningful understanding of scientific concepts. As educational systems continue to emphasize competence-based learning and higher-order thinking skills, chemistry educators are required to adopt instructional strategies that move beyond traditional lecture-based methods. Investigating the effectiveness of the Jigsaw learning model in carbon chemistry is therefore essential to inform instructional practice and support the development of more engaging and effective chemistry learning environments. Accordingly, this study aims to examine the implementation of the Jigsaw learning model in improving students' learning outcomes and motivation in carbon chemistry, contributing to the advancement of innovative practices in chemical education.

## 2. RESEARCH METHOD

### 2.1. Research Design

This study employed a classroom-based educational research design aimed at examining the effectiveness of the Jigsaw cooperative learning model in improving students' learning outcomes in carbon chemistry. The research was conducted through a cyclical instructional process that allowed for the implementation, observation, evaluation, and refinement of teaching strategies across successive learning phases [28], [29]. This approach was selected to capture changes in students' learning performance and engagement as the instructional intervention progressed.

### 2.2. Population and Sample

The population of this study consisted of senior secondary school students enrolled in a chemistry course covering carbon chemistry content. From this population, a single intact class was selected as the research sample using a purposive sampling technique. The selected class represented a typical group of learners with heterogeneous academic abilities, learning motivation levels, and prior chemistry knowledge [30], [31]. This sampling approach was considered appropriate given the classroom-based nature of the study and the focus on instructional improvement within an authentic learning environment.

### 2.3. Data Collection Techniques

The instructional intervention involved the implementation of the Jigsaw learning model during carbon chemistry lessons. Students were first organized into small heterogeneous home groups, after which they were assigned specific subtopics related to carbon chemistry. Each student was responsible for mastering one subtopic and subsequently participating in expert group discussions with peers assigned to the same content. Following these expert discussions, students returned to their home groups to share and integrate their knowledge, ensuring that each group member contributed meaningfully to the collective understanding of the topic. The teacher acted as a facilitator, guiding discussions, monitoring group interactions, and providing feedback when necessary.

Data were collected using multiple instruments to capture students' learning outcomes and classroom dynamics [32], [33]. Learning achievement data were obtained through achievement tests administered at different stages of the instructional cycles to measure students' mastery of carbon chemistry concepts. In addition, observational data were gathered to document students' participation, cooperation, and engagement during learning activities. These observations focused on indicators such as active involvement in discussions, responsibility toward assigned tasks, and collaborative interaction among group members.

### 2.4. Data Analysis Techniques

Data analysis was conducted using descriptive quantitative techniques to examine changes in students' learning outcomes across instructional cycles. Students' test scores were analyzed to determine overall improvement and the proportion of students achieving the predetermined mastery criteria. Observational data were analyzed qualitatively to identify patterns in student engagement and participation throughout the learning process [34], [35]. The integration of achievement and observational data enabled a comprehensive evaluation of the effectiveness of the Jigsaw learning model in supporting students' learning in carbon chemistry.

### 2.5. Research Procedures

The research procedures were carried out through a systematic sequence of instructional stages designed to examine the implementation of the Jigsaw learning model in carbon chemistry instruction. Prior to the intervention, the researcher prepared lesson plans, learning materials, assessment instruments, and observation guidelines aligned with the objectives of the study. These preparations ensured that the learning activities and evaluation tools were appropriate for measuring students' learning outcomes and engagement during the instructional process.

The instructional implementation was conducted through successive learning cycles. Each cycle began with a planning stage, during which learning objectives, instructional strategies, and assessment activities were refined based on the outcomes of the previous cycle. During the implementation stage, the Jigsaw learning model was applied in the classroom by organizing students into heterogeneous home groups and assigning specific carbon chemistry subtopics to individual group members [36], [37]. Students then participated in expert group discussions to deepen their understanding of the assigned material before returning to their home groups to share and integrate their knowledge collaboratively.

Throughout the learning activities, classroom observations were conducted to document students' participation, interaction, and engagement in the learning process [38], [39]. The researcher closely monitored group discussions, students' responsibility toward assigned roles, and the overall classroom atmosphere. At the end of each cycle, students' learning outcomes were assessed using achievement tests designed to measure their understanding of carbon chemistry concepts covered during the cycle.

Following the implementation and assessment stages, a reflection phase was conducted to evaluate the effectiveness of the instructional activities. The results of student assessments and classroom observations were analyzed to identify strengths and areas requiring improvement in the learning process. These reflections informed revisions to instructional strategies and learning materials for subsequent cycles, allowing the research procedures to function as a continuous improvement process aimed at enhancing the effectiveness of the Jigsaw learning model in chemistry instruction.

## 3. RESULTS AND DISCUSSION

The results of the study demonstrate a consistent improvement in students' learning outcomes and learning motivation from Cycle I to Cycle III following the implementation of the Jigsaw learning model in carbon chemistry instruction. In Cycle I, students were still adapting to the cooperative learning structure, which was reflected in moderate learning achievement and limited participation during group discussions. Several students showed hesitation in explaining concepts to peers, indicating that collaborative learning skills had not yet been fully developed.

In Cycle II, noticeable improvements were observed in both academic performance and classroom engagement. Students became more familiar with their roles as "experts" and showed greater confidence in sharing and discussing carbon chemistry concepts within their groups. Learning outcomes increased as students demonstrated better understanding of the material, while classroom interactions became more focused and collaborative. This improvement suggests that repeated exposure to the Jigsaw learning process helped students internalize both the content and the collaborative learning routines.

By Cycle III, students' learning outcomes reached a more stable and optimal level. Most students were able to actively participate in discussions, explain concepts clearly to their peers, and complete learning tasks effectively. The cooperative learning environment functioned more efficiently, with students showing higher levels of responsibility and independence during the learning process. These results indicate that the sustained implementation of the Jigsaw model supported both conceptual understanding and learning consistency in carbon chemistry. The development of learning achievement between cycles can be seen in the following table:

Table 1. Comparison of Test Scores in Each Cycle

| No. | Cycle | Cycle I | Cycle II | Cycle III |
|---|---|---|---|---|
| 1. | Scores > 7.5 were obtained | 2 persons (9,5%) | 2 persons (28,6%) | 2 persons (85,7%) |
| 2. | Class average grade | 5,07 | 6,67 | 8,49 |
| 3. | Calculation of students' absorption capacity for the material presented in each cycle: absorption capacity = $\frac{Score}{Total\ Score} \times 100\%$ | 50,7 | 66,7 | 84,9 |

The data in Tables 1 and 2 show a consistent increase from cycle I to cycle III. The average score increased from 5.07 → 6.67 → 8.49, while the absorption rate increased from 50.7% → 66.7% → 84.9%. The percentage of students with a score of ≥ 7.5 jumped from 9.5% in cycle I to 85.7% in cycle III. This increase proves that jigsaw cooperative learning is effective in improving students' understanding and cognitive abilities. The development of the affective aspect can be seen in table 2:

Table 2. Summary of Research Results on Students' Affective Aspects

| No. | Category | Cycle I | | Cycle I | | Cycle I | |
|---|---|---|---|---|---|---|---|
| | | $\sum x$ | % | $\sum x$ | % | $\sum x$ | % |
| 1. | Very Good | 1 | 4,76 | 4 | 19,04 | 3 | 14,29 |
| 2. | Good | 4 | 19,04 | 6 | 28,79 | 7 | 33,33 |
| 3. | Fair | 6 | 28,79 | 8 | 38,09 | 10 | 47,62 |
| 4. | Poor | 8 | 38,09 | 3 | 14,29 | 1 | 4,76 |
| 5. | Very Poor | 2 | 9,52 | 0 | 0 | 0 | 0 |

The affective aspect also showed improvement, reaching the very good and good categories from Cycle I to Cycle III. Students demonstrated improvements in cooperation, responsibility, respect for others' opinions, learning motivation, and curiosity. The number of students categorized as "poor" and "very poor" decreased drastically to almost none in Cycle III.

The development of students' affective aspects from Cycle I to Cycle III also showed positive changes, aligning with the developmental theory of cooperative learning. Mutual respect, responsibility, and the ability to work together increased significantly. Cooperative models, including Jigsaw, can improve social attitudes and learning motivation through intensive group interaction. The shift from the "poor" and "very poor" categories to almost none in Cycle III indicates that collaborative activities play a significant role in changing student learning behavior. The students' learning motivation can be seen in table 3:

Table 3. Learning Motivation Data

| No. | Class Interval | Interval | F | (%) |
|---|---|---|---|---|
| 1. | Very High | 109-123 | 3 | 14,29 |
| 2. | High | 95-108 | 5 | 23,81 |
| 3. | Medium | 80-94 | 10 | 47,62 |
| 4. | Low | 65-79 | 2 | 9,52 |
| 5. | Very Low | 52-64 | 1 | 4,76 |

Motivation data shows that the majority of students fall into the "moderate" (47.62%) and "high" (23.81%) categories, with a small proportion reaching the "very high" (14.29%) category. These findings demonstrate that the jigsaw model significantly fosters intrinsic motivation in students. The learning motivation of students, which is predominantly in the moderate to high category, also indicates that Jigsaw not only improves cognitive aspects but also fosters intrinsic motivation. Students feel more responsible for the material because they hold specific roles in expert groups; cooperative success lies in students' sense of ownership of the learning process.

Furthermore, the increase in positive attitudes toward learning—from 42.86% of students who liked learning in Cycle I to 90.18% in Cycle III—proves that Jigsaw provides a more engaging, clear, and focused learning experience. Student attitudes toward learning can be seen in Table 4:

Tabel 4. Student Attitude Questionnaire

| No. | Answer | Cycle I | | Cycle II | | Cycle III | |
|---|---|---|---|---|---|---|---|
| | | $\sum x$ | % | $\sum x$ | % | $\sum x$ | % |
| 1. | Yes | 9 | 42,86 | 14 | 66,67 | 19 | 90,18 |
| | Uncertain | 9 | 42,86 | 3 | 14,29 | 2 | 9,5 |
| | No | 3 | 14,29 | 4 | 19,05 | 0 | 0 |
| 2. | Yes | 10 | 47,62 | 14 | 66,67 | | |
| | Uncertain | 5 | 23,81 | 7 | 33,39 | | |
| | No | 6 | 28,57 | 0 | 0 | | |

The results of the attitude questionnaire showed an increase in student acceptance of jigsaw learning from cycle I to cycle III. The number of students who liked the learning increased from 42.86% to 90.18%. Students also considered the method clearer and easier to follow. This improvement reinforces the finding that the jigsaw model not only improves cognitive outcomes but also positive attitudes and student engagement. Overall, the results of this study demonstrate that Jigsaw is able to overcome the weaknesses of the separate lecture and lab methods implemented in cycle I. Collaboration in expert groups and home groups allows students to build stronger understanding, both through discussion and visual representations. Improvements in cognitive, affective, and motivational aspects indicate that this model works comprehensively to improve the quality of learning. Thus, this study strengthens previous findings regarding the effectiveness of Jigsaw in science learning and provides new empirical evidence in the context of hydrocarbons at the high school level.

The improvement in learning quality achieved through the implementation of the Jigsaw model can be understood as a result of the shift in students' roles from passive recipients of information to active learning agents. In the abstract context of carbon chemistry, the Jigsaw structure encourages students to construct meaning through explaining, interpreting, and discussing concepts with peers. This activity demands deeper cognitive engagement, so that conceptual understanding is not merely procedural but also conceptual. The mutual teaching process between students allows for the natural clarification of misconceptions, a situation rarely achieved in teacher-centered learning.

From the perspective of social-constructivist learning theory, the effectiveness of the Jigsaw model in this study demonstrates that learning becomes more meaningful when knowledge is constructed through social interaction [40], [41]. Discussions within expert and home groups create space for negotiation of meaning, scientific argumentation, and collaborative reflection. This is particularly relevant in chemistry learning, where students often struggle to connect symbolic, macroscopic, and microscopic representations [42], [43]. Through cooperative discussions, students have the opportunity to integrate these three levels of representation more systematically.

In addition to cognitive aspects, Jigsaw learning also contributes to strengthening students' affective and motivational dimensions [44], [45]. Individual responsibility for specific subtopics fosters a sense of ownership in the learning process, which in turn increases self-confidence and intrinsic motivation. When group success depends on the contributions of each member, students are encouraged to actively engage and demonstrate a positive attitude toward learning. This indicates that the Jigsaw model is not only effective as an academic strategy but also as a means of developing learning attitudes and social skills essential for 21st-century learning.

The practical implications of these findings suggest that the Jigsaw model can be a strategic alternative for chemistry teachers in addressing low student participation and motivation in complex material. Implementing this model allows teachers to create a more inclusive, collaborative, and process-oriented learning environment. With careful planning, Jigsaw can be integrated into the chemistry curriculum without the need for complex additional resources, making it relevant to a variety of school contexts.

However, the effectiveness of the Jigsaw model depends heavily on the teacher's readiness to manage group dynamics and ensure the involvement of all students. Without proper management, there is the potential for unequal participation among group members. Therefore, teachers need to provide clear guidance regarding student roles, actively monitor group interactions, and provide constructive feedback throughout the learning process.

Overall, this discussion confirms that the success of implementing the Jigsaw model in carbon chemistry learning lies not only in improving learning outcomes but also in its ability to build an active, collaborative, and meaningful learning ecosystem. These findings strengthen the argument that the cooperative approach is a relevant pedagogical strategy to address the challenges of modern chemistry learning.

Previous studies in chemical education have consistently shown that cooperative learning approaches contribute positively to students' conceptual understanding and engagement in chemistry learning [46], [47]. Research on the Jigsaw learning model indicates that structured peer collaboration enables students to actively process abstract chemical concepts through explanation, discussion, and shared responsibility [36], [48], [49]. In chemistry classrooms, where topics often involve symbolic representations and complex conceptual relationships, cooperative learning has been found to support deeper understanding by encouraging students to articulate reasoning and confront misconceptions collaboratively. These findings align with the results of the present study, which demonstrate that the Jigsaw learning model facilitates improved learning outcomes and increased student motivation in carbon chemistry instruction.

The findings of this study have important implications for chemistry teaching practice, particularly in promoting student-centered learning environments that support both cognitive and motivational development. The use of the Jigsaw learning model encourages active participation, peer interaction, and shared responsibility, making it a promising instructional strategy for teaching abstract chemistry topics [50], [51]. However, this study is subject to certain limitations. The research was conducted in a single classroom with a limited sample size, which may restrict the generalizability of the findings. Additionally, the study focused primarily on short-term learning outcomes and motivation, without examining long-term retention or transfer of knowledge. These limitations suggest that the results should be interpreted cautiously and highlight the need for further research involving larger samples and extended instructional periods.

## 4. CONCLUSION

Based on the results of the research, discussion, and reflection on the learning activities, it can be concluded that the implementation of the Jigsaw cooperative learning model on hydrocarbon material is effective in increasing the activity, motivation, and learning achievement of students in Senior High School. The increase in activity is seen consistently in each cycle, followed by an increase in students' cognitive, affective, and psychomotor abilities, and is reinforced by a positive response to the learning process which indicates that Jigsaw is able to create a more meaningful collaborative learning atmosphere. These findings indicate that the Jigsaw model is worthy of being recommended as an alternative chemistry learning strategy, especially for materials that require conceptual understanding and group cooperation. In addition, further research is recommended to test the effectiveness of this model on other chemistry materials, expand the research sample, and integrate digital media to enrich interactions and maximize learning outcomes. Future studies are recommended to investigate the effectiveness of the Jigsaw learning model across different chemistry topics and educational levels to enhance the generalizability of the findings. Additionally, longitudinal research is needed to examine the long-term impact of cooperative learning on students' conceptual retention, motivation, and transfer of chemistry knowledge.

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## AUTHOR CONTRIBUTIONS

Conceptualization, T.I.W., S.J.F., and K.R.; Methodology, T.I.W. and S.J.F.; Software, T.I.W.; Validation, T.I.W., S.J.F., and K.R.; Formal Analysis, T.I.W.; Investigation, T.I.W. and K.R.; Resources, S.J.F. and K.R.; Data Curation, T.I.W.; Writing – Original Draft Preparation, T.I.W.; Writing – Review & Editing, S.J.F. and K.R.; Visualization, T.I.W.; Supervision, S.J.F.; Project Administration, T.I.W.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

## USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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