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Improving Chemistry Learning Outcomes with Jigsaw for Biology Education Students

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ABSTRACT: This study aims to overcome the difficulties experienced by biology education students in studying basic chemistry courses, with a primary focus on improving their learning outcomes. Before conducting the research, a survey questionnaire on learning difficulties in chemistry was conducted. Based on the results of the questionnaire survey, many students which 58.3% of students reported having significant difficulty in studying chemistry, while 41.7% agreed that chemistry was difficult. consider chemistry a difficult subject, resulting in a lack of motivation, boredom, drowsiness, and difficulty understanding the material in a short time. To address this challenge, the jigsaw cooperative learning model is applied. In this approach, students are divided into two groups: the original group and the expert group. The expert group is tasked with exploring and discussing certain topics, which are then shared with the original group. Before learning begins, students are given a pretest to measure their initial understanding, followed by the learning process using the jigsaw model, and ending with a posttest to assess the increase in understanding. The increase in learning outcomes is calculated using the N-Gain score, and the analysis results show that the average N-Gain score across the four basic chemistry subtopics (the nature of chemistry, scientific methods, the classification of materials in chemistry, and the physical and chemical properties of materials) falls into the high improvement category. These findings indicate that the application of the jigsaw cooperative model is effective in improving chemistry learning outcomes for students majoring in biology education. Additionally, the results of the learning satisfaction questionnaire indicate that the learning process runs smoothly and without significant obstacles, allowing for optimal learning outcomes.

Keywords: chemistry course, cooperative learning, jigsaw, student outcomes

INTRODUCTION

Students in the Biology Education at University of PGRI Ronggolawe Tuban study program only take chemistry courses up to basic chemistry, but they often complain the difficulties they face in the subject. The number of students who participated in this study was 12 students in 5th semester in 2024. The results of a survey of Biology Education students at University of PGRI Ronggolawe Tuban, showed that 41,7% of students found chemistry difficult, while 58,3% considered it sufficient. The percentage of difficulty was broken down as follows: (1) mastery of basic chemistry material: 50,91%, (2) the learning/lecture process: 38,29%, and (3) the implementation of practical work: 69,73% [1]. Chemistry is one of the subjects considered quite difficut for most students because its complex and abstract concepts are among the reasons why students have difficulty learning it [2]. One of the factors that causes students to have difficulty understanding Basic Chemistry is the lack of skills in reading and understanding textbooks, as well as difficulty in connecting Basic Chemistry concepts with everyday life, which leads to decreased motivation to learn [3].

Learning takes place using a jigsaw-type cooperative learning model, which is chosen with the aim of improving understanding of concepts through the exchange of information between students. Interest in cooperative learning has grown rapidly over the last three decades as research has been published

that clearly demonstrates how it can be used to promote achievements in reading and writing, conceptual development in science, problem-solving in mathematics, and higher level thinking and reasoning [4]. The research findings show that the jigsaw-type cooperative learning model influences students' ability to understand concepts and improves their understanding of learning problems, as well as their ability to solve them [5]. The new findings of this research indicate that cooperative learning using the jigsaw-type model can increase students' learning motivation, including motivation to understand the material in depth to become experts, motivation to collaborate, and motivation to convey information to others effectively [6]. The jigsaw model is a cooperative learning method that uses small teams to learn material. The jigsaw-type cooperative learning model is a cooperative learning model with specific characteristics, where students are divided into two groups: expert groups and original groups [7]. Expert groups are given different sub-materials to study in depth, and then they come together in their original groups (or initial groups) to share the information they have studied in their respective expert groups. By using the jigsaw-type cooperative learning model, all students are encouraged to take an active role in discovering and constructing their own knowledge [7]. From the descriptions above, it can be concluded that cooperative learning involves learning in small heterogeneous groups to work together, contribute ideas to construct concepts, and solve problems with shared responsibility, common goals, and positive interdependence, while also practicing interaction, communication, and socialization [8]. This setting provides a social interaction component in which usual Chemistry lectures do not provide [9].

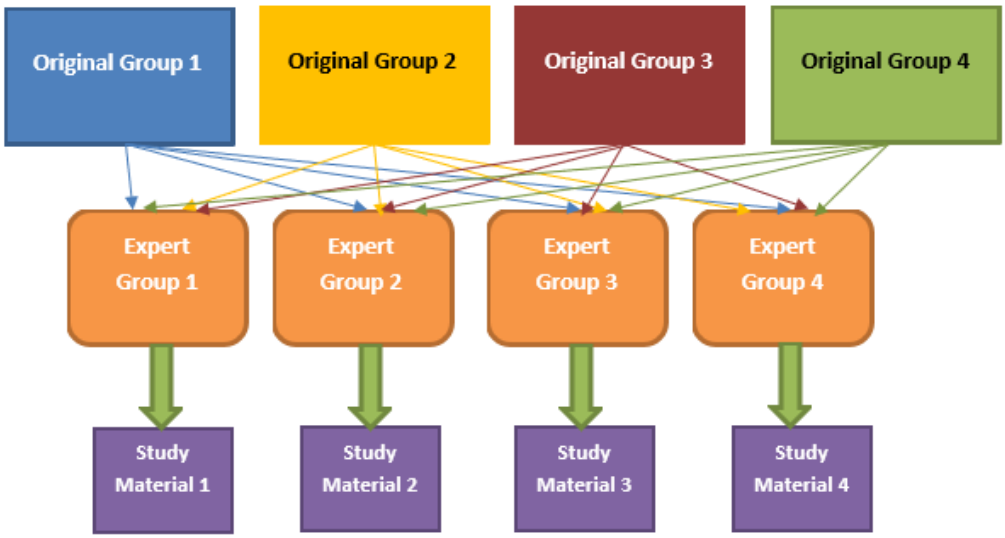

FIGURE 1. Illustration of the division of original and expert groups

This study uses a jigsaw-type cooperative learning model to address the problems faced by students who consider chemistry courses difficult. Studying together by sharing materials will lighten the burden of the material that each student needs to learn. In addition, studying together allows students to exchange different learning experiences, complement each other's weaknesses, and create a more comfortable learning atmosphere. The innovation of this research is that the jigsaw-type cooperative learning model can overcome the fear of the difficulty of basic chemistry courses that biology education students often face, while also improving their learning outcomes in these courses. The purpose of this study is to improve the learning outcomes of biology education students in basic chemistry courses, which are considered difficult, by using the jigsaw-type cooperative learning model.

RESEARCH METHODS

The rsearch method aims to determine learning difficulties and student satisfaction in chemistry courses using questionnaires. Students were informed to fill out both questionnaires. Each questionnaire contained 10 questions. Students were given 10 minutes to fill out each question. The information obtained from filling out the previous chemistry learning difficulties questionnaire can be

useful for finding out what problems they face when learning chemistry. The learning satisfaction questionnaire is useful for finding out how satisfied they are with learning chemistry using the jigsaw method. Both types of questionnaires use a Likert scale with numbers ranging from 1 to 5, where 1 indicates “strongly disagree” and 5 indicates “strongly agree”. The Likert scale is a psychometric tool commonly used in questionnaires [10]. The percentage is obtained by dividing the number of respondents in the selected group by the total number of respondents.

The improvement in learning outcomes is measured using the N-Gain score, which is calculated by comparing the pretest and posttest values. The N-Gain score is calculated using the following formula:

$$\text{N-Gain Score} = \frac{\text{Posttest Score} - \text{Pretest Score}}{\text{Ideal Score} - \text{Pretest Score}}$$

The category of the magnitude of the increase in the N-Gain score can be referred to in the normalized Gain criteria [11] in Table 1.

TABLE 1. Normalized Gain Criteria

N-Gain Score	Interpretation
0.70 ≤ g ≤ 1.00	High
0.30 ≤ g < 0.70	Medium
0.00 < g < 0.30	Low
g = 0.00	No Increase
-1.00 ≤ g < 0.00	Decrease

RESULT AND DISCUSSION

A. The Chemistry Learning Difficulties Questionnaire

Table 2 is a table depicting the overall percentage of responses to the 10 questions in the questionnaire discussed above. This table provides details for each question, each of which is measured using a five-point Likert scale. In the Likert scale used, point 1 indicates strongly disagree, point 2 indicates disagree, point 3 is sufficient, point 4 indicates aagree, and point 5 indicates strongly agree. The percentage results are displayed based on the answers given by the respondents. Each percentage in the table represents the distribution of responses for each question, starting from the lowest to the highest level, which provides a clearer picture of the respondent’s views or opinions on each aspect addressed.

A questionnaire on general chemistry learning difficulties that students previously faced was created before the learning was carried out. Based on the survey results from the questionnaire, 58.3% of students reported having significant difficulty in studying chemistry, while 41.7% agreed that chemistry was difficult. However, when asked whether chemistry was fun, 66.7% of students said they enjoyed it quite a lot, and 33.3% agreed that chemistry was fun. These results indicate that although most students find chemistry challenging, they remain interested and appreciate its enjoyable aspects. This suggests that they may still be able to master chemistry due to their interest and enjoyment in learning, despite facing challenges during the learning process. The process of achieving success in learning depends heavily on student interest. When students are interested, they are more likely to stay motivated, work diligently, and optimize their learning and knowledge [12].

The results of the question regarding whether students get bored quickly when studying chemistry showed that 33.3% of students disagreed, 41.7% felt somewhat bored, and 25% felt bored quickly. Meanwhile, the result of the question about whether students need a long time to study chemistry revealed that 33.3% felt it took a considerable amount of time, 58.3% agreed that studying chemistry does take a long time, and 8.3% strongly agreed with statement. These two results show a correlation: students may get bored quickly when studying chemistry, but they also realize that to fully understand chemical concepts, they need a lot of time. The role of effective time management is essential for learning activities, as it is an internal factor that positively influences the learning process [13].

The results of the question regarding whether students often feel sleepy while studying chemistry showed that 8.3% of students strongly disagreed, 33.3% disagreed, 41,7% felt somewhat sleepy, and 16.7% agreed with the statement. This indicates that the majority students, specifically 58.7% either feel sleepy or tend to feel sleepy during chemistry lessons. Additionally, the results of the question about student’s interest in studying chemistry revealed that 8.30% strongly disagreed, indicating a high level

of interest, 33.3% disagreed, 33.3% felt somewhat uninterested, and 25% agreed that they had a low interest in chemistry courses. This lack of interest with only 25% of students interested in chemistry can contribute to boredom, which may then cause students to feel sleepy during the learning process. The correlation between these two survey results suggests that students with lower interest in chemistry are more likely to feel sleepy during class. There are two factors that influence student's interest in learning: internal factors and external factors. Internal factors are those that encourage student's interest and come from within themselves, such as attention, curiosity, motivation, and personal needs. These factors include: 1) Interest in Learning, 2) Comfort in the Learning Process, 3) Willingness to Learn, 4) Student Participation, and 5) Student Health. External factors, on the other hand, include environmental aspects such as family support and the learning atmosphere, as well as elements like learning facilities [14].

The results of the question regarding students who lack motivation to learn chemistry show that 16.7% strongly disagree, and 41.7% disagree, meaning they are motivated to learn chemistry. Meanwhile, 33.3% of students feel somewhat motivated, and 8.3% agree that they lack motivation to learn chemistry. Furthermore, the question about student's level of concern for learning chemistry shows that 8.3% strongly disagree, and 8.3% disagree, indicating that they are less engaged during the learning process. On the other hand, 41.7% of students feel somewhat concerned about learning chemistry, 33.3% agree that they care about learning chemistry, and 8.3% strongly agree that they are attentive and engaged during chemistry lessons. Based on these results, it can be concluded that students who are less motivated to learn chemistry tend to be less engaged or uninterested during the learning process. Motivation is a complex aspect of human behavior that can influence the amount of energy a person invests in doing something. It affects a person's effort, persistence, and ability to find solutions to the obstacles they face when solving problems [15].

The survey results about learning chemistry individually showed that 8.3% of students strongly disagree, and 41.7% disagree with the statement that they prefer to learn chemistry individually, meaning they prefer to learn chemistry in groups. Meanwhile, 41.7% felt neutral, and 8.3% somewhat agreed that they prefer to learn chemistry individually. On the other hand, the survey results regarding learning chemistry in groups showed that 8.3% of students disagreed with learning chemistry in groups, 25% felt neutral about learning chemistry in groups, and 66.7% agreed with learning chemistry in groups. The approach used during group learning involves the teacher providing motivation to the students, encouraging them to develop their imagination and the technique employed in group learning is to give students the freedom to explore and develop their ideas [16].

TABLE 2. The Percentage of Responses from the Chemistry Learning Difficulties Questionnaire

No	Indicator	Result				
		1	2	3	4	5
1.	Chemistry is difficult	0%	0%	58.3%	41.7%	0%
2.	Chemistry is fun	0%	0%	66.7%	33.3%	0%
3.	Students get bored quickly while studying chemistry	0%	33.3%	41.7%	25%	0%
4.	It takes a long time to understand chemistry	0%	0%	33.3%	58.3%	8.3%
5.	Students often feel sleepy when studying chemistry	8.3%	33.3%	41.7%	16.7%	0%
6.	Students have a lack of interest in studying chemistry	8.3%	33.3%	33.3%	25%	0%
7.	Students have no motivation to learn chemistry	16.7%	41.7%	33.3%	8.3%	0%
8.	Students have a caring attitude when studying chemistry	8.3%	8.3%	41.7%	33.3%	8.3%
9.	Students enjoy learning chemistry individually	8.3%	41.7%	41.7%	0%	8.3%
10.	Students enjoy learning chemistry in groups	0%	8.3%	25%	66.7%	0%

B. Survey on Chemistry Learning Satisfaction

After implementing the jigsaw-type cooperative learning method in basic chemistry courses, the number of students who became motivated and enthusiastic about learning chemistry increased. Students were given a questionnaire about learning satisfaction. Specially, 25% answered 'sufficient', 66.7% answered 'agreed', and 8.3% answered 'strongly agree'. The jigsaw-type cooperative learning method also facilitated student's understanding of the basic chemistry course, with 41.7% answering

'sufficient', 50% answering 'agree', and 8.3% answering 'strongly agree'. Both points in the survey are interconnected, as student's motivation and enthusiasm for learning contribute to a better understanding of the basic chemistry course. The interests of students are the first step in achieving the desired learning outcomes [17].

The arrangement of the learning environment greatly affects learning outcomes. Therefore, having a condusive classroom environment during discussions using the jigsaw-type cooperative learning method is very important. Based on the survey results, 41.7% of students answered that it was sufficient, 50% agreed that the classroom atmosphere was conducive, and 8.3% strongly agreed. In addition to the classroom atmosphere, the lecturer's concern during learning also supports student's comfort. Specially, 16.7% of students felt that the lecturer cared enough, 25% felt the lecturer cared, and 58.3% strongly agreed that the lecturer was attentive to the learning difficulties they experienced. To increase student's interest in learning at school, attention and concern from both parents and teachers are needed. Parents who pay attention to their children's academic achievements, along with teachers who support them at school, will influence the level of their discipline in learning, helping them become high-achieving students [18].

The jigsaw-type cooperative learning method involves several learning steps that must be followed. For learning to take place effevtively, each step needs to be carried out with discipline regarding time management. According to the survey, 8.3% of students disagreed, 41.7% felt that time discipline was sufficient, and 50% considered that timing of each learning step to be appropriate. Time management has a great impact on the quality of learning, especially for students [19]. Additionally, the directions or assignments given to students must align with the material being studied. Specifically, 16.7% of students found them to be somewhat relevant, 50% considered them relevant, and 33.3% felt they were very relevant. Learning outcome tests must measure what has been learned during the learning process, in accordance with the objectives or expected outcomes [20].

The cooperative learning model requires solid teamwork to achieve a common goal, improving student's understanding of the material in basic chemistry courses. According to the survey results, 8.3% of students felt that their group was not very cohesive, 33.3% felt that their group was somewhat cohesive, 50% felt that their group was cohesive, and 8.3% felt that their group was very cohesive. Overall, the compactness within the study groups was considered successful. Communication, motivation, the ability to handle conflict, competitiveness, and cooperation are some of the factors that influence group formation [21]. To support the success of a learning goal, learning resources play an important role. Complete and adequate learning resources help students understand the material more effectively. Based on the survey results, 16.7% of students considered the available learning resources to be somewhat complete, while 75% felt that the existing resources were complete and met their various needs. Additionally, 8.3% of students thought that the learning resources provided were very complete. Through these learning resources, the educational process will be as effective as possible [22].

In addition to the classroom atmosphere and learning resources, the facilities provided by the campus are also crucial in supporting smooth and effective learning. Adequate facilities create a comfortable learning environment and help facilitate an optimal learning process. Based on the survey results, 8.3% of students expressed disagreement with the existing campus facilities, possibly feeling that these facilities did not adequately support their learning. Meanwhile, 58.3% of students felt that the campus facilities were sufficient to support teaching and learning activities, though some areas may still require improvement. Additionally, 33.3% of students considered the campus facilities to be adequate, providing enough support fot the smooth running of their learning process. Complete facilities support academic activities, making the learning process easier at the college [23]. The measurement of increased student understanding of a subject must align with the material being studied to ensure the results are relevant and accurately reflect student's understanding. In other words, to ensure that the evaluation or test accurately reflects to student's understanding, the test material must be closely related to the content that has been taught. According to the survey, 50% of students agreed that there was be a correlation between the test material and the material being studied, while the other 50% strongly agreed. This indicates that most students recognize the importance of the relationship between the material tested and the material they are studying in order to achieve accurate and relevant results.

Table 3 presents the overall percentage of responses to the 10 questions in the learning satisfaction questionnaire that was explained previously. This table provides details for each question, which is

assessed using a five-point Likert scale. The Likert scale has five categories: 1 for “strongly disagree”, 2 for “disagree”, 3 for “sufficient”, 4 for “agree”, and 5 for “strongly agree”. The percentages shown in the table are calculated based on the answers given by the respondents. Each percentage illustrates the distribution of responses from the respondents for each question, ranging from the lowest to the highest value. This provides a clearer picture of the respondent’s views or opinions on each aspect measured in the learning satisfaction questionnaire.

TABLE 3. The Percentage of Responses to the Chemistry Learning Satisfaction Questionnaire

No	Indicator	Result				
		1	2	3	4	5
1.	Students are motivated and enthusiastic	0%	0%	25%	66.7%	8.3%
2.	The jigsaw-type learning method makes it easier to understand basic chemistry	0%	0%	41.7%	50%	8.3%
3.	The classroom atmosphere is conducive	0%	0%	41.7%	50%	8.3%
4.	The lecturer cares about students who have difficulty learning in class	0%	0%	16.7%	25%	58.3%
5.	Time management is followed	0%	8.3%	41.7%	50%	0%
6.	Assignments given are in accordance with the material taught	0%	0%	16.7%	50%	33.3%
7.	Group cohesion is encouraged	0%	8.3%	33.3%	50%	8.3%
8.	Learning resources are complete	0%	0%	16.7%	75.%	8.3%
9.	Campus facilities are adequate	0%	8.3%	58.3%	33.3%	0%
10.	The test given by lecturer is in accordance with the material studied	0%	0%	0%	50%	50%

C. Increase in Student Learning Outcomes

The jigsaw-type cooperative learning method is used in basic chemistry courses, covering topics such as the nature of chemistry, scientific methods, the classification of materials in chemistry, and the physical and chemical properties of materials. To observe the increase in learning outcomes, students were initially asked to answer questions based on their prior knowledge. Afterward, the jigsaw-typr cooperative method was applied to four selected materials (the nature of chemistry, scientific methods, the classification of materials in chemistry, and the physical and chemical properties of materials). Once the learning method was implemented, students were asked to answer questions to explain what they had learned with their group members, both in the initial and expert groups. They were also asked to write down the new knowledge they gained to complement their initial understanding.

In the first material, namely the nature of chemistry, the increase in learning outcomes achieved by students in the high increase category occupies the top position to improve learning outcomes. This is because the material on the nature of chemistry had never been encountered before, making it new knowledge for students. Intial knowledge is the knowledge that students build before the learning process [24]. After further study with the expert group and discussions with the original group, student’s knowledge of the nature of chemistry increased significantly.

In the second material, specifically the scientific method, there was an increase in score for students in the high category (5 students), the medium category (2 students), and the low category (5 students). The lower increase in scores for the low category was due to the fact that students majoring in biology education had frequently applied the scientific method in other courses, making steps and concepts of the method already familiar to them. Knowledge can be obtained through a scientific approach via research guided by a theory, this theory then grows and develops into scientific research, which is systematic and based on empirical data [25]. However, most students still need to study this material further. This is evident from the greater increases in scores in the high and medium categories.

The third topic in this learning material discusses the classification of materials in chemistry, including the differences between elements, compounds, and mixtures in chemistry. In the analysis of learning outcomes, it is evident that the largest increase in score occurred in the medium category, indicating that most students have a fairly good understanding but still need further reinforcement. Students are considered to have intial knowledge of the basic concepts in the classification of material, such as the different between elements, compounds, and mixtures, which they have previosly learned.

However, an increase in scores in the high category was also recorded, although it ranked second, indicating that some students were able to understand the material more deeply and develop a more complex understanding. In contrast, the increase in scores in the low category was very limited, suggesting that there are still some students who have difficulty understanding the basic concepts of the classification of matter. This highlights the need for a more specific and intensive approach to help students who are struggling to improve their understanding of this material.

The fourth topic in this learning material discussess the physical and chemical properties of a substance. In the early stages, an analysis of student responses showed that they did not fully understand and could not identify the fundamental differences between the physical and chemical properties of a substance. Students tended to confuse these two concepts, leading to inaccurate understandings. However, after the implementation of the jigsaw-type cooperative learning model, where students worked in groups to study topics collaboratively, their understanding of differences between physical and chemical properties became clearer. Through discussions and the division of tasks in expert gropus, they were able to develop a deeper and more structured understanding. As a result, there was a significant increase in their scores, especially in the high-score category, indicating that most students made very good progress in understanding the material. This approach has proven effective in improving student's comprehension of concepts that were initially difficult to grasp.

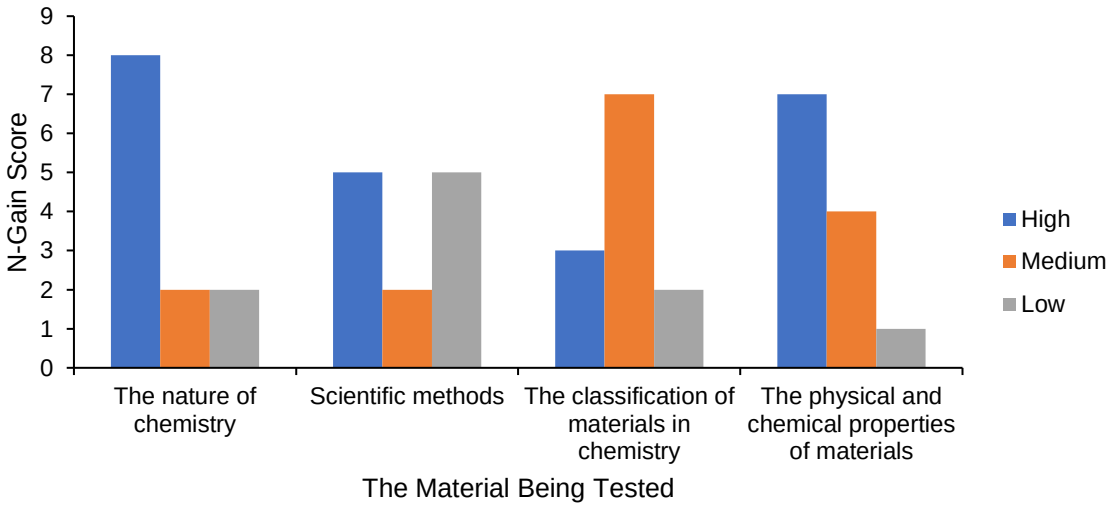

FIGURE 1. N-gain score for the tested materials

Figure 1 shows a diagram depicting the N-Gain scores obtained across four learning topics. The increase in N-Gain scores was then divided into three categories: high, medium, and low. Of these three categories, the increase in N-Gain scores in the high category was dominant in this study. This indicates that the majority of respondents experienced a significant increase in their scores. Therefore, the success of this study in improving learning scores can be considered achieved, as the majority of participants showed a significant increase in the topics studied.

CONCLUSION

Biology education students often face difficulties in learning chemistry due to the complexity of the concepts involved. To overcome this problem, a cooperative learning model is applied, which aims to reduce the burden of material that students need to understand. By using this model, students can study in groups, which is expected to create a more comfortable learning atmosphere and support active interaction among group members. One type of cooperative learning model applied is the jigsaw method, which is effective in breaking down difficult chemistry concepts into simpler parts. In this model, each group member is given a specific part of the material to study in depth, and then they share their knowledge with other group members. This makes it easier to understand the chemistry material and makes the learning process more structured. The results of applying the jigsaw method in basic chemistry courses show a significant increase in student learning outcomes. The increase in scores

falls into the high category and occurs across all subtopics of basic chemistry studied. Additionally, a learning satisfaction survey conducted after the lessons showed that the learning process ran smoothly and without significant obstacles, which allowed for optimal results to be achieved. Thus, the jigsaw cooperative learning model has proven effective in improving student's understanding of basic chemistry and in producing maximum learning outcomes.

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