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Impact of STAD-Cooperative Computational Media on Intermolecular Forces Learning Outcomes and Motivation

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Abstract

This study seeks to delve into the potential benefits and implications of utilizing computational chemistry-based learning media within a classroom environment, particularly when coupled with the STAD type cooperative learning model. The central focus of this research is to determine the effect of this innovative learning approach on student learning outcomes and motivation, especially when applied to the intricate subject of forces between molecules. This topic is of great relevance given the inherent complexities associated with intermolecular forces. The population under consideration for this research consisted of grade X students attending high schools in the bustling city of Medan. Out of several classes, a detailed examination was conducted on two specific classes: X IPA 3 and X IPA 5. These chosen classes represented a balanced sample size of 72 students, with each class containing 36 students. To ensure the rigor and validity of this study, the research instruments employed were twofold. Firstly, test instruments, presented as 20 multiple choice questions to gauge the student's grasp on the subject. Secondly, a non-test form containing 30 statements to evaluate qualitative factors such as motivation and perspective. To maintain the credibility of the research, the quality of the instruments was thoroughly scrutinized using various parameters like validity, reliability, question difficulty level, and differentiating power. These parameters ensured that only the most effective questions were selected as research instruments. Preliminary data analysis techniques showed promising results. In evaluating learning outcomes through hypothesis testing, the t-count> t-table value stood at 5.03>1.666. Similarly, the results for learning motivation hypothesis testing produced a t-count> t-table value of 3.12>1.666. From this preliminary data, it becomes evident that there is a positive effect of computational chemistry-based learning media using the STAD type cooperative learning model on student learning outcomes and motivation concerning the subject of forces between molecules.

Keywords: *Computational Chemistry, STAD, Intermolecular Forces, Cooperative Learning*

INTRODUCTION

Education plays a major role in preparing quality human resources. Education is closely related to learning activities, learning activities are interactions and between students to gain knowledge, learning experiences as well as skills. Chemistry is one of the subjects that is considered complicated by students. The low student learning outcomes in chemistry learning show the lack of student attention and motivation in learning. In the learning process, students are not encouraged to improve their thinking skills but students are shown only memorizing information without mastering its application in everyday life (Sanjaya, 2007).

One of the subjects in chemistry is chemical bonding. Learning the subject of chemical bonds requires students to have memorization skills and the ability to create compounds from a combination of

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elements and determine the type of bond and the method of bond formation (Laksono, 2012).

Computational chemistry is a branch of chemistry that uses chemical theory transferred into a computer program to calculate data related to the properties of molecules and their changes. Computational chemistry is also able to carry out simulations of large systems (or many protein molecules, liquid gases, solids, and liquid crystals), and practice the program on real chemical systems (Prianto, 2010). Computational chemistry procedures have a very flexible nature and almost all materials of simple or high difficulty levels can be modeled properly using computational chemistry. The availability of various computational chemistry software should be able to be utilized as an alternative. In chemistry education research, the learning media utilized is computational chemistry-based learning media that uses structural images of molecular modeling results. The learning process by presenting a variety of media with a model will affect student motivation and learning outcomes. The STAD type cooperative learning model is a Cooperative Learning approach that emphasizes activities and interactions between students to motivate and help each other in mastering lessons in order to achieve optimal achievement (Wijaya & Arismunandar, 2018).

According to research by (Hia et al., 2022) suggests that the use of 3D-based learning media and molecular animation on chemistry learning outcomes can improve learning outcomes. The results of his research show the value of tcount = 3.45 and ttable = 1.996 at a significant level of 5%. (Dewita et al., 2020) stated that the use of the STAD type cooperative learning model and learning media based on 3D visualization and molecular animation can improve student learning outcomes on molecular shape material with an average pretest value of 35.33 and posttest of 86.17 experiencing an increase in learning outcomes. (Hasibuan et al., 2020) suggested that learning media based on computational methods in molecular form material based on BNSP can improve student learning outcomes. This is evidenced by the sig value (0.046) which is smaller than 0.05. Therefore, the author tries to use computational chemistry-based learning media using NWChem software to attract students' attention and make learning easier.

NorthWest Chemistry (NWChem) software is a popular computational chemistry program that has been designed and developed to work efficiently on parallel processing supercomputers (Valiev et al., 2010). The NWChem program is designed to handle the following: 1) Biomolecules, nanostructures, interfaces and solid states 2) Chemical processes in complex environments 3) Hybrid quantum/classical simulations 4) Excited states and non-linear optical properties 5) UV-Vis simulations, photo electron, X-ray spectroscopy 6) Gaussian or plane wave basis functions 7) Ab-initio molecular dynamics and excited states and 8) Relativistic effects.

The importance of incorporating computational approaches in chemistry education cannot be understated. As identified by Prianto (2010), computational chemistry has the potential to bridge the gap between theoretical knowledge and its practical application. By using chemical theory and computer programs, students can gain a deeper understanding of molecular properties and changes. This not only makes the learning process more engaging but also provides a tangible framework for understanding abstract concepts.

In the context of the subject matter, chemical bonding, and intermolecular forces, Laksono (2012) emphasized the necessity for students to have strong memorization skills. However, mere memorization may not guarantee a comprehensive understanding. By integrating computational chemistry-based learning media, like the NWChem software, students are offered visual representations that can enhance their grasp of these concepts. Dewita et al. (2020) and Hia et al. (2022) highlighted the effectiveness of 3D-based learning media and molecular animation in improving student outcomes. By leveraging such tools, educators can transform the traditional passive learning process into an interactive experience.

Moreover, the cooperative learning model, particularly the STAD type, as detailed by Wijaya & Arismunandar (2018), underscores the significance of interactions between students for optimal achievement. When combined with computational chemistry tools, this approach not only promotes better understanding but also fosters collaboration and teamwork among learners. Hasibuan et al. (2020) found positive impacts of computational-based learning media on student outcomes, reinforcing the belief that the synergy between cooperative learning and advanced software can indeed revolutionize the chemistry learning landscape.

LITERATURE REVIEW

In this study, researchers found several relevant previous studies, namely as follows:

Hia et al. (2022) in a study entitled "The Effect of 3D-Based Learning Media and Molecular Animation with SAVI Type Cooperative on Chemistry Learning Outcomes of Class X High School Students on Electrolyte and Non-Electrolyte Solution Materials" the results showed the results of the analysis of student responses to learning media based on 3D visualization and molecular animation conducted with the help of a guttman scale questionnaire, it was found that the percentage score of the student response questionnaire to the media was 92.42%. It can be concluded that the scale of the level of achievement of the media response, then the media is said to be very feasible to be applied in the learning process.

Dewita et al. (2020) in a study entitled "The Effect of Learning Media Based on 3D Visualization and Molecular Animation on Learning Outcomes of Molecular Forms" the results showed that student learning outcomes on molecular form material taught using the STAD type cooperative learning model as well as 3D visualization-based learning media and molecular animation with an average pre-test value of 35.33 and post test 86.17 had improved learning outcomes.

Simatupang (2016) in a study entitled "The Use of Power Point Media in the Numbered Head Together (NHT) Type Cooperative Learning Model to Improve Student Chemistry Learning Outcomes" the results showed the effect of applying the NHT learning model using power point media on student learning outcomes on chemical bonding material in class X SMA Swasta Teladan Medan. This is evidenced by the value of tcount = 2.739 and ttable = 1.66883 at a significant level of 5%. The value of tcount> ttable. The research equation with the research to be carried out lies in the use of power point media and the dependent variable, namely student learning outcomes, while the difference lies in the learning model, research location and material taught.

Hadisaputra et al. (2017) in a study entitled "Chemical Practicum-Based Computational Chemistry for High School" the results showed that computational chemistry-based chemistry practicum can be a solution for chemistry practicum in high school. Computational chemistry-based chemistry practicum has advantages such as time, energy and cost efficiency, minimizing hazards and waste practices. Computational chemistry-based chemistry practicum development program is very beneficial for teachers and students to optimize the learning process, especially at the high school level.

Bancin & Syafriani (2020) in a study entitled "Application of STAD and Discovery Learning Models Aided by Macromedia Flash to Improve Student Learning Outcomes" the results showed that there was a significant difference in the learning outcomes of students taught using the Student Team Achievement Divisions (STAD) model aided by Macromedia Flash compared to the learning outcomes of students taught with Discovery Learning aided by Macromedia Flash on reaction rate material. where the average posttest score of the experimental class I was 80.76 while the average posttest score of the experimental class II was 76.52, where the average posttest score of experimental class I was 80.76 while the average posttest score of experimental class II was 76.52, from this value learning using the STAD model was 0.0424% better than learning outcomes using the Discovery Learning model. The research equation with the research to be carried out lies in the learning model as well as in the dependent variable, namely learning outcomes, while the difference lies in the learning media, learning materials and research locations.

Nainggolan (2022) in a study entitled "Implementation of Flash Animation on Student Activity and Learning Outcomes on Chemical Bonding Material" the results showed that STAD type cooperative learning using flash animation media can improve student learning outcomes. This is evidenced by the value of tcount> ttable (15.1.6775) at a significance level of 5% (α = 0.05) then Ha is accepted and Ho is rejected. The equation of this research with the research to be carried out lies in the learning media, learning model and the dependent variable, namely learning outcomes while the difference lies in the class, research location and chemical bonding sub-material, in this study using ionic and covalent bonding sub-materials.

Based on the research that has been done above, it can be used as a benchmark and comparison with the research to be carried out, which is proven that the use of power point media and STAD type cooperative learning models can improve student learning outcomes.

Based on these studies, I would like to emphasize on the interaction between students to improve learning outcomes and student motivation with computational-based media using the STAD type cooperative learning model on the subject of chemical bonds in one of the high schools in Medan in the 2022/2023 academic year.

As educational technology continues to evolve, the importance of tailoring teaching methodologies to better suit contemporary students' learning preferences cannot be overstated. As indicated by Dewita et al. (2020), students' ability to grasp and retain complex molecular forms drastically improved with the integration of 3D visualization-based learning media and molecular animation. This underscores the pivotal role such media plays in enhancing the learning process. While traditional methods primarily centered on theoretical knowledge, computational tools like 3D visualization provide an immersive and interactive experience, enabling students to conceptualize and understand abstract ideas more holistically.

Similarly, Hadisaputra et al. (2017) emphasized the efficiencies brought about by computational chemistry-based practicums. Their benefits are not just confined to enhancing understanding but also extend to practical advantages such as cost, time, and energy efficiency. The marriage of computational techniques with traditional learning methods provides students with a comprehensive and streamlined learning experience, reducing potential gaps in understanding. Furthermore, as highlighted by Bancin & Syafriani (2020), integrating dynamic learning media like Macromedia Flash with cooperative learning models can further boost learning outcomes. When students are presented with engaging, interactive media within a structured cooperative framework, it fosters a conducive environment for active learning and peer interactions.

Lastly, it's essential to highlight the adaptability and flexibility of these approaches across different subjects and complexity levels. As Simatupang (2016) and Nainggolan (2022) both emphasized, even with varying subjects, locations, and class structures, the integration of dynamic media and cooperative learning frameworks consistently results in enhanced student outcomes. This adaptability underscores the universal applicability and potential of these methodologies in diverse educational settings, further validating the necessity of their integration in modern pedagogical strategies.

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RESEARCH METHOD

This study was conducted in one of the Senior High Schools in Medan City in the odd semester of the 2022/2023 study period. The population in this study were all X grade students among Senior High Schools in Medan which amounted to 7 classes. The sampling technique used in this study was random sampling. The samples used were students of class X IPA 3 and X IPA 5, each of which amounted to 36 people. The research instrument used was a test instrument in the form of 20 multiple choice questions. The stages of this research are:

1) Research Preparation Stage

At this stage identifying the hypothesis, preparing the Teaching Implementation Plan (RPP) as a reference in implementation, compiling test instrument questions, and testing the questions to be used by testing validity, reliability, difficulty level and differentiation.

2) Research Implementation Stage

At this stage make 2 classes, namely the experimental class and the control class, carry out pretests in both classes, provide learning to both classes according to the lesson plans made and provide posttests and motivation questionnaires at the end of the learning process.

3) Final Stage of Research

At this stage the pretest and posttest scores are tabulated, conduct statistical tests and draw conclusions. Hypothesis testing is carried out through the following stages:

1) Normality Test
2) Homogeneity Test
3) Hypothesis Test
4) Gain Test

Analysis of the data obtained is calculated normality test to determine whether the data is normally distributed or not using the chi squared formula. Calculating the homogeneity test to determine whether the data has a homogeneous variance or not. Then calculate the gain test to determine the increase in learning outcomes (Silitonga, 2014).

FINDINGS AND DISCUSSION

The results showed that the pretest and posttest scores of the experimental and control classes. The learning outcome data is shown in Figure 1.

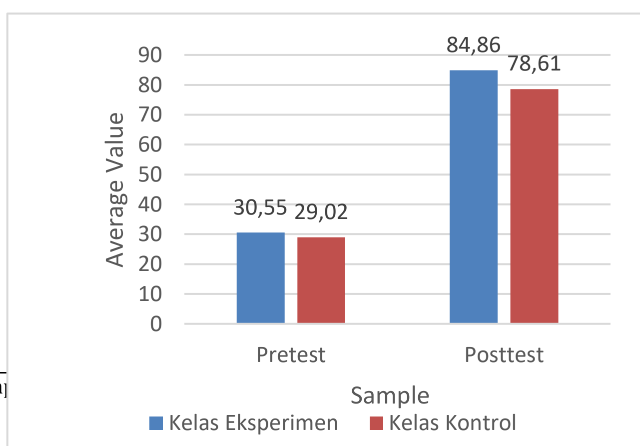

Figure 1. Learning Outcome Data

Based on the data in Figure 1, it is depicted that the average pretest and posttest scores of the experimental and control classes were obtained. From these results, it can be seen that the increase in learning outcomes in the experimental class was 78% and the learning outcomes in the control class increased by 69%. So it can be concluded that the increase in learning outcomes of the experimental class is higher than the control class. This shows that computational chemistry-based learning media using the STAD type cooperative learning model can improve student learning outcomes.

Bancin & Syafriani (2020) have conducted research on STAD and Discovery Learning assisted by Macromedia Flash. The results showed that in the reaction rate material, the average posttest value of experimental class I was 80.76 while the average posttest value of experimental class II was 76.52. Based on this research, it is in line with the research I have done that the STAD learning model can improve learning outcomes. However, the results of the acquisition of the average value are higher than the research I have done which is 84.86. This is because the use of computational chemistry learning media helps students to understand the material of molecular forces that are abstract to be more concrete with the depiction of molecular modeling.

After the learning process is complete, a student learning motivation questionnaire is given. Data on student learning motivation results are in Figure 2.

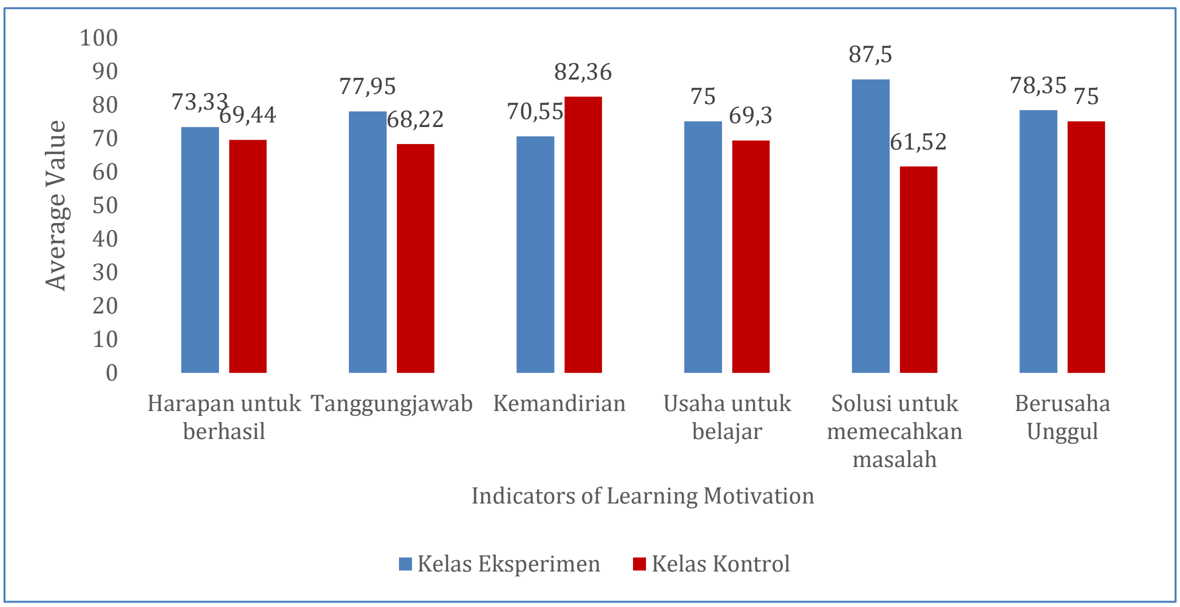

Figure 2. Learning Motivation Result Data

Based on Figure 2, the results of the calculation of the motivation questionnaire indicators obtained data in the experimental class, namely: hope to succeed by 73.33%, responsibility by 77.95%, independence by 70.55%, effort to learn by 75.00%, solutions to solve problems by 87.50% and trying to excel by 78.35%. While the results of the calculation of the motivation questionnaire indicators obtained data in the control class, namely: hope to succeed by 69.44%, responsibility by 68.22%, independence by 82.36%, effort to learn by 69.30%, solutions to solve problems by 61.52% and trying to excel by 75.00%. Based on these data, the highest indicator in the experimental class is the solution to solving problems. This event can be caused by the STAD type cooperative learning model in the discussion phase and giving questions distributed by the teacher can motivate students to solve the problems given. So that with this group discussion, students are more enthusiastic in learning, trying to learn in the hope that their learning outcomes will be better. In the control class, the highest data was obtained on the independence indicator. This event can be caused by conventional learning methods that require students to be able to work on tasks individually, thus motivating students to be able to learn independently. Based on the results of this study in line with research conducted (Sudarsa et al., 2013) showed that the application of STAD type cooperative learning model can increase student learning motivation.

Based on the results of the data normality test calculation, the calculated chi squared value in the experimental class is 10.28 and the control class is 8.53 smaller than the chi squared table which is 11.07. Therefore, it can be concluded that the research data is normally distributed, so it has met the requirements for further testing. Based on the results of the homogeneity test, the data obtained was F-count < F-table (1.71 < 1.75). So it can be concluded that the research data (α = 0.05) is declared homogeneous, so it has met the requirements for hypothesis testing.

Hypothesis Test Results

The results of the hypothesis test calculation of learning outcomes and student learning motivation are contained in Table 1 and Table 2.

Table 1. Hypothesis Test Results of Learning Outcomes

Class	(X)	Varians	T Count	T Table	α	Description
Eksperimental	84,86	20,69	5,03	1,666	0,05	Ha accepted
Control	78,61	35,45				

From the results obtained, namely tcount> ttable (5.03> 1.666), then H_0 is rejected and H_a is accepted. So it can be concluded that there is an effect of computational chemistry-based learning media using the STAD type cooperative learning model on student learning outcomes on the subject of forces between molecules.

The results of the student learning motivation hypothesis test can be seen in Table 2.

Table 2. Hypothesis Test Results of Learning Motivation

Class	(X)	Varians	T Count	T Table	α	Description
Eksperimental	92,58	86,87	3,12	1,666	0,05	Ha accepted
Control	85,61	93,84				

From the results obtained, namely tcount> ttable (3.12> 1.666), then H0 is rejected and Ha is accepted. So it can be concluded that there is an effect of computational chemistry-based learning media using the STAD type cooperative learning model on student learning motivation on the subject of forces between molecules.

Gain Test Results

The results of the gain test calculation for pretest and posttest data can be seen in Table 3.

Table 3. Gain Test

Class	Pretest Score	Posttest Score	Gain	Description
Eksperimental	30,55	84,86	0,78	High
Control	29,02	78,61	0,69	Medium

The results obtained showed that the increase in learning outcomes of the experimental class was higher than the control class. Where the increase in the experimental class was 78% and the increase in the control class was 69%. Then the difference between the increase in student learning outcomes of the experimental class and the control class is 9%.

The experimental class learning was applied with STAD (Students Team Achiviement Divisions) type cooperative learning with Microsoft Office Power Point media and the control class with conventional learning. This cooperative method emphasizes learning in heterogeneous groups helping each other, working together to solve problems, and uniting opinions to get maximum success both group and individual. So in this cooperative learning model, learning activities are carried out in groups to work together, help each other build concepts and solve problems.

The increase in student learning outcomes taught with the STAD type cooperative model using power point is significantly greater than those taught with conventional learning models. From the research results, the increase in learning outcomes (gain test) of students in the experimental class amounted to 78% while the control class students amounted to 69%.

Sourced from the results of this research in line with research conducted (Dewita et al., 2020) shows that the use of learning media based on 3D visualization and molecular animation on the learning outcomes of molecular shapes shows student learning outcomes in the subject of molecular shapes molecules taught using the STAD type cooperative learning model and learning media based on 3D visualization and molecular animation with an average pretest value of 35.33 and posttest 86.17 experienced an increase in learning outcomes. This is because in using the STAD type cooperative learning model using power point, students interact and discuss with each other in solving the problems given by the teacher. By actively looking for answers to the questions given, students do not find it difficult to remember the material taught and increase students' memory of the material and can certainly improve student learning outcomes.

In addition, in the experimental class, the STAD type cooperative learning model using computational chemistry-based learning media made it easier for students to understand the existing learning because the material that is usually explained by theory can be seen directly with moving animations. This can certainly improve learning outcomes and student motivation in the experimental class higher than the control class. In contrast to the control class taught with a conventional learning model, although the teacher can easily control the class and can summarize or explain the main points of important material in a short time, students become passive. Students only listened and relied on what the teacher presented and there were students who did not hear or listen to the teacher properly. These things can be found throughout the lesson that students do not learn actively, so their learning motivation is lacking.

CONCLUSIONS

The results showed the influence of computational chemistry-based learning media using the STAD type cooperative learning model on student learning outcomes on the subject of intermolecular forces. From the results obtained, namely tcount> ttable (5.03> 1.666) and the influence of computational chemistry-based learning media using the STAD type cooperative learning model on student learning motivation on the subject of chemical bonds on the subject of intermolecular forces. From the results obtained, namely tcount> ttable (3.12> 1.666).

LIMITATION & FURTHER RESEARCH

The limitations of the study are those characteristics of design or methodology that impacted or influenced the interpretation of the findings from your research. Further research should suggest the number of gaps in our knowledge that follow from our findings or to extend and further test of the research.

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