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Implementation of Differentiated Learning with Project Based Learning Model to Increase Students' Interest and Learning Outcomes on Molecular Structure Material

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ABSTRACT: This is a Classroom Action Research (CAR) that aims to increase students' interest and learning outcomes in class XI chemistry material, which is the structure of molecules, at SMA Negeri 1 Cangkringan, Sleman, Yogyakarta. with a total of 34 students. Differentiated learning was used alongside a project-based learning model to conduct learning activities. This research began with pre-cycle activities to collect data on student profiles for mapping differentiated learning based on students' learning styles and initial abilities. Furthermore, the data collected was used to conduct classroom action research in two cycles. Each cycle consists of several stages, including planning, action implementation, observation, and reflection. To obtain data on the study's findings, data collection was conducted qualitatively and quantitatively for students' interests and learning outcomes. The findings revealed that by implementing differentiated learning through the project-based learning model, students' learning outcomes improved from 74% classical completeness in cycle 1 to 95% in cycle 2. In the cycle 1, 74% of students achieved the minimum competency standards and in the cycle 2 it increased to 95%. Students' interest in learning increased in all indicators from cycle 1 and improved even more in cycle 2. As a result, it is possible to conclude that the use of differentiated learning in conjunction with a project-based learning model can increase the interest and learning outcomes of chemistry students in class XI MIPA 1 SMA Negeri 1 Cangkringan during the 2023/2024 academic year on molecular structure materials.

Keywords: differentiated learning, project-based learning, learning interest, learning outcomes, molecular structures

INTRODUCTION

Education is an effort to increase the intelligence of the nation's people. An essential outcome of education is the development of highly skilled and competitive human resources who can contribute to the advancement of national quality and effectively address global challenges with robust competencies and strong character [1]. Education is also an indicator of a nation's quality that can be seen by other countries. As a result, education is a critical issue for the government to address. According to Article 3 of Law No. 20/2003 on the National Education System, the purpose of national education is to maximize students' potential to become human beings who are faithful, devoted to God Almighty, noble, healthy, knowledgeable, capable, creative, independent, democratic, and responsible. With the goal of national education, teachers should be able to explore ideas by thinking creatively and innovatively when planning the learning process to make it interesting. Interesting learning can be accomplished by connecting the material taught to the students' daily live problems, allowing students to better understand the material [2].

An increase in student learning outcomes is one indicator of successful learning. Learning potential can be increased by implementing high-quality and effective learning methods or models [3]. Learning will be effective if teachers can develop appropriate learning strategies and designs to meet the diverse learning needs of their students, including culture, motivation, and learning styles. Learners are born with various characteristics and uniqueness, and their learning needs vary accordingly. As a teacher, you should always try to meet their needs so that they can be properly accommodated, allowing their potential to develop optimally and making learning meaningful. Teachers need to determine the appropriate learning methods and models. The step that should be taken is by implementing differentiated learning. Differentiated learning is a learning approach that is carried out to meet the needs of each learner according to their inherent talents and interests. This learning process contains four aspects, which are content, process, product, and learning environment differentiation [4].

Differentiated learning is an effort to adjust the learning process to the needs of each learner [5]. To improve learning outcomes, the learning process is tailored to the learner's interests, learning profile, and level of readiness. The principle behind differentiated learning is flexible grouping of learners. Teachers organize learning in groups so that students can work alongside their peers for a set amount of time [6]. Teachers and students work together to develop a commitment to achieving the desired learning outcomes, and time is used flexibly to adjust to learners' processes and learning outcomes [7]. Differentiated learning is in line with the philosophy of educational thought according to Ki Hajar Dewantara, that education (opvoeding) provides guidance to all the natural forces possessed by children so that children can achieve the highest safety and happiness both as a human being and as a member of society [8].

One type of learning model that can be used in differentiated instruction is project-based learning. The project-based learning model is based on constructivism, which holds that knowledge is created cognitively through learner activities [9]. This activity incorporates learners' scientific skills and attitudes, allowing them to meaningfully develop their own understanding through real-world experience [10]. The project-based learning model is often referred to as a learning method that uses problem issues in its system with the aim of facilitating students in the process of understanding and absorbing the theory given [11]. The model uses a contextual approach and fosters learners' skills in critical thinking. Therefore, they are able to consider the best decision taken as a solution to the problem [12].

The project-based learning model can be implemented in molecular structure material. This step is a solution to make it easier for students to understand the concept of molecular structures by making a project on the structure of a molecule. Molecular structure or molecular geometry is a three-dimensional arrangement of atoms in a molecule [13]. Molecular structure is one of the topics in chemistry that is often difficult for students to understand. This material is related to the three-dimensional structure of the molecule which is influenced by the number of bonds and bond angles around the central atom. The difficulty in learning this topic is usually caused by its abstract nature, so it requires understanding of concepts, memorization, and skills to be able to determine the structure of the molecule correctly.

One of the success factors for learning is students' willingness to participate in learning activities [14, 15]. Learning activities are effective when people enjoy, or when they are interested in learning [16]. Interest is a powerful motivator in learning activities. Interest is related to one's perceived needs; the higher the perceived need, the greater the interest and attention to learning, which leads to improved learning outcomes [17]. Learning interest can be measured using four indicators: feelings of pleasure, learner acceptance, learner interest, and learner involvement [18].

The novelty of this study lies in the integration of differentiated instruction with the Project-Based Learning (PjBL) model to enhance students' interest and learning outcomes in abstract chemical topics, specifically molecular geometry. This approach is strategically designed to address students' diverse learning needs by considering their interests, learning profiles, and readiness levels, utilizing flexible grouping in alignment with the principles of differentiated instruction. The PjBL model facilitates experiential learning by engaging students in constructing molecular models, thereby addressing challenges in comprehending molecular geometry concepts. Furthermore, this research underscores the pivotal role of learning interest as a key indicator of success, assessed through four dimensions: enjoyment, acceptance, curiosity, and engagement. Additionally, the study integrates Ki Hajar Dewantara's educational philosophy, which emphasizes the holistic development of students' potential, with the application of a constructivist approach that is both contextual and relevant. This innovative synthesis offers a significant contribution to chemical education pedagogy, particularly in teaching abstract and complex concepts. The research questions asked in this study are:

1. Can the application of differentiated learning using the Project-Based Learning model on molecular form material be implemented to increase students' interest in learning?

2. Can the application of differentiated learning using the Project-Based Learning model on molecular material improve student learning outcomes?

3. What is the percentage increase in student learning outcomes in each cycle after implementing differentiated learning using the Project-Based Learning model in molecular form material?

4. What is the percentage increase in students' interest in learning in each cycle after implementing differentiated learning using the Project-Based Learning model in molecular form material?

Based on the explanation above, this study aims to enhance students' interest and learning outcomes in molecular geometry by applying differentiated instruction through the Project-Based Learning (PjBL) model. The implementation of this approach is expected to address the diverse learning needs of students, thereby fostering increased engagement and improving their academic performance.

RESEARCH METHODS

Materials and Tools

The research was conducted at SMA Negeri 1 Cangkringan in the odd semester of the 2023/2024 academic year. This research is classified as Classroom Action Research (CAR) using direct observation data during the learning process in the classroom. Classroom Action Research is a scientific activity conducted by teachers within the classroom, using interventions aimed at enhancing the quality of teaching. Additionally, this research supports teachers in developing their professional skills [19]. This research was conducted with the aim of increasing students' interest and learning outcomes. The subjects in this study were students of class XI MIPA 1 totaling 34, consisting of 22 women and 12 men, with 2 observers, namely fellow teachers in one school involved in the course of the research. The object in this study was the interest and learning outcomes of participants in studying chemistry subject matter of molecular structures using differentiated learning with a project-based learning model.

The research activities commenced with the pre-cycle stage, which involved observing students to assess their initial abilities and learning styles. These pre-cycle activities were conducted over two meetings. The analysis of students' initial abilities was carried out using the Quizizz platform, while their learning styles were assessed through a questionnaire administered via Google Forms. Data collected from the diagnostic assessment of initial abilities and the learning style questionnaire were utilized to map students' learning profiles. This mapping served as the foundation for the study, titled The Application of Differentiated Learning with the Project-Based Learning Model to Enhance Students' Interest and Learning Outcomes in Molecular Geometry. The pre-cycle activities were conducted collaboratively, involving teachers as researchers and students as participants.

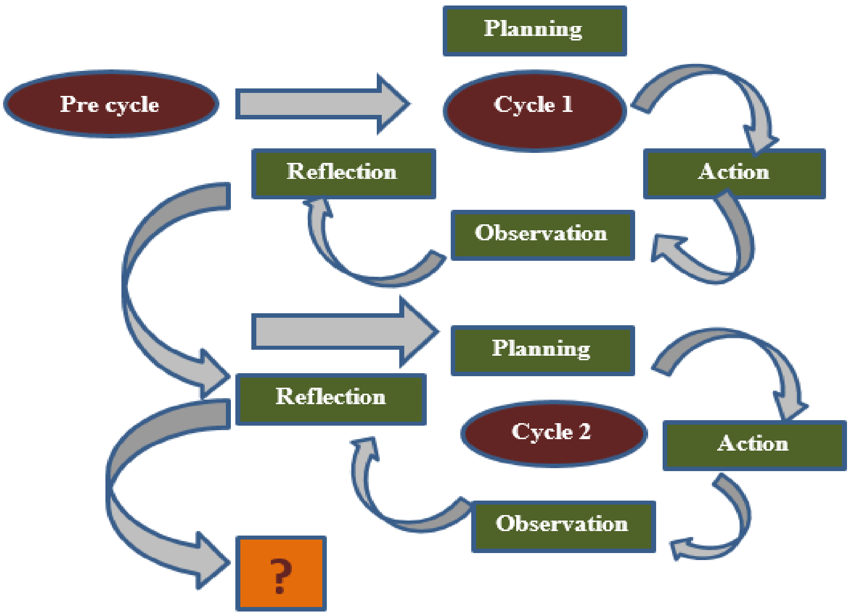

FIGURE 1. Classroom Action Research Design

This study was conducted in two cycles, each of which followed the stages of Classroom Action Research (CAR). Each cycle consisted of four meetings. During the planning stage, researchers developed strategies to address the problems identified in the initial analysis. This stage involved the creation of differentiated learning resources, including teaching modules, instructional materials, student worksheets, and assessment tools. In the implementation stage, learning activities were carried out according to the prepared plan, involving teachers as researchers, students as participants, and observers. The observation stage focused on collecting data and evaluating the implementation of the learning process. Observations were conducted by teachers and observers, with students' learning outcomes assessed through multiple-choice tests and their interest in learning measured using a Likert scale. The Likert scale facilitates the quantification of respondents' agreement levels with various statements, thereby supporting more comprehensive and detailed data analysis [20]. The final stage, reflection, involved evaluating all activities conducted during the cycle to identify strengths and weaknesses. The results of this evaluation were then used to guide improvements in the subsequent cycle. The chart for the class action research design can be seen in Figure 1.

The variables in this study include both independent and dependent variables. The independent variables is the differentiated learning using project-based learning models and while the dependent variables are students' interest in learning and their academic achievement. Questionnaires and documentation were used to collect data on students' educational interests. The questionnaire used in this study was designed to assess the increase in students' interest in learning when differentiated learning was paired with a project-based learning model. This study used a questionnaire in the form of an attitude scale. Meanwhile, to determine students' learning outcomes, formative tests took place throughout the learning process, as well as tests at the end of each cycle in the form of descriptions and multiple-choice tests. The data analysis technique used was quantitative analysis for learning outcomes and qualitative analysis to draw conclusions based on observation sheets. The results of the formative tests given each cycle, with the standard of teaching completeness criteria 75 and the percentage of classical completeness of 90%, were used to assess the study's success.

RESULT AND DISCUSSION

Result

Pre-Cycle Results

At the pre-cycle stage, initial analysis is carried out to determine students' initial abilities through cognitive diagnostic assessments. This assessment is carried out by giving a test using the Quizziz platform which includes chemical material that has been studied in the previous semester and is related to the material to be studied. The test is structured in the form of multiple-choice questions. Apart from that, students' interest in learning is measured through a questionnaire using a Likert scale and observation techniques. The results of the diagnostic assessment in the form of a multiple-choice test at the pre-cycle stage are presented in Table 1.

TABLE 1. Diagnostic Assessment Data of Pre-Cycle Activities

No.	Aspect	Description
1	Learners who took the test	34 people
2	Learners who completed the test	8 people
3	Learners who did not complete	26 people
4	Percentage of completed learners	24%
5	Percentage of learners who did not complete	76%
6	Highest score	85
7	Lowest score	25
8	Average	48.38

Table 1 shows a 24% completion rate, indicating that students were divided into three groups based on their initial abilities: high, medium, and low. Then, the students were divided into groups that heterogenously. Figure 1 shows the classical completeness obtained during the pre-cycle.

A non-cognitive diagnostic assessment was conducted to determine the learning styles of students. This aligns with the study conducted by Pepayosa et al who stated that ‘Learning style is one aspect of non-cognitive diagnostic assessment that can be used to determine learning outcomes‘ [21]. The assessment was conducted with a questionnaire using Google Form platform. The questionnaire results data are presented in Table 2.

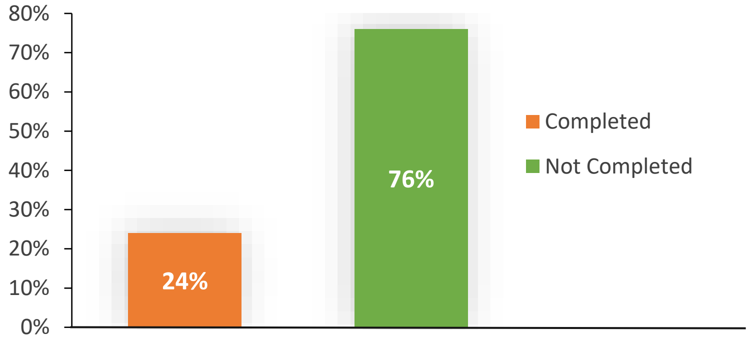

FIGURE 2. Pre-Cycle Classical Completion Diagram

TABLE 2. Learner Learning Style Data

No.	Learning Style	Total	Percentage
1	Visual	14 people	41.17%
2	Auditory	8 people	23.53%
3	Kinesthetic	8 people	23.53%
4	Combined	4 people	11.76%

Table 2 shows that there are 14 students who have a visual learning style, 8 students who have an auditory learning style, 8 students who have a kinesthetic learning style, and 4 students who have a combined learning style.

Students' interest in learning in pre-cycle activities was measured using 4 indicators, including; feelings of pleasure, interest, engagement, and involvement of students using a questionnaire. From the questionnaire distributed to students, the data presented in Table 3 was obtained.

TABLE 3. Student Learning Interest Questionnaire Data on Pre-Cycle Activities

No.	Indicator	Percentage
1	Learner's sense of pleasure	45%
2	Learner interest	40%
3	Learner attention	40%
4	Learner engagement	30%

Cycle 1 Learning Outcomes

After implementing the learning process in Cycle 1, data on chemistry learning outcomes for the molecular structure material were obtained using differentiated learning models and project-based learning (Table 4).

TABLE 4. Data on Student Learning Outcomes Cycle 1

No.	Aspect	Description
1	Learners who took the test	34 people
2	Learners who completed the test	25 people
3	Learners who did not complete	9 people
4	Percentage of completed learners	74%
5	Percentage of learners who did not complete	26%
6	Highest score	90
7	Lowest score	40
8	Average	75.14

Table 4 displays data on student learning outcomes in cycle 1. By implementing differentiated learning using the Project Based Learning learning model, it was discovered that out of the 34 students who took the test, 25 completed, while 9 did not. The highest score is 90, while the lowest score is 40. The average score for all students is 75.14. Figure 3 below shows the classical completeness obtained in Cycle 1.

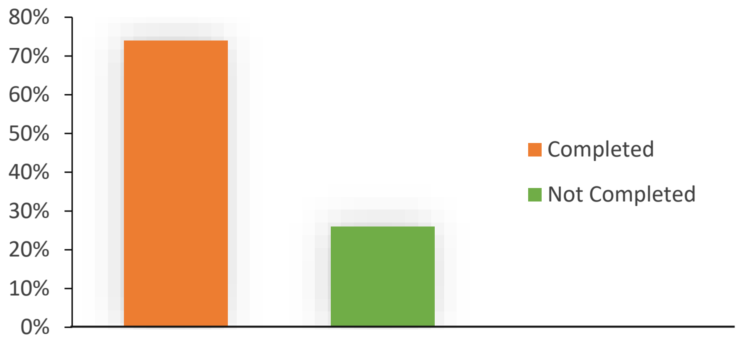

FIGURE 3. Diagram of Classical Completeness Cycle 1

In addition, interest in learning increased during the first cycle. The following data show the results of learning interest in cycle 1.

Cycle 2 Learning Outcomes

After carrying out cycle 2 learning activities, data on chemistry learning outcomes on molecular structure material were obtained by implementing differentiated learning using the Project Based Learning learning model.

Table 6 displays data on student learning outcomes in cycle 2. After implementing differentiated learning using the Project Based Learning learning model, the number of students who completed the test increased from 25 to 31. There are still three students who did not complete. The highest score is 95, while the lowest score is 56. The average score for all students is 81.61. Figure 3 below shows the classical completeness obtained in Cycle 2.

TABLE 6. Data on Student Learning Outcomes Cycle 2

No.	Aspect	Description
1	Learners who took the test	34 people
2	Learners who completed the test	31 people
3	Learners who did not complete	3 people
4	Percentage of completed learners	91%
5	Percentage of learners who did not complete	9%
6	Highest score	95
7	Lowest score	65
8	Average	81.61

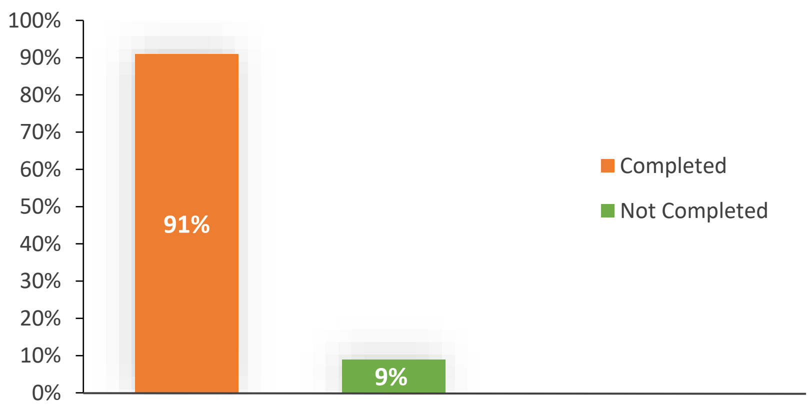

FIGURE 4. Cycle 2 Classification Completion Diagram

Furthermore, the interest in learning of students in cycle 2 also increased. Table 7 is data on students' interest in learning in cycle 2.

TABLE 7. Data on Students' Learning Interest Questionnaire in Cycle 2 Activities

No.	Indicator	Percentage
1	Learner's sense of pleasure	84%
2	Learner interest	82%
3	Learner attention	80%
4	Learner engagement	76%

Discussion

This research is divided into three phases: the pre-cycle, Cycle 1, and Cycle 2. The pre-cycle phase is a crucial step in conducting classroom action research. Its primary objective is to gather as much data as possible to design a comprehensive, effective, and efficient plan that directs and focuses the implementation of the research. The findings from the pre-cycle activities, specifically mapping students' profiles through cognitive diagnostic tests (initial ability tests) and non-cognitive diagnostic tests (learning style assessments), were used to group students homogeneously based on their learning styles and heterogeneously based on their initial abilities. Based on these profiles, the learning process was implemented using a differentiation approach in terms of process, content, and product. The research was conducted over two cycles, with each cycle consisting of four meetings.

In both cycle 1 and cycle 2, there was a significant improvement in learning outcomes through the application of differentiated learning strategies combined with Project-Based Learning. However, the learning outcomes in cycle 1 cannot be considered excellent, as they did not achieve the classical completeness criterion of 90%. Despite this, the number of students who achieved completeness exceeded those who did not. Students' interest in learning during cycle 1 remained low, although there was some improvement. This was largely due to flaws in the learning process during cycle 1. Additionally, the use of differentiated learning with the project-based learning model was still relatively new in the classroom, and students were in the process of adapting to its stages and syntax. Through the implementation of differentiated learning, students received instruction tailored to their individual learning needs, leading to a more effective learning process. Furthermore, nearly all students actively participated and engaged in the learning activities. Differentiated learning allowed students to access various references aligned with their learning styles and create products based on their personal preferences.

Based on the implementation of cycle 1, the results showed that the classical completeness rate was 74%. This percentage had not yet reached the expected performance indicator, which requires meeting the classical completeness standard of 90%. Additionally, students' interest in learning was still not optimal. To address these shortcomings, the researcher made improvements for the next cycle. As a researcher and teacher, efforts were made to support each learner by providing guidance during project-based learning activities in their respective groups, particularly through discussions aimed at assisting students with lower learning abilities. Differentiation strategies were employed to accommodate diverse learning needs while making the learning process more engaging. The teacher also implemented scaffolding techniques and peer tutoring, where students who had already grasped the material helped their peers who needed additional support. Furthermore, learning was enriched by presenting examples of molecular structures through engaging media or physical models, helping students better understand concepts and complete their projects effectively.

Based on the implementation of cycle 2, classical completeness reached 95%, and students' interest in learning showed a significant improvement. This indicates an increase in both the outcomes and engagement of students, with 31 students achieving the completeness standard. Students' interest in learning across all indicators also improved. This progress can be attributed to the teacher's efforts, which included incorporating ice-breaking activities at the beginning of the lesson to spark students' interest and enhance their concentration. Additionally, scaffolding techniques were applied during the learning process to support students in developing independence and mastering concepts or skills effectively [22]. Learners actively engaged in group discussions during learning activities, with the teacher serving as a facilitator to provide assistance and guidance to all groups, particularly those with learners who had lower initial abilities. Differentiated learning was implemented successfully, creating a meaningful experience for students. They learned according to their individual needs and interests and were able to present products aligned with their preferred learning styles. For example, the visual group presented products in the form of molecular structure illustrations on paper, with some utilizing the Colorado PhET application. The audio group created molecular structure songs and recorded them, while the kinesthetic group produced molecular models using toy balls. The Colorado PhET application is a platform offering interactive simulations for various concepts in physics, chemistry, biology, mathematics, and other sciences. This tool aims to enhance students' understanding through a more interactive and practical learning experience [23, 24]. Differentiated learning is more effectively implemented through a project-based learning model, as each stage encourages students to be more creative in solving problems. By applying this model, learners can develop essential 21st-century skills, including collaborating with peers, solving problems creatively, thinking critically, and effectively communicating their ideas.

Differentiated learning involves differentiation in content, product, and process. Content differentiation is implemented by allowing students to use any learning resources they prefer, as long as they remain within the context of the learning objectives. Additionally, to differentiate the learning process, teachers utilize a variety of media tailored to students' needs. They incorporate molecular structure learning videos, the PhET Colorado app, and molecular structure songs with lyrics created based on the material. This approach aims to make learning more meaningful, enhancing students' enjoyment and increasing their interest in learning.

CONCLUSION

The research concluded that applying differentiated learning combined with a project-based learning model improves the interest and learning outcomes of Class XI MIPA 1 students at SMA Negeri 1 Cangkringan, Sleman, on molecular structures. Learning outcomes increased across the pre-cycle, Cycle 1, and Cycle 2, achieving a 90% classical completeness standard. In the pre-cycle, only 8 students (24%) met the minimum competency criteria, while 26 students (76%) did not. Diagnostic analyses showed 14 students had visual learning styles, 8 had auditory, 8 had kinesthetic, and 4 had a combination. In Cycle 1, 25 students (74%) achieved the criteria, but student interest was still low, prompting a continuation to Cycle 2. By Cycle 2, 31 students (95%) met the criteria, achieving classical completeness. Therefore, this approach effectively enhances student engagement and performance in learning molecular structures.

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