



Science Learning in Solar System Material with Differentiated Learning Styles Using the Project-Based Learning (PjBL) Model to Improve Cognitive Learning Outcomes

Puspananda Damayanti¹, Andista Candra Yusro^{1*}, and Tutik Wahyuni²

¹ PGRI Madiun University, Madiun, Indonesia

² SMP Negeri 1 Jogoroto, Jombang, Indonesia

*andista@unipma.ac.id

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Abstract

This study aims to describe the observation of improving cognitive learning outcomes with learning style differentiation learning with the use of the Project Based Learning (PjBL) model. The study was carried out at a junior high school in Jombang district. The population based on the object of observation was carried out, namely class VII F and VII D students for the 2022/2023 school year, with a total population in this study of 62 people. Class VII D served as the control group for the study, and Class VII F served as the experimental group. The research sample was taken using the total sampling technique. Data was collected using tests with instruments like pretest and posttest question sheets. The average value of N-gain shows that the study's findings—namely, the improvement in learning outcomes of diversified learning styles utilizing the Project Based Learning (PjBL) model—have improved. The study's findings revealed that the average n-gain value in the experimental class was 0.74 in the high category and 0.69 in the medium category for the control class. These findings suggest that differentiated learning with the use of the PjBL model approach increases student learning outcomes more than conventional learning.

Keywords: Differentiated Learning; Learning Styles; Project Based Learning

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INTRODUCTION

Education is an effort that aims to develop human qualities in a structured way. Achievement targets in education are relatively standard and must be fulfilled by students. Learning is the process that humans attempt to achieve changes in attitudes, skills, and knowledge after interacting with their

environment (Maryam, 2018; Seven, 2020; Sudjana, 2010). The abilities humans acquire after the learning process are referred to as learning outcomes. Learning outcomes are interpreted as a result obtained by someone who has finished developing their abilities to the fullest in learning activities. Skills, knowledge, and



attitude changes are indicators of learning outcomes (Hilmi et al., 2017; Putri et al., 2017)

Science subjects are related to students' abilities in a variety of knowledge related to the natural surroundings through a process of discovery. In the science learning process, students are directed to develop problem-solving skills by applying concepts appropriate to their problems. Science education is also required to find solutions to a situation to obtain more meaningful knowledge about nature (Hidayati, 2017; Supiandi et al., 2016). As a result, during the scientific learning process, students have the chance to conduct experiments to determine the veracity of a fact or concept from the content they are studying so that students have the skills to observe, analyze, prove, and draw conclusions from an object and write down a situation or a process that silent (De Jong et al., 2013; Gunawan et al., 2017; Karyatin, 2017; Sari et al., 2017).

Each educational unit's science curriculum should be interactive, motivating, enjoyable, and challenging to encourage students to participate fully and to give them enough room to exercise their initiative, creativity, and independence following their talents, interests, physical development, and psychological development (Pebriyanti, 2023; Wahyuni, 2022). The variety of goods learning styles and backgrounds of students provides an overview of their different characteristics. The diversity possessed by each student is a challenge for an educator to determine learning that brings success to each student in implementing the learning process in class. The success of implementing education can be influenced by several factors, including teachers' readiness to prepare learning for students.

Based on the results of observations and pre-research activities at school, learning has not been implemented

optimally. Based on the observations, the results were that students' learning needs did not design learning, and they were less able to express their abilities in learning activities. They were less able to express their abilities in learning exercises.

One strategy for addressing the variety of student characteristics is to the diversity of learning styles in a class, is to apply appropriate learning, namely differentiated learning. Each student has a different way of trying to achieve a specific goal. So, to respond to these other learning styles, educators use other learning processes, media, or content to fulfill their learning goals. Differentiated learning is an effort to recognize and carry out learning according to different characteristics. Differentiated learning is also defined as learning that the teacher carries out in the classroom with various actions; for all students from different backgrounds to learn successfully, it is important to establish learning materials and evaluation methods, as well as methods for acquiring knowledge and for building, reasoning, and processing ideas (Eviana, 2023; Septa et al., 2022). Differentiated learning shows that educators can better identify, investigate, and serve the different learning needs of diverse learners. By adjusting the learning needs of each learner and considering their readiness, interests, and learning profiles, a differentiated learning strategy can be utilized (Minasari & Susanti, 2023; Pebriyanti, 2023). Learning differentiation consists of 3 aspects, namely content, process, and product differentiation. Content differentiation is how we teach material to students according to their learning styles. Process differentiation refers to how students perceive their learning content by engaging in various activities. Meanwhile, teachers demand product diversity by offering a range of product versions based on their learning styles.

The effects of differentiated instruction in the science classroom were studied, and it was discovered that differentiated activities have a very significant position in the classroom to, at the very least, raise the level of student confidence and certainty (Variacion et al., 2021).

In addition to the incompatibility of learning with the needs of students, learning activities designed by the teacher have not fully activated students to discover their knowledge independently. In addition, the learning that is carried out tends to be conventional and based on textbooks without interactive and fun learning activities, so student learning outcomes are not optimal.

Implementing a PjBL strategy is one option to solve the abovementioned issues. PjBL has several advantages; many educational specialists have stated that these techniques are essential in the twenty-first-century classroom. Studies have indicated that PjBL improves Hispanic pupils' academic performance (Galvan & Coronado, 2014). The Minister of Education and Culture cited PjBL as a style of instruction that encourages students to take an active role in their education. This is in line with research Hidayati et al. (2023) conducted that PjBL can encourage student participation in learning activities in class. PjBL significantly enhances the learning outcomes of students (Elisabet et al., 2019; Fini et al., 2018; Mursid et al., 2022; Rahardjanto & Fauzi, 2019; Solihatin & Syahrial, 2019; Yustina et al., 2020). Additionally, this is corroborated by the findings of Khoiri et al. (2016) studies in the journal (Sitompul et al., 2020). Using the problem-based learning methodology, it examines students' creative potential and learning results. The paradigm of PjBL is found to be beneficial in terms of student learning results.

Physics is a challenging topic, and many students dislike it because there are too many formulae to remember. In response, the instructor must identify the best learning model to transform the stigma of a physics topic that is full of complaints, seems tough, and is boring into something more appealing, easy, entertaining, and pleasurable. Identifying traits through needs mapping is extremely beneficial in classifying pupils and making strategy development easier. As a result, new learning methodologies that actively engage pupils are required to overcome things. Differentiated Learning using the PjBL model is a teacher's attempt to modify the classroom learning process to match the specific learning requirements of pupils.

The findings of earlier studies demonstrate that the use of differentiated and PjBL improves student learning outcomes. According to Wahyuni (2022), applying a differentiated approach can be integrated with PjBL models, problem-based learning, and Blended Learning's Station Rotation, improving student learning outcomes. Research conducted by Eviana (2023) states that using varied learning can enhance student learning outcomes as a measure of student capacities. Simangunsong et al. (2022) in their research stated that student learning outcomes can increase effectively by applying the PjBL model. Ramadhani (2020) in their research showed that the application of the PjBL model can improve student learning outcomes.

Based on the finding data obtained by the author during observations at the school where the research was conducted, the authors decided to apply differentiated learning styles using the PjBL model to improve student learning outcomes. The difference in this study lies in using a process and product differentiation learning style approach

combined with a PjBL model. This learning may transform the stigma of physics learning, which is full of complaints, appears difficult, and uninteresting, into something more interesting, easy, entertaining, and fun to improve student learning outcomes.

METHOD

The study was conducted in March 2023 at a junior high school in Jombang for 2022/2023. This study uses a non-equivalent control group and a quasi-experimental design (Sugiyono, 2015), as seen in Table 1.

Table 1 Nonequivalent control group design

Sample	Pret est	treatment	Postt est
I	Y ₁	T ₁	Y ₂
II	Y ₁	T ₂	Y ₂

Information:

- I : control class (VII D)
- II : experimental class (VII F)
- Y₁ : pretest
- Y₂ : posttest
- X₁ : conventional learning strategy
- X₂ : differentiated learning styles using the PjBL model (Sugiyono, 2015)

The researcher determined the population based on the object of observation, namely class VII F students for the 2022/2023 academic year, with a total population in this study of 62 people. Class VII D was the control class sample, and class VII F was the experimental class sample in the study sample. The research sample was taken using the total sampling technique. Differentiated learning tactics served as independent factors in this study, while student learning results were the dependent variable.

In collecting research data, researchers used tools in the form of questions in the cognitive domain using objective exams consisting of 10 multiple-choice questions and two essay

questions. The exam is administered twice: once before the learning activities (pretest) to assess students' prior knowledge and once after the activities (posttest) to assess students' subsequent knowledge. The indicator of the essay can be seen in Figure 1, and the scoring rubric can be seen in Figure 2.

Skor 25	Peserta didik mampu menjawab dengan jelas/tepat sesuai dengan kajian teori yang ada
Skor 20	Peserta didik mampu menjawab dengan jelas/tepat mendekati dengan kajian teori yang ada
Skor 15	Peserta didik mampu menjawab tidak terlalu jelas/tepat dengan kajian teori yang ada
Skor 10	Peserta didik mampu menjawab tidak sesuai dengan kajian teori yang ada
Skor 0	Peserta didik tidak menjawab pertanyaan yang diberikan

Figure 1 Indicator of essay

1. multiple choice questions assessment guide

Question number	Question value
1-10	5
Maximum number of score	50

2. essay assessment guide

Question number	Question value
1-2	25
Maximum number of score	50

$$Score = \frac{(number\ of\ multiple\ choice) + (number\ of\ essay\ score)}{max\ score} \times 100$$

Figure 2 Rubric Assessment

An indicator of completeness in knowledge learning outcomes is when students exceed the Standard of minimum completeness that the school has set, namely ≥ 75 in the acquisition of scores. The extent to which learning results have increased in the knowledge aspect is known based on the calculation results from the *N-gain test*. The *N-gain test* measures the increase in student learning outcomes after and before implementing differentiated learning styles using the PjBL model to improve student learning outcomes. The data obtained is then converted to determine the category of *N-gain* (Dalila et al., 2022).

Data obtained through Nonequivalent Control Group Design were analyzed by homogeneity test. The one-way ANOVA test was run on the

homogeneity data using the SPSS software with a significance threshold of 5%. The homogeneity test criteria state that if the significance number is more than 0.05, the data are homogenous; otherwise, they are not.

RESULTS AND DISCUSSION

Aspects of process and product differentiation are used in applying learning style differentiation with a PjBL model. According to the student's learning styles, the teacher provides three activities. For students who learn visually, the instructor gives activities such as reading books and watching films, evaluating the outcomes of those

observations, and studying literature in the form of clips as learning products. For students with an auditory learning style, the teacher gives tasks such as watching and listening to films and then analyzing the findings in the form of podcasts as a product. The teacher provides role-playing activities to become planets in the solar system for students with a kinesthetic learning style and then interprets the results of observations in the form of solar system dioramas as product differentiation. Students are active in doing learning projects. Figure 3 depicts some of the results of student learning outcomes.



Figure 3 Student projects

In collecting research data, researchers used tools in the form of questions in the cognitive domain using objective exams consisting of 10 multiple-choice questions and two essay questions. Multiple-choice questions involve student precision in reading and interpreting the questions, but essay questions are descriptive questions that are unquestionably more complicated than multiple-choice questions. Essay test instruments in the form of questions or tasks are provided to test takers with written narrative responses. Students improve their abilities to analyze

rationally, analytically, and methodically in finding responses to problems through essay questions. The evaluation techniques for the two types of questions differ. The distinction between the two sorts of questions is in weighting the value of each correct response. The assessment results are summed together to determine the final score for each student. The value of pretest and posttest activities resulted in improved learning outcomes. *The pretest* is a matter that is done before learning to differentiated learning styles with the PjBL model is applied. *The*

posttest is a problem that is done after learning style differentiation with the PjBL model is applied. The collected findings were examined using N-gain analysis, as shown in Table 2.

Table 2 Recapitulation of pretest value results

Component	Experiment class	Control Class
Min value	36	35
Maximum value	70	60
Average	42.4	41.0

Students in the control class (VII D) and the experimental class (VII F) completed the pretest. Following the pretest results in the experimental class, the lowest score attained was 36, and the best score gained was 70. The experimental class achieved an average score of 42.4. The pretest results in the control class revealed that the lowest score was 35, and the best score was 60. Students in the control group had an average pretest score of 41.0. The chart indicates that pretest results are typically low since the questions are designed to assess students' initial understanding when they have not studied the content and learning has not been applied. After students study the material and apply learning style differentiation learning with the PjBL model. Table 3 shows that the posttest results of the pupils have increased.

Table 3 Recapitulation of posttest score results

Component	Experiment class	Control Class
Min value	78	76
Maximum value	95	88
Average	85.9	81.8

After the learning treatment, different posttest results were obtained in the two classes. In the experimental class, the lowest score was 78, and the highest score achieved was 95. The experimental class earned an average value of 85.9. The pretest results in the

control class revealed that the lowest score was 76, and the highest scores were 88. Students in the control group had an average pretest score of 81.8. The average *pretest score* of students in the control class was 81.8. The data in Table 3 and Table 4 shows that the students' *posttest scores* increased from the *pretest scores*. The boost in student learning outcomes is also shown in the normalized *N-gain*. The average *N-gain value* of students is seen in Table 4.

Table 4 Average N-gain value

Component	Experiment class	Control Class
N-gain	0.75	0.69
Category	Tall	Currently

It is clear from Table 4 that the n-gain values derived from the two classes differ. An average n-gain value of 0.75 was achieved in the experimental class, indicating that learning with varied learning styles utilizing the PjBL model applied to the class had a high criteria effect on enhancing learning outcomes (Dalila et al., 2022; Putri & Marpaung, 2019). An average n-gain value in the control class was 0.69 was obtained, indicating that learning using conventional methods moderately improved learning outcomes. Students were said to have an increase in the high category if they had an N-gain score ≥ 0.7 .

The *n-gain* category of students in the experimental class can be seen in Figure 4.

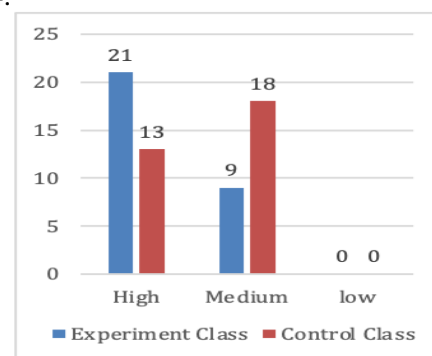


Figure 4 Percentage diagram for *N-gain categories* of students in the experimental class

N-gain scores in the experimental class show that as many as 21 student learning outcomes have increased with high *N-gain criteria*, nine students have experienced improved knowledge learning outcomes with medium *N-gain value categories*, and no student has received the requirements Low *N-gain*. The number of students' *N-gain* scores in the experimental class showed that as many as 13 student learning outcomes had increased with high *N-gain standards*, 18 students had increased their knowledge learning outcomes with medium *N-gain value categories*, and no students received the criteria Low *N-gain*. According to the data, 100% of student learning outcomes have improved in the medium and high categories. The graph demonstrates that the number of n-gain scores in the high category in the experimental class is much greater than in the control class. The N-gain value is calculated by dividing the difference between the average posttest and pretest scores by the greatest change in score and multiplying the average pretest score by 100. As a result, diversified learning styles through the PjBL approach can increase student learning results. The pretest and posttest scores and the value of N-gain indicate that student learning outcomes have been met (Oktriviani et al., 2017; Putri & Marpaung, 2019). In the implementation of differentiated learning, a classroom climate that supports the characteristics of each student is created in which every student in the class will welcome and feel welcome; all students respect each other, students feel as safe as possible in learning, there is the hope of growing mastery of students, teachers teach to achieve student success, there is justice that students feel in a real form. Teachers and students collaborate for mutual scholastic success (Minasari & Susanti, 2023). Students prefer learning that takes place in flexible groupings

under a differentiation strategy. When students are struggling, or there is simultaneously stuff they don't comprehend, grouping might make it simpler for them to discuss and ask questions. As a result, pupils are not bored, and their job, particularly when addressing issues, is easier because they share a similar learning style. Because of the comfort that problem-solving discussions provide students, they are likely to make it simpler for them to comprehend the content they are studying (Harmini & Effendi, 2018; Septa et al., 2022). The percentage of completeness of student learning outcomes can be seen in Figure 5.

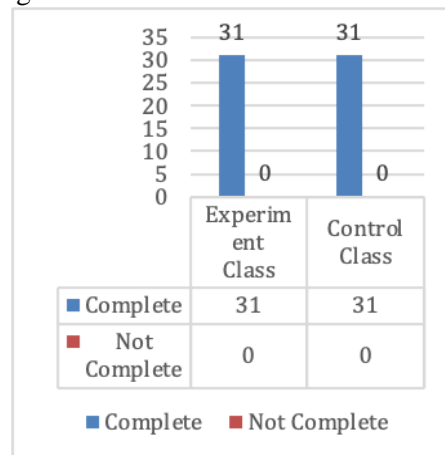


Figure 5 Diagram of student knowledge learning outcomes completion

Figure 5 depicts the experimental and control classes, it was found that 100% of students had *posttest scores* in the complete category, and 0% had *posttest scores* in the incomplete category. A student's score is said to be done if the score is ≥ 76 , namely the KKM score for science learning. The data received indicates that learning is being carried out efficiently and that it is being used to improve learning outcomes. This follows Millatana (2019) that if the number of students who complete KKM is $>75\%$, then learning will be effective and successful.

Then, to establish if the experimental and control classes were from homogenous groups, a homogeneity test

was performed. Table 5 displays the results of homogeneity calculations.

Table 5 Pretest value homogeneity test results

		Levene Statistics	df1	df2	Sig.
Student learning outcomes	Based on Means	3.108	1	60	.083

According to Table 5, the homogeneity test performed in the control and experimental classes yielded a significant value based on a mean of 0.083. Based on the homogeneity test output results, a significant level (Sig)

based on the mean is $0.083 > 0.05$, suggesting that the two classes are homogenous. At the same time, the posttest is shown in Table 6.

Table 6 Posttest value homogeneity test results

		Levene Statistics	df1	df2	Sig.
Student learning outcomes	Based on Means	3.684	1	60	.060

Based on Table 6, the homogeneity test performed in the control and experimental classes yielded a significance value of 0.060 based on the mean. Based on the homogeneity test output results, a significant level (Sig) based on the mean is $0.060 > 0.05$, suggesting that the two groups are homogenous.

Using the PjBL model provides experience to students in managing a project/learning product and managing resources such as tools and materials used to complete assigned projects. The PjBL model has stages, namely: 1) having basic questions; 2) preparing project planning; 3) arranging production schedule; 4) monitoring students and project progress (monitoring the students and progress of the project); 5) assessment of the results (assess the outcome); 6) evaluation of experience (evaluation of the experience). In completing the project, students are guided to associate and understand concepts that can improve students memory of the lessons and material that has been studied to survive

in long-term memory. After applying this learning model, students will be directed to make products as the result of solving problems or material being studied, but also actively increasing understanding of concepts or solving existing problems so that the quality of the process and the quality of learning outcomes can be seen which can improve results. Learn students. This is consistent with findings by Simangunsong et al. (2022) that the PjBL model can increase student learning outcomes, increase student activity in learning, and understand and relate lesson concepts so that students' memories persist in long-term memory. Other research is in line; namely, Gusteti & Neviyarni (2022), that differentiated learning can be integrated with several PjBL models adapted to student learning styles and can improve learning outcomes in learning science.

Differentiated lessons are carried out, namely product differentiation learning as a response to the diversity of student learning styles. Students with a visual learning style are given an assignment in

the form of making clippings about the characteristics of the solar system, students with an auditory learning style are given an assignment in the form of making recordings about the characteristics of the solar system, students with a kinesthetic learning style are allowed to make a madding work on the solar system. Making products aims to determine students' understanding of solar system material. The implementation of learning activities went well because all students were actively involved in learning activities. These results align with the opinion of Pane et al. (2022) in Minasari & Susanti (2023), which states that the learning activities go well after applying differentiated learning. Differentiated learning allows students to develop their creativity, initiative, and independence by utilizing their abilities, interests, and physical and psychological development (Eviana, 2023; Wahyuni, 2022). Through differentiated learning, all the needs of students in learning science can be accommodated according to their interests or learning profiles, increasing students' knowledge in each class.

CONCLUSION

The study concludes that using the PjBL model for different learning styles improves learning results. On learning outcomes, all students declared complete in learning. Student learning outcomes also experienced an increase in the high category based on the average n-gain value. According to the research findings, the average n-gain value acquired in the experimental class was 0.74 in the high category, whereas the average value obtained in the control class was 0.69 in the medium category. Based on the results of research data analysis and conclusions, the researchers provide suggestions, including: in learning activities, the teacher can consider the characteristics of students by using differentiated learning

strategies so that the learning outcomes obtained by students are as expected. A differentiated approach can be integrated with the PjBL model, which can be used as an alternative for further learning. The weakness of this study is that it has not implemented aspects of content differentiation in learning activities.

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