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Analysis of the Relationship between Learning Motivation and Students Cognitive Involvement in Problem-Based Learning through Lesson Study on the Material of Speed and Average Rate

Rindy Puspita Anggrini*, Lusia Andini, Gita Salsabilla Nurma Yahya, Neneng Lestari, Nova Susanti

Physic Education Department, Universitas Jambi, Jambi, Indonesia
*e-mail: rindynew12@gmail.com

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Abstract: Education in the 21st century emphasizes active student engagement, where intrinsic motivation is expected to emerge as observable cognitive participation, particularly through verbal discussions. However, although Lesson Study (LS) and Problem-Based Learning (PBL) are widely reported to strengthen intrinsic motivation, high motivation does not always translate into high verbal cognitive engagement, indicating a potential mismatch influenced by non-cognitive factors. This study aims to analyze the effectiveness of Lesson Study (LS) and Problem-Based Learning (PBL) in fostering students' intrinsic motivation and identify non-cognitive factors that influence the mismatch between motivation and verbal cognitive engagement. This descriptive study used mixed methods, involving 25 students of the Physics Education Study Program. Data were collected through motivation questionnaires (quantitative) and transcripts of group discussion recordings (qualitative) during the implementation of Lesson Study and PBL and processed using descriptive statistics. The quantitative results showed that students' learning motivation was in the high category across all indicators, including persistence, interest, achievement, and independence. However, the qualitative results of the transcripts of verbal cognitive engagement revealed significant variation, where some students exhibited low verbal activity despite having high motivation levels. This inconsistency suggests that high intrinsic motivation has not yet fully translated into active cognitive engagement due to the intervention of affective, social, and situational factors. Thus, Lesson Study and PBL have proven effective in fostering intrinsic motivation, but strengthening collaborative strategies is necessary to ensure optimal cognitive engagement for each individual.

Keywords: Cognitive Engagement; Learning Motivation; Lesson Study; Non-Cognitive Factors; Problem-Based Learning.

Introduction

Education in the 21st century places active student engagement as a primary prerequisite for successful learning, encompassing affective, behavioral, and cognitive dimensions [1]. Two crucial pillars in achieving this engagement are learning motivation and higher-order cognitive activity. Motivation serves as an intrinsic driving force that triggers students to initiate and sustain learning efforts, while cognitive activity, often manifested in problem-solving and verbal discussions, is tangible evidence of the thinking process [2], [3]. To create a learning environment that fosters both of these aspects, innovative learning models are essential. One framework considered effective is the combination of enhancing teacher professionalism through Lesson Study (LS) with a student-centered learning model, namely Problem-Based Learning (PBL), which collectively has the potential to create deep and meaningful learning experiences [4], [5], [6].

Several previous studies have widely supported the effectiveness of Lesson Study in improving the quality of learning and Problem-Based Learning in encouraging active participation [7], [8], [9]. Studies show that the implementation of PBL can increase student learning motivation, especially intrinsic motivation, which is reflected in indicators such as perseverance, tenacity, and interest in learning [10], [11], [12]. With the presence of authentic problems, students feel challenged and responsible for their learning process. Moreover, when reinforced with the Lesson Study cycle, where teachers collaboratively design, implement, and reflect on learning, the classroom environment becomes more supportive and structured to foster students' internal drive [13].

Although the effectiveness of Lesson Study and Problem-Based Learning in fostering motivation has been confirmed, the causal relationship between high motivation and active cognitive engagement has not been consistently validated across all contexts. Cognitive engagement, as reflected through verbal activities (speaking, arguing, asking questions) and critical thinking processes, is a key indicator of deep understanding [14]. Some literature shows that high motivation is not necessarily directly proportional to verbal activity in the classroom [15], [16]. This is due to the presence of affective, social, and situational factors such as anxiety, group dynamics, or a lack of self-confidence that can prevent students from translating their internal drive (motivation) into visible and measurable cognitive actions.

Based on this gap, the scientific novelty of this study lies in the analysis of the data discrepancies found. Initial results suggest that high student learning motivation scores, particularly in the dimensions of perseverance, tenacity, interest, achievement, and independence, are not

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consistently observed in high verbal cognitive activity across the sample. This study critically highlights that Lesson Study and Problem-Based Learning are successful in fostering intrinsic motivation, but are not optimal in ensuring the realization of active cognitive engagement in each individual. The primary issue raised is identifying and explaining non-cognitive factors that hinder the manifestation of cognitive engagement, despite students' affective or motivational conditions already being in the high category. Thus, the main objective of this scientific article is to analyze the effectiveness of Lesson Study and Problem-Based Learning in fostering students' intrinsic motivation and identifying non-cognitive factors that influence the discrepancy between high motivation and verbal cognitive engagement.

Research Methods

This study employed a descriptive, mixed-methods approach, combining quantitative and qualitative methods to provide a comprehensive understanding of the relationship between students' learning motivation and their cognitive engagement in the learning process. This approach was chosen because it can provide a more comprehensive understanding of learning phenomena, both in terms of outcomes and processes.

The research subjects were seventh-semester Physics Education students who attended a lecture on average speed and velocity. The learning activities were carried out through Lesson Study, which consisted of three stages: Plan, Do, and See [17]. Twenty-five students participated, divided into eight small discussion groups, each consisting of three to four members.

The learning design used is Problem-Based Learning (PBL). In the problem-orientation stage, the lecturer presents a contextual problem related to motion phenomena, such as comparing the travel times of two vehicles on different routes. Next, students engage in group discussions, data investigations, presentations of results, and reflections. In these activities, the lecturer acts as a facilitator and observer, while students actively engage as problem solvers. The PBL model was chosen because it can foster critical thinking skills and increase student active involvement in discovering concepts [18].

The research instrument consists of two types, namely a learning motivation questionnaire and transcripts of student discussion recordings. The learning motivation instrument in this study adapted the learning motivation questionnaire developed by Suhudi [1], with indicators referring to Sardiman's (2012) learning motivation theory using 5 main indicators, namely: 1) perseverance in learning; 2) tenacity in facing difficulties; 3) interest and sharpness of attention in learning; 4) achievement in learning; 5) independence in learning. The questions in the questionnaire refer to the ARCS Motivation Model, developed by Keller in 1987, which consists of four components: Attention, Relevance, Confidence, and Satisfaction (Table 1). Meanwhile, transcripts of student discussion recordings were used to analyze the frequency of mentioning concept keywords such as average speed/velocity, average velocity/speed, displacement, and distance, which indicate the level of cognitive engagement.

Table 1. Table Assessment scores on the student motivation questionnaire

Alternative Answer Score		
Alternative Answer	Positive (+)	Negative (-)
Strongly Agree	4	1
Agree	3	2
Disagree	2	3
Strongly Disagree	1	4

Resource: [19].

The research procedure includes three main stages. The Plan stage involves designing PBL-based learning activities and preparing research instruments. In the Implementation (Do) stage, the model lecturer carries out learning according to the learning plan that has been reviewed together and improved (revised) according to suggestions and input. Meanwhile, the course team acts as an observer (in addition to the model lecturer). The Do stage in this study involves implementing learning and collecting data through questionnaires and recordings of group discussions. In the Reflection (See) stage, which immediately follows the learning process, a post-class discussion or reflection activity is held. The reflection is attended by all group members/observers and is intended to review the results of each group member's observations and the recording of the learning process. At this reflection stage, the purpose is to jointly identify solutions to emerging problems, thereby enabling better preparation and implementation of the next learning. The See stage in this study is carried out by reflection on learning outcomes by lecturers and observers to assess the effectiveness of activities and the level of student involvement [20].

Data obtained from the learning motivation questionnaire were analyzed quantitatively by calculating the average score for each indicator to determine the motivation level category (high, medium, or low). Discussion transcript data were analyzed qualitatively through coding and keyword frequency analysis, both using NVivo software and manually. The results of these two analyses were then compared descriptively to examine the relationship between learning motivation and students' cognitive engagement.

Results and Discussion

The implementation of Problem-Based Learning (PBL) in this research was conducted through a Lesson Study approach, which focuses on enhancing the quality of students' learning processes. The material used was Speed and Average Rate, which are basic concepts in physics and relevant to everyday life.

The learning process begins with the teacher distributing Student Worksheets containing contextual problems related to the topic of speed and average velocity. The worksheet is designed to enable students to solve problems through scientific steps: observing phenomena, identifying variables, formulating hypotheses, calculating average velocity and velocity, and drawing conclusions.

Students work in small groups to discuss and solve problems in the worksheet. At this stage, the instructor does not provide direct answers but facilitates by asking provocative questions to foster curiosity and critical thinking. This learning process encourages students to play

an active role in constructing their own knowledge, which is the essence of the PBL approach.

Table 2. Indicator Percentage

No.	Indicators	Percentage	Category
1	Perseverance in learning	80,11%	High
2	Persistent in facing challenges	75,56%	High
3	Interest and Sharpness of Attention in Learning	77,55%	High
4	Achieving in Learning	77,84%	High
5	Independent in Learning	74,43%	High

Table 3. Number of Words

Student Code	Keywrods	Student Code	Keywrods
A1	41	A13	14
A2	31	A14	36
A3	2	A15	6
A4	19	A16	20
A5	11	A17	8
A6	9	A18	35
A7	3	A19	45
A8	4	A20	15
A9	17	A21	19
A10	8	A22	7
A11	9	A23	4
A12	6	A24	46

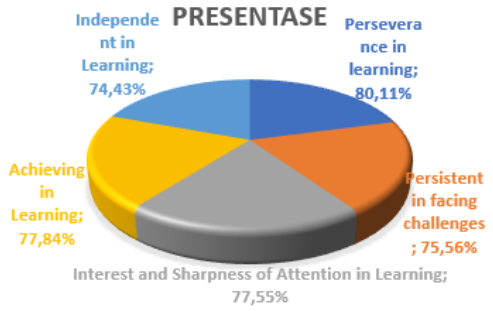

Figure 1. Indicator percentage diagram

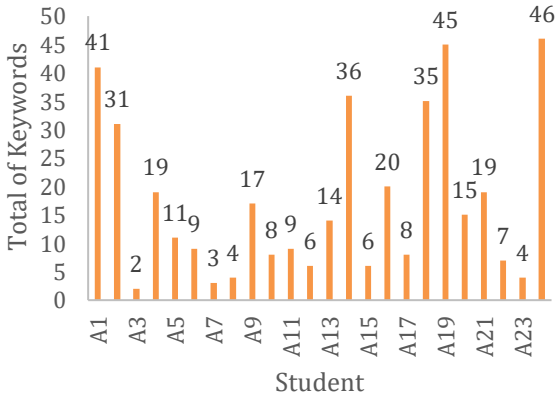

Figure 2. Number of Word diagram

Lesson Study is used to reflect on each stage of the learning process. In the planning stage, lecturers design student worksheets and learning scenarios; in the do stage, PBL activities are implemented; and in the see stage, reflection is conducted with observers to analyze student engagement and the effectiveness of the student worksheets used.

Student Cognitive Engagement

Analysis of the verbal activity transcripts showed that students' cognitive engagement varied between individuals. The transcripts revealed students with a high number of keywords (e.g., A19 with 45 and A24 with 46 keywords), indicating intense thinking activity in discussions and problem-solving. However, there were also students with a low number of keywords (e.g., A3 and A8 with only 2–4 keywords), indicating minimal cognitive engagement.

High cognitive engagement is reflected in students who can explain the reasoning behind their answers, connect concepts to real-world contexts, and critically express their peers' opinions. This is as explained in Bloom's Taxonomy, where the cognitive aspect reflects students' ability to remember, understand, apply, analyze, evaluate, and even create new ideas [21]. In contrast, students with low engagement are more likely to be passive, simply listening or repeating statements without making any new contributions.

These results suggest that not all students are cognitively prepared to actively engage in problem-solving, despite their relatively high motivation to learn. One reason for this is differences in initial abilities and confidence in expressing opinions. Furthermore, some students may not be accustomed to a student-centered learning approach, requiring time to adapt to the PBL method.

The Relationship between Learning Motivation and Students' Cognitive Engagement

The results of the questionnaire analysis show that, in general, students have a high level of learning motivation in all indicators, with a percentage of perseverance in learning of 80.11%, tenacity in facing challenges of 75.56%, interest and sharpness of attention in learning of 77.55%, achievement in learning of 77.84%, and independence in learning of 74.43%. These data indicate that students have a strong drive to learn and actively participate in learning activities. This high motivation indicates that students are effectively ready to engage in learning processes that require deep thinking, as applied in the Problem-Based Learning (PBL) model. This is also proven by the results of research in the form of the PBL model being more effective in facilitating students who have high learning motivation [22].

However, when the results of this motivation were compared with transcript data of students' verbal activities during the implementation of Lesson Study, it was found that high learning motivation was not always followed by high cognitive engagement. Students with high levels of motivation did not necessarily show active thinking activities, such as asking questions, providing arguments, or explaining concepts. Some students tended to be passive, despite having high internal enthusiasm for learning. This indicates a gap between motivation as an internal intention and cognitive engagement as actual behavior in the learning process.

High cognitive engagement is typically observed in students who possess a strong achievement motivation and a genuine curiosity about the material. Students in this category actively solve problems in worksheets, ask questions during discussions, and are able to understand the concepts of speed and average rate in relation to real-world phenomena around them. In contrast, students with low cognitive engagement often simply agree with their peers' opinions without providing in-depth explanations or justification. This suggests that learning motivation alone is insufficient; a supportive learning environment and effective learning strategies are necessary to channel this motivation into higher-order thinking activities.

In the context of problem-based learning, the relationship between learning motivation and cognitive engagement is mutually reinforcing. Because learning motivation is an important element in the learning process [23]. Intrinsically motivated students are encouraged to think critically in solving problems, while successful experiences in thinking and discussing strengthen their learning motivation. In other words, the higher a student's motivation, the greater the likelihood of cognitive engagement in the learning process. Conversely, low cognitive engagement can indicate that motivation has not yet fully manifested in active learning behavior. Therefore, the role of the lecturer as a facilitator in PBL is crucial in helping students actualize their motivation into productive thinking activities through appropriate discussion management and prompting questions.

The Role of Lesson Study

Lesson Study plays a crucial role in optimizing the implementation of the Problem-Based Learning (PBL) model because it allows for continuous reflection and refinement of the learning process. In this study, Lesson Study was implemented through three main stages: plan, do, and see. In the planning stage, the lecturer and the observation team designed a problem-based learning plan that focused on the material's speed and average rate. Student Worksheets were developed as the primary instrument, containing contextual problems and prompting questions to stimulate students' critical thinking skills. Through the worksheet, students were guided to independently discover the concepts of speed and average rate based on real-world data and phenomena [24].

Figure 3. Planning Stages

In the do stage, learning activities are carried out according to the predetermined plan. Student worksheets are distributed to students, and then students work in small groups to solve the given problems. During this activity, the lecturer acts as a facilitator, not as the primary source of information. The lecturer provides light guidance in the form of reflective questions to keep students on the path of scientific thinking. This activity encourages students to engage more actively in discussing, debating, and applying their prior knowledge to the concepts being studied. Through this process, students' learning motivation increases because they feel directly involved in finding solutions, rather than simply receiving explanations.

Figure 4. Stages Do

The observation or reflection stage is an important aspect of Lesson Study, where the lecturer and observers review the learning to assess the effectiveness of activities and student engagement. Based on the reflection conducted, it was found that at the beginning of the lesson, some students were still passive in working on the Student Worksheet. This was caused by the worksheet content being too procedural and not challenging enough, which prevented it from fostering curiosity and maximum cognitive engagement. After the reflection stage, the worksheet was revised by adding more complex and contextual problems, such as analyzing the comparative speed of two vehicles under different road conditions. The results of this revision had a positive impact on increasing student engagement in the next learning cycle.

Lesson Study activities also contribute to creating a collaborative learning environment between lecturers and students. Students become more confident in expressing their ideas, while lecturers gain a deeper understanding of their students' characteristics and learning needs. This open and reflective learning environment enables students to translate their motivation into concrete cognitive activities, such as critical thinking, data analysis, and drawing logical conclusions. Thus, Lesson Study serves not only as a tool for evaluating learning but also as a strategy for continuously improving the quality of the learning process.

Overall, the combination of Lesson Study and Student Worksheets in the implementation of PBL has proven effective in fostering students' intrinsic motivation and cognitive engagement. This is a similar study which proves that worksheets can increase student activity in learning [8]. Through contextually designed worksheets, students are encouraged to think independently and creatively as they solve problems. Meanwhile, the Lesson Study reflection cycle ensures that any weaknesses in the learning process can be identified and corrected immediately. With this approach, students not only understand the concepts of speed and average rate conceptually but also develop scientific attitudes and higher-order thinking skills, which are the main goals of learning physics.

Analysis of Low Transcripts

Some students showed low transcript scores with a small number of keywords. This suggests that high learning

motivation does not always align with cognitive engagement as observed verbally. Several factors can influence this condition, including affective factors such as anxiety, lack of confidence, or fear of making mistakes when speaking in front of friends; social factors such as the dominance of certain group members that makes other students passive; and situational factors such as fatigue and academic pressure when working on student worksheets. Thus, low transcript scores do not always indicate low learning motivation, but can be caused by affective, social, or situational barriers [25]. This is an important reflection for teaching, as it helps create a more balanced discussion atmosphere and supports the cognitive engagement of all students.

Conclusion

The results of the study indicate that students' learning motivation in problem-based learning through Lesson Study is in the high category across all indicators, including perseverance, tenacity, interest, achievement, and independence in learning. However, the results of the cognitive engagement transcript reveal variations, where some students exhibit low verbal activity despite having high motivation levels. This indicates that high learning motivation has not been fully realized in active cognitive engagement, because it is influenced by affective, social, and situational factors during the learning process. Thus, Lesson Study learning and the application of Problem-Based Learning have proven effective in fostering students' intrinsic motivation, but collaborative strategies are needed to ensure that each student is optimally involved in thinking and reasoning activities.

Author's Contribution

R.P. Anggrini: Data Processing, Discussion, Article Preparation Flow. G.S.N. Yahya: Introduction and Citation; L. Andini: Methods and Documentation; N. Lestari: Guidance in Data Collection. N. Susanti: Suggestions and Input on Implementation.

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