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The Effect of Wordwall-Assisted Brain-Based Learning to Cognitive Learning Outcomes on Optical Equipment Material

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Abstract: Improving student learning outcomes will always be influenced by how teachers teach and provide innovation in learning. This study focuses on evaluating the cognitive learning achievements of class XI high school physics students in the Optical Instrument material, using the Wordwall-assisted Brain Based Learning model. The study is a quasi-experiment with all students in class XI of MS SMAN Plus Riau Province. A sample of 59 students with class XI MS 1 as the experimental group and class XI MS 4 as the control group. Daily tests were conducted to collect data on cognitive learning outcomes, which were analyzed both descriptively and inferentially. The findings indicate a significant difference in cognitive learning outcomes between the experimental and control groups, with the former achieving an average outcome of 81.83 and the latter attaining an average of 73.10. These results demonstrate that the Wordwall-assisted BBL learning model can enhance the cognitive learning outcomes of grade XI students in Senior High School, specifically in the Optical Equipment material.

Keywords: Brain Based Learning Model; Cognitive Learning Outcomes; Optical Equipment; Wordwall

Introduction

The success or failure of achieving educational goals depends largely on the experience of students in the teaching and learning process (Hamid & Ali, 2014). Every human being will never be separated from the teaching and learning process. Teaching and learning are essential components of education because they involve teacher-student interaction (Hermawan, 2014). The process of learning is not simply the transfer of knowledge from teacher to student. Instead, students must be active participants in constructing their own knowledge through real-world experiences (Kartikaningtyas et al., 2017).

Learning physics plays a crucial role in enhancing the quality of a nation. The purpose of physics education is to help students develop their intellectual abilities, critical thinking, logical reasoning, and scientific understanding. It enables them to comprehend concepts better and solve problems, particularly those related to everyday life (Nurmayani et al., 2018). Students often struggle to understand a subject because teachers tend to focus on formulas rather than practical applications in everyday life, which can make students lose interest in learning physics (Martina et al., 2021).

Students' cognitive learning outcomes on physics material are still relatively low and students still have difficulty in understanding physics lessons (Dalila et al., 2022). This can be attributed to various factors, such as lack of learning motivation, perception of physics as a difficult subject that mainly involves complex formulas and calculations, and limited variation in teaching strategies and learning models (Solihah et al., 2023). In the context of physics education, it is essential to update learning activities. This can be achieved by presenting learning opportunities that enable students to construct their knowledge (Ernita et al., 2021). Physics learning should also provide opportunities for students to acquire knowledge that aligns with their existing understanding, which they have gained through their interaction with their surroundings (Tuwoso, 2016). The learning objectives can be achieved by using an

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appropriate learning model, which is aligned with the students' needs. The learning model is one of the key strategies in organizing the concepts presented by the teacher (Aristawati et al., 2021).

Indonesia is currently in the Intelligence Age, where human life depends on how the brain functions, including in the learning process. This is known as Brain Based learning (Yufiarti & Rihatno, 2017). Effective learning is learning that is able to balance all students' thinking potential. In other words, effective learning is learning that is able to balance the potential of students' right brain and left brain (Riskiningtyas &; Wangid, 2019). Therefore, it is important to have a learning model that enhances thinking ability and optimizes brain performance. Brain Based Learning is a suitable model that takes into account brain function and is scientifically designed to cater to individual interests. This approach helps students easily absorb the material learned (Haryanto & Rahmawati, 2019). Brain Based Learning highlights the significance of individuals as learners and decision-makers in the learning process (Chamidiyah, 2015). Teachers facilitate brain-based learning strategies that empower students' cognitive abilities for meaningful learning (Jazuli et al., 2019).

According to Caine &; Caine, the purpose of the Brain Based Learning model is to direct learning from just memorization to meaningful learning (Sukoco & Mahmudi, 2016). The steps of the Brain Based Learning model consist of 7 stages, namely: Stages pre-exposure, preparation, initiation and acquisition, elaboration, incubation and memory encoding, verification and confidence checking, and celebration and integration (Iski et al., 2019).

The impact of science and technology on education has led to a need for teachers to incorporate technology in the teaching and learning process (Abdillah & Syaban, 2023). Learning in today's digital age has shifted its focus towards students, with teachers no longer being the central figure in the process. As a result, teachers need to be more creative in designing lessons that incorporate technology (Rinantari et al., 2023). The use of learning media is crucial in education and learning. Learning media assists educators in improving teaching activities, simplifying the learning process, and fostering student interest in learning (Oxana et al., 2023). Utilizing learning media is a way to support student learning. Learning media refers to physical tools that are used to convey learning material (Alika & Radia, 2021).

21st century learning emphasizes the acquisition of information and knowledge through effective communication, collaboration, and critical thinking (Nufus et al., 2022). In the 21st century, teachers are expected to incorporate innovative teaching methods that are adapted to the modern era. One such method is the use of educational games, which is particularly suitable for the Brain Based Learning model. A wordwall game is a great example of an educational game that can hone students' brain skills, offering several interesting features to choose from. Wordwall provides interactive features that can motivate and encourage active participation from students (Amri &; Sukmaningrum, 2023).

Optical instrument materials are effective for enhancing brain activity during physics learning, despite their abstract and complex concepts (Wahyudi et al., 2022). This material helps students understand the function of optical instruments around them and includes many images, such as optical instruments and the process of forming shadows on them. The National Examination is a form of learning evaluation used to determine the learning outcomes of students. According to Puspendik's data from the National Examination (UN) in 2017, the percentage of students who correctly answered questions on optical instrument material was 51.10% nationally, 38.86% in Riau province, and 48.84% in the city of Pekanbaru (Puspendik, 2017). This data highlights that students understanding of optical instrument material and their learning outcomes are still low. Therefore, appropriate learning models and media should be implemented to help improve student learning outcomes.

Based on the conditions that have been described, Researchers are attempting to improve the concentration and motivation of students during physics learning by implementing the wordwall-assisted Brain Based Learning model. This learning model uses educational games and creates patterns, contexts, and learning relationships with the mind. Teachers must provide innovation and variety in learning to make this model effective. If students' motivation and interest in learning increases, their cognitive learning outcomes will improve. Sopiana & Rusmaini (2021) strengthened this research by showing that variations in teacher teaching and student learning motivation have a significant impact on improving cognitive learning outcomes.

Method

This research employs a quantitative approach utilizing a quasi-experimental research method. Quasi-experimental research refers to a study in which researchers are unable to manipulate subjects, resulting in the use of a random sample that is typically used to determine the control and experimental groups (Abraham & Supriyati, 2022). Experimental research involves researchers directly intervening in the field to observe and analyze the differences between the two groups of the research sample (Rukminingsih et al., 2020). The design used in this study is the nonequivalent posttest only control group design, as illustrated in Table 1.

Table 1. Nonequivalent Posttest Only Control Group Design

Class Group	Treatment	Post-test
Experiment	X	Y_2
Control	-	Y_2

(Rukminingsih et al., 2020)

To select the sample for this research, a normality test and homogeneity test were conducted on the daily test of light waves. The resulting research samples were class XI MS 1 as an experimental class and class XI MS 4 as a control class, comprising a total of 59 students. The cognitive learning outcomes test instrument consisted of 20 multiple-choice questions on optical instrument material. This test was given after the application of the wordwall-assisted Brain Based Learning model in the experimental classes and conventional learning in the control classes. After the research was conducted, the test results from both class groups were analyzed using descriptive and inferential analysis.

Descriptive analysis techniques in this research were used to compare the students' cognitive learning outcomes before and after treatment. The difference in student learning outcomes between the classes using the Brain Based Learning model and those using conventional learning was obtained by comparing the average scores obtained between the experimental and control classes, without the need to test its significance. Descriptive analysis is a technique of analyzing data by describing or summarizing previously collected data without intending to make general conclusions (Sugiyono, 2018). The average learning outcomes of students were then categorized into excellent, good, sufficient, and less classifications, as seen in Table 2.

Table 2. Categorizing cognitive learning outcomes for learners.

Category	Value Range
Excellent	$85 \leq N \leq 100$
Good	$70 \leq N < 85$
Sufficient	$55 \leq N < 70$
Less	<55

(Ditjen Dikdasmen, 2017)

The process of inferential analysis is a complex statistical method that enables researchers to examine the significance of differences between multiple groups or the correlation between two variables (Miaz, 2015). Inferential analysis in this research was employed to investigate the variance in cognitive learning outcomes between experimental classes that used the wordwall-assisted Brain Based Learning model and control classes that used conventional learning methods. The inferential analysis in this study used normality, homogeneity and hypothesis tests with independent sample t tests.

Result and Discussion

This study analyzes the cognitive learning outcomes of students who undergo daily Optical Tools tests. The data indicates that cognitive learning outcomes for each category of optical instrument material differ between experimental classes that use the wordwall-assisted Brain Based Learning model and control classes that use conventional learning models. Table 3 displays the learners' cognitive learning outcomes.

Table 3. Learners' Cognitive Learning Outcomes

Value range (%)	Category	Experiment percentage (%)	Control percentage (%)
$85 \leq N \leq 100$	Excellent	46.70	31
$70 \leq N < 85$	Good	43.30	34.50
$55 \leq N < 70$	Sufficient	10	34.50
<55	Less	0	0
Average		81.83	73.10
Category		Good	Good

Based on the data in Table 3, the experimental class had 30 students while the control class had 29 students. The cognitive learning outcomes of the students in the experimental class, which applied the Brain Based Learning model with the help of Wordwall, was compared to the control class, which used the conventional learning model. The average percentage of cognitive learning outcomes in the experimental class was 81.83, which was categorized as good, while the control class had an average of 73.10, also categorized as good. However, there was an average difference of 8.73 between the two classes. This aligns with (Aprilianti et al., 2021) research, which found that student learning outcomes were higher in classes that used the Brain Based Learning model compared to the control class, with an average difference of 6.09 scores. This is because the Brain Based Learning model creates a more engaging and stimulating learning environment, which helps students develop their thinking skills (Aprilianti et al., 2021).

The use of Wordwall educational games also contributed to the improvement of student learning outcomes Sari et al. (2021), research showed that using Wordwall media can create a more enjoyable learning atmosphere, increasing students' attention and understanding of the material. They get experimental class had an average learning outcome of 86.28

compared to the control class's 62.79, demonstrating a significant difference in learning outcomes between the two classes. The distribution of cognitive domains in each posttest question of the optical instrument material and the achievement of learning outcomes for each aspect level in the experimental and control classes can be seen in Table 4.

Table 4. Achievement Analysis of Cognitive Aspects of Learners

Cognitive level	Number of questions	Experimental class access (%)	Control class access (%)
C1	1	90	89.60
C2	5	94	91
C3	7	75.26	63.06
C4	5	82.68	71.70
C5	2	66.65	58.60

Based on Table 4, you can find information about the cognitive level, distribution, and number of questions on the optical instrument material test. The table also shows the percentage of correct answers on each level for both the control and experimental classes. This information helps to compare the achievement of students in both classes on the posttest questions with cognitive levels ranging from C1 to C5. To make it easier to understand, you can refer to Figure 1 which illustrates the comparison of learning outcomes for each cognitive aspect and the achievement of student learning outcomes.

Based on examining the graph presented in Figure 1, it is evident that the percentage of student learning outcomes in the cognitive aspects of C1 (Remembering), C2 (Understanding), C3 (Applying), C4 (Analyzing), and C5 (Evaluating) is higher in the experimental class compared to the control class. As per Anderson and Krathwol, the cognitive aspect of C1 (Remembering) involves recalling previously acquired information and storing it in students' memories. C2 (Understanding) refers to students being able to construct meaning or interpret learning messages, including what is said, written, and drawn. C3 (Applying) is when students use their learned ideas and concepts to solve real-life problems or situations. C4 (Analysis) can be interpreted when students can use information to classify, categorize, and determine relationships between information, facts, concepts, arguments, and conclusions. C5 (Evaluate) means evaluating an object, object or information according to certain criteria (Nafiati, 2021).

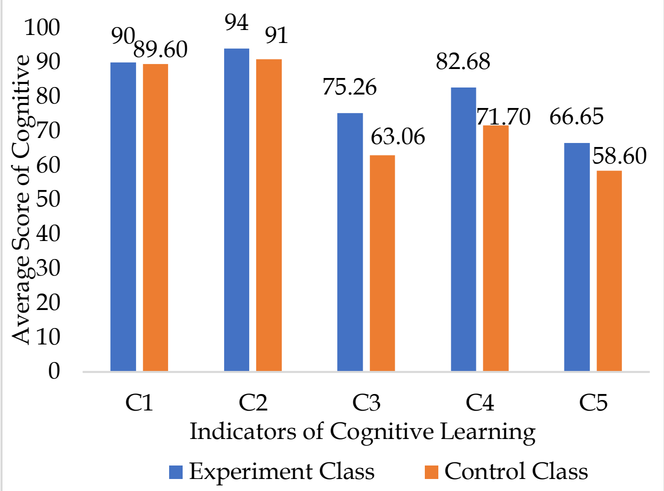

Figure 1. Graphic of Average Comparison of Each Aspect of cognitive learning

The difference in cognitive learning outcomes between the experimental class and the control class is attributed to the Brain-Based Learning model used in the former. This model helped students better understand information and improved their brain performance in analyzing information. Brain-based learning emphasizes the importance of individuals as learners and the significance of individuals as translators and decision-makers in learning that will be translated rationally and logically (Nikmah, 2015).

The Brain Based Learning model has three main strategies that contribute to improved learning outcomes in experimental classes. Firstly, the learning environment challenges students' thinking skills to help them develop their brain power. Secondly, the environment is designed to be enjoyable and comfortable, encouraging students to participate actively. Finally, the learning is active and meaningful, making it more effective for learners. These strategies, as Indriyani (2016) noted, are key factors in determining learning success. The use of educational games, specifically wordwall games, in the experimental class also contributed to the difference in learning outcomes between the experimental and control classes. Wijayanto, E., & Istianah (2017) research supports this, showing that educational games can improve student learning outcomes by presenting material in a more engaging and accessible way. This research is also supported by research conducted by Sari Rahmatin & Suyanto (2019), based on the results and discussion of the research he found that t calculate > t table (3.29 > 1.99) thus H_0 was rejected and H_a was accepted which means: the brain-based learning model affects students' biology learning achievement.

Based on the results of the study, it was found that the percentage of achievement of student learning outcomes in the aspect of remembering (C1) for the experimental class and the control class had almost the same average percentage, namely for the experimental class had a percentage of cognitive learning outcomes of 90% and the control class 89.60%. This is because the aspect of remembering is based on the ability of each student to remember information obtained from learning, for experimental classes information is obtained from LKPD and wordwall while for control classes information is obtained from teacher explanations and books.

The results of the C2 indicator showed that the experimental class had a higher achievement of learning outcomes compared to the control class. The average score percentage for the C2 indicator was 94% for the experimental class and 91% for the control class. This difference in learning outcomes can be attributed to the fact that the experimental class utilized games on Wordwall to gain information, while the control class relied solely on books and PPT presentations from the teacher. This finding is consistent with previous research conducted by Anindyajati & Choiri (2017), which showed that using Wordwall can increase student interest and active participation in the learning process, ultimately leading to improved skills and understanding.

Similarly, in the C3 indicator (Applying), the experimental class scored higher than the control class, with an average score percentage of 72.26% compared to 63.06%. This can be attributed to the implementation of the Brain-Based Learning model, particularly during the initiation and acquisition stages. During these stages, the teacher provides more detailed explanations and engages students' curiosity through LKPD, which includes questions that challenge their cognitive abilities. By identifying and grouping information related to optical instruments and providing reasoning for their answers, students improve their ability to apply learned knowledge to solve problems. This finding is supported by Danisa., et al (2015), who noted that the initiation and acquisition phase can strengthen the application aspect (C3) of learning. Furthermore, the experimental class outperformed the control class in calculation problems with the C3 indicator because the control class was used to standard questions provided by the teacher and struggled with variations. This finding aligns with Artawan (2023), that in conventional learning model, the teacher is responsible for presenting the subject matter first. However, this often leads to a teacher-centered approach, where students have fewer opportunities to engage actively in the learning process. As a result, students may become less self-reliant in constructing their own knowledge, which can ultimately hinder their learning achievement.

The C4 question category, a higher percentage of experimental class students answered correctly compared to the control class. The experimental class had 82.02% correct answer rate, while the control class had 71.20%. This could be attributed to the elaboration stage of the Brain Based Learning model, which encourages active discussions and open-mindedness among students, allowing them to express their ideas well. According to Danisa., et al (2015), this stage enhances the analytical ability (C4) of learners as they process and analyze information using their cognitive abilities and building their own ideas. Similarly, research conducted by Silvana & Wibisono (2016) on the Brain Based Learning model found that the experimental class outperformed the control class in the Analyzing (C4) question category. Sawitri & Rahayu (2018) also suggested that using appropriate learning models and media can improve students' analytical skills. The C4 indicator is one of the indicators of critical thinking, so this research is also supported by research conducted by Herliandry et al. (2018) who obtained research results that the use of the Brain Based Learning learning model has a positive effect on students' physics critical thinking skills. The increase in critical thinking skills in the experimental class was more significant than the control class. The application of the Brain Based Learning model shows a good response and provides opportunities for students to learn with a good mood.

The C5 question category, the experimental class also had a higher percentage of correct answers compared to the control class. The experimental class had a 67.25% correct answer rate, while the control class had 48%. This difference of 19.25% could be attributed to the experimental class's use of word walls and balancing of brain abilities during learning, which made it easier for students to evaluate the questions given. In contrast, the control class relied solely on teacher-provided materials for evaluation. It is worth noting that a higher percentage of students answer correctly on the C5 indicator due to the incubation stage and memory insertion in the Brain-Based Learning model. This is because when students are given the opportunity to repeat and rewrite the concepts given to them in a fun way, their understanding of mathematics is greatly optimized. Through the application of the incubation stage and insertion of memories, students can better remember the concepts taught, thus minimizing misunderstandings in the learning process (Suarsana et al., 2018). Badriah & Ramdani (2018) found that the experimental class outperformed the control class in the cognitive aspect of C5, with the experimental class achieving a good category and the control class achieving a sufficient category in measuring higher-order thinking skills using the Brain Based Learning model.

The experimental class had a higher average percentage of cognitive learning outcomes on evaluating indicators compared to the control class. This is because the experimental class had better analytical skills, allowing them to analyze problems before solving them. Kusumaningrum in (Amalia & Pujiastuti, 2020) stated that problem-solving involves identifying and analyzing patterns to improve thinking skills. Without good analytical skills, students may struggle to evaluate and create solutions.

Overall, the experimental class had a higher average learning outcome (C1-C5) than the control class. However, on certain questions, the control class performed better. Differences in learning outcomes depend on students' seriousness and accuracy when learning and answering daily test questions. Some questions have similar statements that can cause confusion and incorrect answers.

The normality test was conducted on the posttest results of optical instrument material for both experimental and control classes. The data was found to be normally distributed in both classes with a significance value of 0.107 and 0.056 respectively, which was above the significance value of 0.05. Following this, a homogeneity test was performed and it was found that the variance in both classes was homogeneous, as indicated by the Ouput Lavene Test with a significance value of 0.400 > 0.05. Therefore, the prerequisite for conducting a hypothesis test with parametric statistics was fulfilled using the Independent sample t-test hypothesis test. The results of the Independent sample t-test showed a significance value of 0.007 using the SPSS 27 program. This means that the Ha is accepted and H_0 is rejected, indicating that the learning outcomes of the experimental class were better than those of the control class.

Based on the research, it was observed that the cognitive learning outcomes of the experimental class using the Wordwall-assisted Brain Based Learning learning model were higher than those of the control class using conventional learning. This is supported by previous research conducted by Helmahria et al. (2017), where student activities such as discussion, cooperation, and communication were found to increase learning outcomes when the Brain Based Learning learning model was applied. This research is supported by (Gani., et al (2022) findings that using game education can enhance student learning outcomes and prevent monotony in the learning process. Similarly, Sari., et al (2021) found that using Wordwall media in game-based learning activities can improve student learning outcomes by making the learning atmosphere more fun, which increases concentration and understanding of the material. Safira et al. (2023) conducted a research which found that using Wordwall in learning activities led to active and enthusiastic participation by students, ultimately resulting in improved learning outcomes. The research also revealed that Wordwall games had a positive impact on student cognition, with the Match Up feature achieving the highest reliability score of 0.889. Kusmaya., et al (2022) discovered that Wordwall can be effectively integrated throughout the Brain Based Learning model, making learning more enjoyable for students. Their research also demonstrated that using Wordwall in conjunction with the Brain Based Learning model effectively improved students' problem-solving abilities in mathematics.

Conclusion

The experimental class implemented the wordwall-assisted Brain Based Learning model to teach optical instrument material, resulting in cognitive learning outcomes with an average score of 81.83. In comparison, the control class, which received conventional learning, had an average score of 73.1. These scores indicate that the experimental class performed better than the control class. The results of the Independent sample t-test were analyzed using the SPSS 27 program, which found a significance value of 0.007. This value is less than the standard significance level of 0.05, indicating that H_a is accepted and H_0 is rejected. Therefore, it can be concluded that the cognitive learning outcomes of the experimental class are superior to those of the control class. Through research conducted to enhance cognitive learning outcomes in students studying optical instrument material, it has been concluded that classes using the wordwall-assisted Brain Based Learning model have a higher average score than those using conventional learning methods. Furthermore, there are differences in cognitive learning outcomes between students in the two groups, indicating that the use of the wordwall-assisted model can lead to better results for students. These findings demonstrate that incorporating the wordwall-assisted Brain Based Learning model can improve student learning outcomes in comparison to conventional methods.

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Conceptualization: I.M; Data curation: Y.Y, N.I; Funding acquisition: Y.Y, N.I, I.M; Methodology: Y.Y, I.M; Visualization I.M, Y.Y, N.I; Writing-original draft: I.M; Writing-review & editing: Y.Y, N.I, I.M.

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