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EFFECTIVENESS OF AUDIO VISUAL-ASSISTED PBL FOR STUDENTS' COGNITIVE ABILITY AND PROBLEM SOLVING IN ALTERNATIVE ENERGY

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ABSTRACT

The purpose of this study is to assess how well students' cognitive and problem-solving skills in science education are improved by the problem-based learning (PBL) model with audio-visual accompaniment, specifically in the area of alternative energy. The quasi-experimental study included 66 11th graders from a private high school in Bandung. A cognitive capacity exam and a problem-solving ability test were used in the study, and N-Gain computation was used for data analysis. The results showed that students who learned using the PBL model with audio-visual assistance showed a significant improvement in cognitive ability and problem-solving ability. Conversely, students in the control group who used the PBL model without audio-visual assistance experienced a lower improvement. The study's impact demonstrates that the integration of audio-visual elements in the PBL model can effectively enhance students' cognitive abilities and problem-solving skills, which has the potential to be applied more widely in science education.

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1. INTRODUCTION

Problem-solving skills are one indicator of a person's readiness for the increasingly modern world. Solving problems during the learning process, particularly when studying science, might support students' learning activities in creating new information (Mukhopadhyay, 2013). Entering 21st century, students are faced with increasingly complex and dynamic challenges. A rapidly changing world demands that they possess skills beyond just academic knowledge. It is crucial that educators equip their students with critical thinking, creative thinking, and problem-solving skills in this setting. These abilities are critical for future employment and success in life, not just for academic achievement (Mangiduyos & Subia, 2021) and (Barell, 2010).

The 2013 curriculum emphasizes competency-based learning, which places an emphasis on enhancing students' skills and abilities to meet future challenges, as well as cognitive abilities and problem solving skills, specifically creative thinking skills, which include critical thinking abilities and problem solving skills (Cahyadi, 2022). Meanwhile, the demands of the Merdeka curriculum for cognitive abilities and problem solving skills are competency-based learning which

emphasizes developing students' skills and abilities to face future challenges, contextual learning that emphasizes problem-solving skills that takes into account 21st century competencies including teamwork, critical and creative thinking, and thinking (Angga et al., 2022)

Critical thinking and problem solving abilities are still insufficient, as evidenced by the cognitive profiles and problem-solving abilities of students in Indonesia and around the world (Aditya, 2021). Several factors that contribute to poor problem solving skills and cognitive abilities include lack of facilities and infrastructure, development of adaptability skills, and development of cognitive skills (Aripin, 2021)Therefore, The study by Winifred Fachrudin and Afridatul Uluwiyah demonstrates that pupils' cognitive and problem-solving capabilities are still deficient. So, This study offers a way to use problem-based learning (PBL) with audiovisual support to help students in one of the institutions under study improve their cognitive abilities and problem-solving skills. When used in conjunction with contextual learning, audiovisual materials can foster student cooperation, strengthen critical thinking abilities, and enhance problem-solving abilities.

Due to several theoretical and practical reasons, the findings of this research are considered suitable for improving cognitive and problem-solving abilities (ulfa, 2022). Students are better at solving problems because of their impulsive cognitive style, contextual learning, opportunities to work together, and the use of audio-visual media (Saka, 2019)This research provides new insights into the application of PBL models assisted by audio-visual media. In contrast to earlier research, (Angsen M., 2019) study on the use of PBL with media support in the field of reproduction revealed a substantial difference in the experimental and control groups' capacity for problem-solving, as well as (Markus Iyus Supiandi, 2017)study that showed a significant improvement in cognitive learning outcomes and problem-solving abilities through PBL, this research expands the scope by exploring the effectiveness of audio-visual assisted PBL in the topic of alternative energy. The findings of this study demonstrate a greater enhancement in cognitive abilities and problem-solving skills compared to PBL without audio-visual assistance, confirming the positive impact of technology integration in PBL.

The outcomes of literature study are supported by the results of a preliminary study conducted by researchers at one of the private high schools in the city of Bandung. Interviews with physics subject teachers showed complaints about the low problem-solving and cognitive abilities of students, marked by daily test results that frequently remained below the required minimum level of completeness. Judging from the learning carried out in class, students are less interactive and learning is teacher-centered.

Therefore, in physics material, especially energy, there is a lot of information received and must be processed by students. Students must note down, remember and understand all the material because Energy material is a prerequisite material for the next physics material. For this reason, in order to make learning enjoyable, we use problem based learning model. So that students are motivated and understand what they have learned and do not think that physics subjects are difficult and boring. As well as using audio visuals so that students don't get bored of learning and practice problem solving.

According to (Mariyaningsih, 2018) "learning must be innovative and make students active, as is the case with physics learning. Student-centered learning, the teacher only becomes a facilitator and motivator in the learning process." Selection of learning models, teaching media, etc. This is an innovation in learning. With the innovation of learning models and teaching media, It is anticipated that it will enhance physics students' motivation and learning outcomes. In order to help students comprehend the material that teachers are presenting, one learning model employs problem-based learning aided by learning materials that incorporate audiovisuals.

According to (Joyce, 2024)problem-based learning is a learning approach that is used to create curricula, create learning resources, and direct learning. Selecting a problem-based learning approach helps ensure that students are engaged and actively participate in their education by removing monotony from the learning process. Learning model can help students be more active, educative and have a high level of cooperation when discussing to understand a concept. in order to attain learning objectives and pique students' interest in engaging in the learning process. Pinder (2008), asserts that the use of the problem-based learning approach in the educational process is crucial for inspiring, attracting students' interest in learning, and getting good learning results. Students who are motivated and have an interest in taking lessons certainly have a high enthusiasm for learning, so that understanding of the material is easier to accept.

In this modern era, we often lack the ability to utilize technology that is increasingly easy to access, for example audio-visual. (Kurniati & Charles Darwin, n.d.) explains that audio-visual learning media is a combination of audio and visual media which will create sound and image elements in one media, which we often know is video. The relationship between PBL and audio visual can provide students with improved problem solving (Lintuo, 2022) In (Novitasari et al., 2015), According to the findings, applying the audio-visual assisted problem-based learning approach significantly improved learning outcomes.

The following is how the research challenge is expressed in the research statement:

1) How do students' cognitive abilities improve by using the audio-visual assisted Problem Based Learning learning model on alternative energy material?
2) How can students' problem solving abilities be improved by using the audio-visual assisted Problem Based Learning learning model on alternative energy material?
3) What is the effectiveness of the audio-visual assisted Problem Based Learning learning model on alternative energy material?

The purpose of this study is to determine whether using an audiovisual approach in conjunction with a problem-based learning model can enhance students' cognitive and problem-solving skills when studying alternative energy content. Information regarding the impact of audiovisuals and problem-based learning on students' cognitive and problem-solving skills in alternative energy content is anticipated to be provided by this study.

2. METHOD

Quantitative research is the approach used in this investigation. According to (Campbell, 1963)a quasi-experimental research design was used in the study. This research is quantitative in nature as it aims to measure and analyze numerical data objectively, particularly in assessing how much students' cognitive capacities and problem-solving techniques have improved following the adoption of an audio-visual aid-assisted problem-based learning paradigm. The quantitative approach enables researchers to utilize statistics in analyzing data, such as calculating N-Gain, which provides clear and measurable results regarding the effectiveness of the interventions used. The reason for using quasi-experimental design is when researchers do not have full control over the assignment of subjects into experimental and control groups, which often occurs in educational settings where student grouping is predetermined. The quasi-experimental design allows researchers to compare the outcomes of a group that receives the intervention (audio-visual assisted PBL model) with a group that does not get the intervention, even if subject assignment is not done randomly. This provides flexibility in the context of education while still allowing for rather strong evaluation of intervention effectiveness.

This study focused on pupils in the X grade at a private secondary school in Bandung. According to the definition by (Sugiyono, 2013), All of the kids in the school's X-grade are referred to as the population in this study, as they possess relevant characteristics and standards for the research. A sample is a subset of a population that is selected to gather data that represents the population. The sampling technique used in this study is convenience sampling, where the school's available classes and the facilities that facilitate the usage of audio-visual equipment are used to determine the sample, such as Infocus. The sample consists of two groups: a control class with 32 students and an experimental class with 34 students. This research also involves observers who will monitor the implementation of problem-based learning models assisted by audio-visual aids to ensure that the process proceeds as planned.

The test instruments in this research were pretest and posttest which were given before and after treatment, to determine students' cognitive abilities before and after treatment. This test is a multiple choice test that represents indicators based on the four cognitive aspects of Bloom's taxonomy, namely remembering (C1), understanding (C2), applying (C3), and analyzing (C4). To gauge how much students' cognitive capacities to master learning have improved after receiving treatment utilizing the Problem Based Learning learning paradigm with audiovisual assistance, the pretest and posttest results will be compared. This cognitive ability test consists of 14 questions covering alternative energy material. To assess one's capacity for problem-solving in the form of descriptions that represent problem solving indicators, problem identification, defining problems, collecting information, analyzing information, and solving problems. The problem solving ability test consists of 3 questions, each question consists of 7 questions, a total of 21 questions covering problem solving for alternative energy.

The instruments in this study were tested for their validity and reliability before being implemented. Internal validation is conducted by evaluating the instrument through expert assessment and testing on a group of students who have studied Alternative Energy materials. The validity and reliability test results were processed using Rasch analysis and classical test theory with the assistance of Microsoft Excel. The internal validity indicates that all items assessing cognitive ability and problem-solving skills are deemed valid. The external validity was tested on 40 eleventh-grade students in a high school in Bandung City using a Google form. The findings of the reliability test show that the cognitive capacity and problem-solving abilities assessment tool has high and very high levels of dependability. Thus, each item on the test instrument is declared valid and reliable.

After obtaining the pretest and posttest scores, the analysis used to determine the rise in students' cognitive abilities and problem solving abilities is the average N-Gain analysis. The following is Equation (1) which is used to determine the normalized gain score.

$$< g >= \frac{skorposttest - skorpretest}{skorideal - skorpretest} \quad (1)$$

The acquisition categories according to Hake (1999) can be seen in Table 1 below.

Table 1. N-Gain Classification

Nilai N-Gain	Kategori
$(< g >) \geq 0{,}70$	Tinggi
$0.07 > (< g >) \geq 0{,}30$	Sedang
$(< g >) < 0{,}30$	Rendah

(Hake, 1999)

Pearson correlation test to ascertain the closeness of the connection between two or more different variables which is described by the size of the correlation coefficient. The correlation test was used in this study to understand the relationship between the variables being tested, particularly to determine if there is a connection between the implementation of problem-based learning models aided by audio-visual materials and the improvement of students' cognitive abilities and problem-solving skills. Uji korelasi membantu menentukan sejauh mana perubahan dalam satu variabel, seperti penggunaan model pembelajaran berbasis masalah, berhubungan dengan perubahan dalam variabel lain, seperti kemampuan kognitif dan pemecahan masalah. Although the main objective of the research is to evaluate the improvement or enhancement of students' abilities, correlation tests provide additional insights into the strength and direction of the relationship between these variables. This helps to understand whether changes in the independent variable (implementation of the learning model) correlate with changes in the dependent variable (cognitive ability and problem-solving skills), which can provide a clearer picture of the effectiveness of the applied intervention.

Table 2. Correlation Classification

Koefisien Korelasi	Keterangan
$0{,}8 \leq r \leq 1{,}0$	Sangat tinggi
$0{,}6 \leq r \leq 0{,}8$	Tinggi
$0{,}4 \leq r \leq 0{,}6$	Cukup
$0{,}2 \leq r \leq 0{,}4$	Rendah
$0{,}0 \leq r \leq 0{,}2$	Sangat rendah

3. RESULTS AND DISCUSSION

Table 3. Average Pretest and Posttest Scores and N-Gain Cognitive Ability

Kelas	***Pretest***	***Posttest***	**<g>**	**Kategori**
Eksperimen	35,92	89,92	0,82	Tinggi
Kontrol	36,83	60,04	0,35	Sedang

Table 3 shows the average pretest and posttest result for students' cognitive abilities in the experimental and control classes. A 'high' category with an N-gain of less than 0.82 is present in the experimental class; the pretest value is 35.92, and the posttest is 89.92. A'medium' category with an N-gain of 0.35 was present in the control class; the pretest value was 36.83, while the

posttest value was 60.04. So it can be said that the control class had a very good improvement in cognitive abilities. Furthermore, the improvement of students' cognitive abilities is also seen from each aspect which includes three aspects including aspects of understanding (C2), aspects of applying (C3), and aspects of analyzing (C4). A comparison of the average pretest and posttest scores for each aspect of cognitive ability in the experimental and control classes is shown in table 4 below.

Table 4. N-Gain Value of Each Cognitive Aspect

Class	***Experiment***		**Control**	
	<g>	**Category**	**<g>**	**Category**
Understand (C2)	0,79	High	0,38	Medium
Apply (C3)	0,88	High	0,32	Medium
Analyze (C4)	0,85	High	0,35	Medium

Table 5. Average Pretest and Posttest Scores and N-Gain Problem Solving Ability

Class	**Pretest**	**Posttest**	**<g>**	**Category**
Experiment	3,29	79,62	0,79	High
Control	9,15	61,90	0,58	Medium

Furthermore, the improvement in pupils' capacity for problem-solving in each aspect is evident from the test result obtained by students on each question item given during the pretest and posttest. There are five aspects covered in this research, namely aspects of problem identification, defining problems, collecting information, analyzing information, and solving problems. The following table compares the average pretest and posttest scores for each component of problem-solving skills in the experimental class and control group:

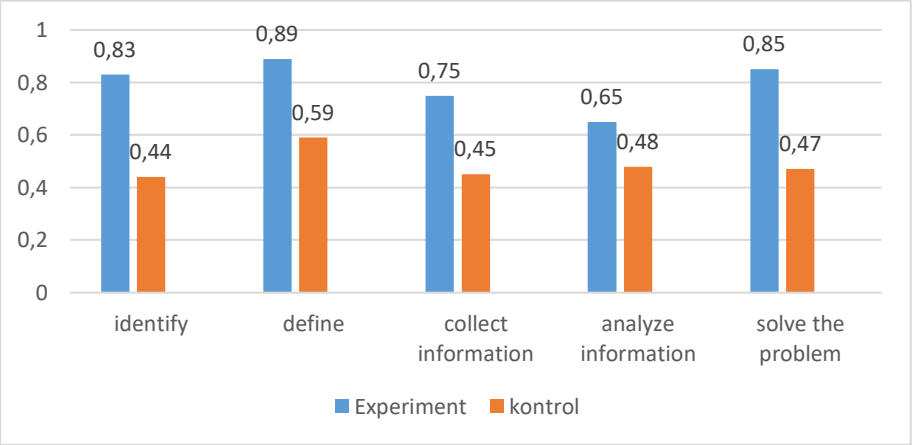

Figure 1 Graph of N-Gain Value of Each Aspect of Problem Solving Ability Problem Solving Ability

It is possible to conclude that the data are homogeneously distributed since the significance value of the average change in the experimental class and control class, which is derived from the

average, is 0.031 and the significance value is 0.862, which is larger than 0.05 (0.862>0.05). Furthermore, hypotheses testing was carried out using the Mann-Whitney (U) test. The results of the analysis that has been studied using the Mann-Whitney (U) test can be seen in table 6 below.

Table 6. Mann-Whitney Test Analysis Results

Data source	Asymp. Sig. (2-tailed)	Decision
N-Gain Experimental Class and Control Class	0,000	H_0 is rejected

The Asymp value can be seen in table 6 above. Since the two-tailed significance value (0.00) is less than 0.05 (0.00<0.05), the null hypothesis is rejected and the initial hypothesis is accepted. A correlation test will be conducted to determine the degree of association between cognitive ability and problem solving ability because there are two variables: students in the experimental group, who are using the audio-visual assisted problem-based learning model, and students in the control group, who are only using the problem-based learning model, may have significantly different increasing cognitive abilities.

The correlation test results indicate a significant relationship between students' cognitive abilities and their problem-solving skills in the topic of alternative energy. These results show a substantial correlation between the two variables, with a significance value of 0.001, which is less than the alpha criterion of 0.05. The correlation criterion with a value of 0.553, which falls into the "Moderate" category, indicates that the relationship between cognitive ability and problem-solving skills is moderate. This explanation is supported by previous theories and research. According to cognitive theory, having strong cognitive abilities often supports effective problem-solving skills. For example, Jerome Bruner's theory (1960) in (Schmidt, 2012) on discovery-based learning suggests that strong critical thinking and cognitive abilities contribute to an individual's ability to solve problems more effectively. The research conducted by (Anderson and Krathwohl Bloom’s Taxonomy Revised Understanding the New Version of Bloom’s Taxonomy, n.d.)suggests that cognitive processes, such as comprehension and analysis, play a crucial role in problem-solving.

Furthermore, research conducted by (Scraw, 2017)demonstrates that high cognitive abilities, such as analytical and reflective skills, might enhance problem-solving abilities. Within this context, research findings indicate that students with high cognitive abilities tend to have better problem-solving skills, albeit this relationship falls under the "Satisfactory" category. This indicates that there is a moderate positive correlation between both abilities, which supports previous theoretical findings and research on the relationship between cognition and problem-solving.

The results collected in this study suggests that both the experimental and control groups shown enhancements in cognitive and problem-solving skills. This result is in line with earlier studies that Sumiyati (2023), Agsen (2021), and (Markus Iyus Supiandi, 2017) which have shown that the problem-based learning paradigm significantly improves these skills. Nevertheless, the research indicates that although both courses shown improvement, the experimental class exhibited a more pronounced gain, so validating the notion that incorporating supplementary resources, such as audio-visual materials, can yield a more considerable enhancement in cognitive and problem-solving abilities.

The data analysis results indicate that the problem-based learning approach, supported by audio-visual aids, has a beneficial effect on students' cognitive and problem-solving skills, especially in the area of alternative energy material. According to this methodology, the use of audio-visual aids enhances collaborative efforts and provides visual representations that streamline the process of resolving problems. Therefore, it can be inferred that the utilization of multimedia resources improves the efficacy of problem-based learning by rendering intricate topics more accessible and captivating for students.

The study revealed that students in the experimental class had enhanced cognitive and problem-solving skills as a result of utilizing accessible audio-visual aids. The problem-based learning approach was utilized at many stages, such as the motivation phase, group orientation, and on LKPD sheets, with the addition of these audio-visuals. During each learning session, audio-visuals were used to demonstrate intricate ideas, greatly enhancing students' understanding and involvement. This method emphasizes the efficacy of integrating multimedia resources to improve educational results.

At this motivational learning stage, the researcher provides motivation in the form of audio visuals which will be linked to the learning material to be studied. The researcher provided motivation in the form of an audio visual entitled "Where does electricity come from" along with the YouTube link used sourced from the PLN Electricity Museum (museum PLN, n.d.) and excerpts of audio visual images given to students:

At the learning stage, orienting students to this problem, the researcher provides problem orientation in the form of audio visuals which will be linked to the learning material to be studied. The researcher provides problem orientation in the form of an audio visual entitled "what if fossil energy becomes extinct" which is sourced from YouTube, how come with the YouTube link (museum PLN, n.d.)and the following is a snippet of the audio visual image given to the students:

At the learning stage of guiding group investigations, the researcher provided LKPD with audio-visual assistance. Each meeting provides audio visuals for each material taught. sourced from the PLN Electricity Museum YouTube with the YouTube link (museum PLN, n.d.)and the following is a snippet of a picture of Ocean energy given to students.

In addition, placing emphasis on cognitive ability at every step of learning greatly enhances the effectiveness of the problem-based learning strategy aided by audiovisuals. Drawing on (Anderson and Krathwohl Bloom's Taxonomy Revised Understanding the New Version of Bloom's Taxonomy, n.d.), directing attention to different cognitive levels, such as comprehension, application, analysis, and evaluation, might improve students' learning results. Research conducted by (Johnson & Mayer, 2009)provides support for the notion that multimedia learning, which involves the use of audio-visual aids, might enhance cognitive processes by stimulating numerous channels of information processing. In addition, the research conducted by Moreno and Mayer (2007) discovered that multimedia presentations are effective in elucidating intricate concepts and promoting more profound cognitive involvement. Therefore, incorporating cognitive elements throughout every phase of the learning process, as evidenced by this study, is consistent with existing theories and reinforces The model's effectiveness in enhancing students' cognitive capabilities.

For the understanding aspect (C2) the experimental class has a gain value of 0.79 in the high category while the control class has 0.38 in the medium category, for the applying aspect (C3) the experimental class has a gain value of 0.88 in the high category while the control class has 0.32 in the medium category, the applying aspect (C4) has a gain value of 0.85 in the high category while the control class is 0.35 in the medium category. This shows that aspects of the

cognitive abilities of students who were given treatment or problem-based learning with the support of by audio visuals during learning activities increased higher.

Bloom's Taxonomy supports the claims by emphasizing the value of concentrating on specific cognitive processes to improve learning outcomes. In addition, According to Mayer's (2009) cognitive theory of multimodal learning, adding visual and auditory cues can significantly improve students' comprehension and application of the content. Research conducted by Moreno and Mayer (2007) supports the notion that multimedia learning environments might enhance cognitive processing and improve information retention. The higher gain values seen in the experimental class demonstrate how well problem-based learning combined with audio-visual assistance can support students' cognitive abilities. Emphasizing aspects of problem-solving skills at every educational level is one of the factors that makes the problem based learning model also effective in the medium category. The following aspects of problem solving abilities in this research are as follows

a. Identification of problems

   At this stage students must know what the problem is presented in the question. In this aspect, the experimental class got an average pretest score of 7.24, then treatment was carried out using the audio-visual assisted problem based learning model and got an average posttest result of 85.29. The results of the pretest and posttest scores show an increase in the problem identification indicators.

b. Defining the problem

   At this stage students are able to define what is the focus of the problem that has been found. In this aspect, the experimental class got an average pretest score of 7.14, then treatment was carried out using the audio-visual assisted problem based learning model and got an average posttest result of 155.23. The results of the pretest and posttest scores show an increase in the indicators defining the problem.

c. Gather information

   At this stage students are able to collect information related to the problem focus provided. In this aspect, the experimental class got an average pretest score of 2.85, then treatment was carried out using the audio-visual assisted problem based learning model and got an average posttest result of 155.7. The results of the pretest and posttest scores show an increase in the information gathering indicator

d. Analyze information

   At this stage students are able to analyze information related to the problem focus provided. In this aspect, the experimental class got an average pretest score of 1.9, then treatment was carried out using the audio-visual assisted problem based learning model and got an average posttest result of 156.1. The results of the pretest and posttest scores show an increase in the indicators of analyzing information.

e. Solve the problem

   At this stage students are able to solve problems related to the problem focus provided. In this aspect, the experimental class got an average pretest score of 0.95, then treatment was carried out using the audio-visual assisted problem based learning model and got an average posttest result of 150.9. The results of the pretest and posttest scores show an increase in the Problem Solving

indicator. Analysis of the relationship between cognitive ability and problem solving ability is carried out using correlation. Correlation is used to determine whether students' problem solving abilities are influenced by their cognitive abilities. The correlation calculation was

completed out on the n-gain value of cognitive ability and the n-gain value of problem-solving ability in experimental class.

This study's findings provide significant insights into the correlation between cognitive talents and problem-solving skills. The correlation coefficient of 0.553, classified as "sufficient," signifies a somewhat positive association between cognitive talents and problem-solving abilities. This implies that as students' cognitive capacities advance, their problem-solving skills also tend to develop.

This finding is noteworthy as it substantiates the concept that enhancing cognitive abilities might result in improved problem-solving results. The modest connection indicates that cognitive talents play a significant role in problem-solving capabilities, but it also suggests that other characteristics may have an impact. This discovery is consistent with theories like Bloom's Taxonomy, which suggests that advanced cognitive processes facilitate intricate problem-solving activities. Additionally, it aligns with the cognitive theory of multimedia learning (Johnson & Mayer, 2009)which proposes that enhancing cognitive engagement through various learning modalities might improve problem-solving abilities. In summary, these results offer proof that interventions targeting cognitive capacities, such as problem-based learning models accompanied by audio-visual aids, can have a beneficial effect on students' problem-solving abilities. This highlights the significance of including techniques that improve cognitive functions in educational environments in order to cultivate more efficient problem-solving abilities in pupils.

4. CONCLUSION

The research and data analysis indicate that the problem-based learning approach, when supported by audio-visual aids, greatly improves students' cognitive and problem-solving skills in the field of alternative energy material. The study determined that the implementation of this approach was classified as "excellent," reflecting its efficacy. The experimental class, which incorporated audio-visual assistance, had a greater improvement in cognitive capacities compared to the control class that just employed the problem-based learning paradigm. Likewise, the enhancement in problem-solving skills was more significant in the experimental group. The correlation coefficient of 0.553 between cognitive ability and problem-solving skills provides more evidence for the beneficial influence of this paradigm. In summary, the results indicate that incorporating audio-visual aids into problem-based learning can greatly strengthen cognitive and problem-solving skills, making it a very successful method for improving education.

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