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The Effect of Problem Based Learning Assisted by Instructional Video on Student Learning Outcomes

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ABSTRACT

This study examined the implementation and effect of Problem-Based Learning (PBL) assisted by instructional video on vocational high-school students' science learning outcomes. A quantitative quasi-experimental design was used with Grade X students at SMKN 1 Sepuluh, Bangkalan. Class X-A served as the comparison group and received Project-Based Learning (PjBL) assisted by instructional video, whereas Class X-B served as the experimental group and received PBL assisted by instructional video. Learning outcomes were measured using a teacher-validated achievement test. The source manuscript reports normality and homogeneity testing followed by hypothesis testing in SPSS 21. The reported between-subjects analysis indicated significant effects for learning model ($F = 17.004$, $p < .001$), instructional video ($F = 28.015$, $p < .001$), and the model-by-video term ($F = 3.572$, $p = .002$), with $R^2 = .779$ and adjusted $R^2 = .760$. The experimental class was reported to achieve higher learning outcomes than the comparison class. These findings support the pedagogical value of combining problem-centered inquiry with audiovisual scaffolding; however, inconsistencies in the reported ANOVA degrees of freedom and the absence of group means and standard deviations limit effect-size interpretation. Future studies should report complete descriptive statistics, validated instruments, and a fully specified factorial or two-group analysis.

Keywords: Problem-Based Learning; instructional video; science education; learning outcomes; vocational education

INTRODUCTION

Science education in vocational schools requires students to connect scientific concepts with complex problems encountered in everyday and occupational contexts. Problem-Based Learning (PBL) is designed around this principle: learners begin with a meaningful problem, identify what they need to know, investigate possible explanations, and construct defensible solutions (Barrows, 1986; Hmelo-Silver, 2004; Savery, 2006). Reviews and meta-analyses show that PBL can support knowledge application, problem solving, critical thinking, and learner engagement when problems, scaffolds, and facilitation are appropriately designed (Dochy et al., 2003; Strobel & van Barneveld, 2009; Walker & Leary, 2009; Yew & Goh, 2016; Trullàs et al., 2022).

The source study was motivated by low science achievement observed at SMKN 1 Sepuluh, Bangkalan, particularly when students were required to reason about complex environmental phenomena.

The intervention combined PBL with instructional video to provide concrete audiovisual representations before and during problem solving. Multimedia learning research suggests that carefully designed combinations of words and visuals can reduce unnecessary processing and support mental-model construction (Mayer, 2009; Mayer, 2021; Fiorella & Mayer, 2018). Video can also provide controllable pacing, replay, demonstrations, and contextual cues that are difficult to reproduce through verbal explanation alone (Kay, 2012; Brame, 2016; Noetel et al., 2021).

The study therefore addressed two purposes: to describe the implementation of PBL assisted by instructional video in science learning and to test whether the instructional model was associated with student learning outcomes. The present English version preserves the empirical results reported in the source manuscript while strengthening the theoretical framing and explicitly identifying reporting limitations in the statistical table.

LITERATURE REVIEW

Problem-Based Learning in Science Education

PBL positions the learner as an active constructor of knowledge and the teacher as a facilitator of inquiry. Its core features include an ill-structured or authentic problem, collaborative investigation, self-directed learning, explanation, and reflection (Barrows, 1986; Hmelo-Silver, 2004; Savery, 2006; Schmidt et al., 2011). PBL is consistent with constructivist perspectives because prior knowledge is activated and reorganized as students seek explanations for a problem (Dolmans et al., 2005; Loyens et al., 2015). Evidence indicates that PBL often produces stronger outcomes for application and long-term skill development than for short-term factual recall, emphasizing the importance of matching assessment to intended competencies (Dochy et al., 2003; Strobel & van Barneveld, 2009; Yew & Goh, 2016).

In science and STEM contexts, problem-centered learning can stimulate argumentation, inquiry, critical thinking, and transfer when learners receive sufficient conceptual and procedural support (Hmelo-Silver et al., 2007; Belland et al., 2017; Lazonder & Harmsen, 2016; Freeman et al., 2014). Scaffolding is especially important for novice learners because minimally guided problem solving can overload working memory (Kirschner et al., 2006; Sweller et al., 2019). Thus, the pedagogical question is not whether students should be active, but how teachers can structure resources and prompts so that productive activity results in disciplinary understanding.

Instructional Video as Multimedia Scaffolding

Instructional video can function as a scaffold by making dynamic processes visible and by giving learners access to narrated visual explanations. Cognitive theory of multimedia learning proposes that learning improves when verbal and pictorial information are coordinated without overloading limited working-memory capacity (Mayer, 2009; Mayer, 2021). Segmenting, signaling, coherence, and learner

control are particularly relevant design principles for educational video (Guo et al., 2014; Brame, 2016; Fiorella & Mayer, 2018). Reviews indicate that video can improve learning when it is concise, aligned with learning goals, and embedded in active learning tasks rather than used as passive entertainment (Kay, 2012; van der Meij & van der Meij, 2013; Noetel et al., 2021; Fyfield et al., 2019).

Within PBL, video can provide a common problem stimulus, illustrate environmental or scientific phenomena, and offer information that students can revisit while developing explanations. This combination is theoretically compatible with dual coding and cognitive load perspectives because audiovisual representations can support schema construction when extraneous details are controlled (Paivio, 1990; Sweller et al., 2019). At the same time, video does not automatically improve learning; prompts, questions, discussion, and accountability are needed to transform viewing into generative processing (Chi & Wylie, 2014; Fiorella & Mayer, 2015; Kizilcec et al., 2014).

Learning Outcomes and Assessment

Learning outcomes should be interpreted as evidence of what students can demonstrate after instruction, and valid conclusions require alignment among objectives, teaching activities, and assessment tasks (Biggs & Tang, 2011; Brookhart, 2013). In quasi-experimental educational research, transparent reporting of group assignment, sample size, baseline comparability, descriptive statistics, assumptions, effect sizes, and exact inferential tests is necessary for evaluating practical as well as statistical significance (Shadish et al., 2002; Lakens, 2013; Wasserstein et al., 2019). Achievement tests should also be supported by evidence of content validity and reliability rather than expert review alone (AERA et al., 2014; DeVellis & Thorpe, 2021).

A broader learning-sciences perspective also supports combining problem solving, multimedia, and active assessment. Animation and interactive multimedia are most effective when they direct attention to task-relevant relations rather than adding decorative complexity (Bétrancourt, 2005; Moreno & Mayer, 2007; Zhang et al., 2006). Retrieval practice and distributed opportunities to explain or test understanding can strengthen retention (Dunlosky et al., 2013; Roediger & Karpicke, 2006; Pan & Rickard, 2018). Feedback and formative assessment further improve learning when students can act on information about the gap between current and intended performance (Hattie & Timperley, 2007; Black & Wiliam, 2009; Panadero et al., 2018; Wisniewski et al., 2020). Productive struggle can also be valuable when followed by appropriate instruction and consolidation (Kapur, 2016). Finally, evidence from active-learning research cautions that students may feel they learn less even when performance improves, reinforcing the need to evaluate achievement rather than preference alone (Prince, 2004; Deslauriers et al., 2019).

METHODS

Research Design and Participants

The source study used a quantitative quasi-experimental approach. The population comprised Grade X students at SMKN 1 Sepuluh, Bangkalan. The manuscript identifies Class X-A as the comparison class receiving Project-Based Learning (PjBL) assisted by instructional video and Class X-B as the experimental class receiving Problem-Based Learning (PBL) assisted by instructional video. Sampling was described as simple random sampling. Because the source does not provide a consistent explicit sample size, this version does not infer one from the ANOVA table.

Instrument and Procedure

Student learning outcomes were measured using a test sheet. Before administration, the test was reviewed by peer teachers in the same science field. The PBL class followed a problem-centered instructional sequence supported by video, while the comparison class received PjBL with video. The science content focused on the impact of pollution on human health and the environment. The source manuscript states that implementation followed the lesson plan and that students in the PBL-video class showed greater enthusiasm and active solution seeking.

Data Analysis

The manuscript reports use of SPSS version 21, a One-Sample Kolmogorov-Smirnov normality test, a homogeneity test, paired-samples t testing, and one-way ANOVA. However, the results table presented is a Tests of Between-Subjects Effects table containing main effects and an interaction term. Because this differs from the stated analysis plan, the table is reproduced as reported and interpreted cautiously rather than being reclassified without the original dataset.

RESULTS AND DISCUSSION

Reported Between-Subjects Effects

Table 1 reproduces the inferential statistics reported in the source manuscript. The corrected model was significant ($F = 38.914$, $p < .001$), and the reported R^2 was .779 (adjusted $R^2 = .760$). The learning-model term was significant ($F = 17.004$, $p < .001$), the instructional-video term was significant ($F = 28.015$, $p < .001$), and the model-by-video term was reported as significant ($F = 3.572$, $p = .002$).

Table 1. Reported tests of between-subjects effects

Source	Type III SS	df	Mean Square	F	Sig.
Corrected Model	9239.401	5	1847.880	38.914	.000
Intercept	210106.199	1	210106.199	4451.947	.000
Learning model	767.882	1	767.882	17.004	.000
Instructional video	2530.417	2	1265.208	28.015	.000
Learning model × video	331.730	2	165.865	3.572	.002
Error	2619.583	24	45.165	—	—
Total	316425.000	30	—	—	—
Corrected Total	11858.984	63	—	—	—

Note. Values are reproduced from the source manuscript. $R^2 = .779$; adjusted $R^2 = .760$. The reported degrees of freedom are internally inconsistent (e.g., Total df = 30 while Corrected Total df = 63), so the underlying sample size and exact factorial structure cannot be verified from the manuscript alone.

Interpretation of the Learning-Model Effect

The manuscript reports that the experimental PBL-video class achieved higher learning outcomes than the comparison PjBL-video class. This pattern is pedagogically plausible because PBL requires students to organize information around a problem, articulate hypotheses, seek evidence, and justify solutions (Hmelo-Silver, 2004; Yew & Goh, 2016). Active-learning research more broadly shows that structured student activity and explanation can improve achievement compared with predominantly expository instruction (Freeman et al., 2014; Chi & Wylie, 2014). However, because both groups received instructional video and the source does not report group means, standard deviations, pretest equivalence, or effect sizes, the magnitude of the PBL advantage cannot be calculated.

Contribution of Instructional Video

The reported significant video term is consistent with research showing that instructional video can support comprehension through visualization, replay, and learner-controlled pacing (Kay, 2012; Brame, 2016; Noetel et al., 2021). In the present instructional logic, video did not function merely as a tutorial; it provided information and context that could help students understand the problem before proposing solutions. Such use is most defensible when video is concise, aligned with the task, and accompanied by questions or discussion that require active processing (Guo et al., 2014; Fiorella & Mayer, 2018; Kizilcec et al., 2014).

Interaction and Statistical Reporting

The manuscript interprets the model-by-video term as evidence that PBL assisted by instructional video affected learning outcomes. Because the design description indicates that both classes used video, whereas the ANOVA table treats video as a factor with df = 2, the exact meaning of this interaction cannot be established from the available text. This is an important reporting issue: factorial interactions require clearly defined factor levels and cell sizes (Shadish et al., 2002). Statistical significance should also be accompanied by descriptive statistics, confidence intervals, and effect sizes to support substantive interpretation (Lakens, 2013; Wasserstein et al., 2019).

LIMITATIONS

Several limitations should be considered. First, the manuscript does not report consistent sample-size information, group means, standard deviations, or pretest equivalence. Second, the stated analysis plan (paired t test and one-way ANOVA) does not match the factorial between-subjects table shown in the results. Third, the degrees of freedom in that table are internally inconsistent. Fourth, instrument validation is described as peer-teacher review without reliability coefficients or detailed validity evidence. Finally, the study was conducted in one vocational school and one science topic, limiting generalization. These limitations do not erase the reported classroom pattern, but they prevent precise estimation of effect magnitude and causal attribution.

CONCLUSION AND RECOMMENDATIONS

The source study concludes that PBL assisted by instructional video was implemented according to the lesson plan and was associated with higher science learning outcomes than the comparison condition. The reported analysis indicates significant terms for learning model, instructional video, and their interaction, with $R^2 = .779$. The combination is educationally coherent because PBL structures inquiry around authentic problems while video can supply concrete audiovisual information that supports problem representation. Future research should use a clearly specified design, report the exact sample and group allocation, establish pretest equivalence, provide means and standard deviations, report effect sizes and confidence intervals, and document the validity and reliability of the achievement test. Replication across vocational programs and science topics would strengthen the evidence base.

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