LAPORAN AKHIR

Penelitian Internasional Kerjasama

PROJECT-BASED LEARNING ON STEAM-BASED STUDENT'S WORKSHEET WITH ECOPRINT TECHNIQUE: EFFECTS ON SCIENTIFIC REASONING AND STUDENT CREATIVITY

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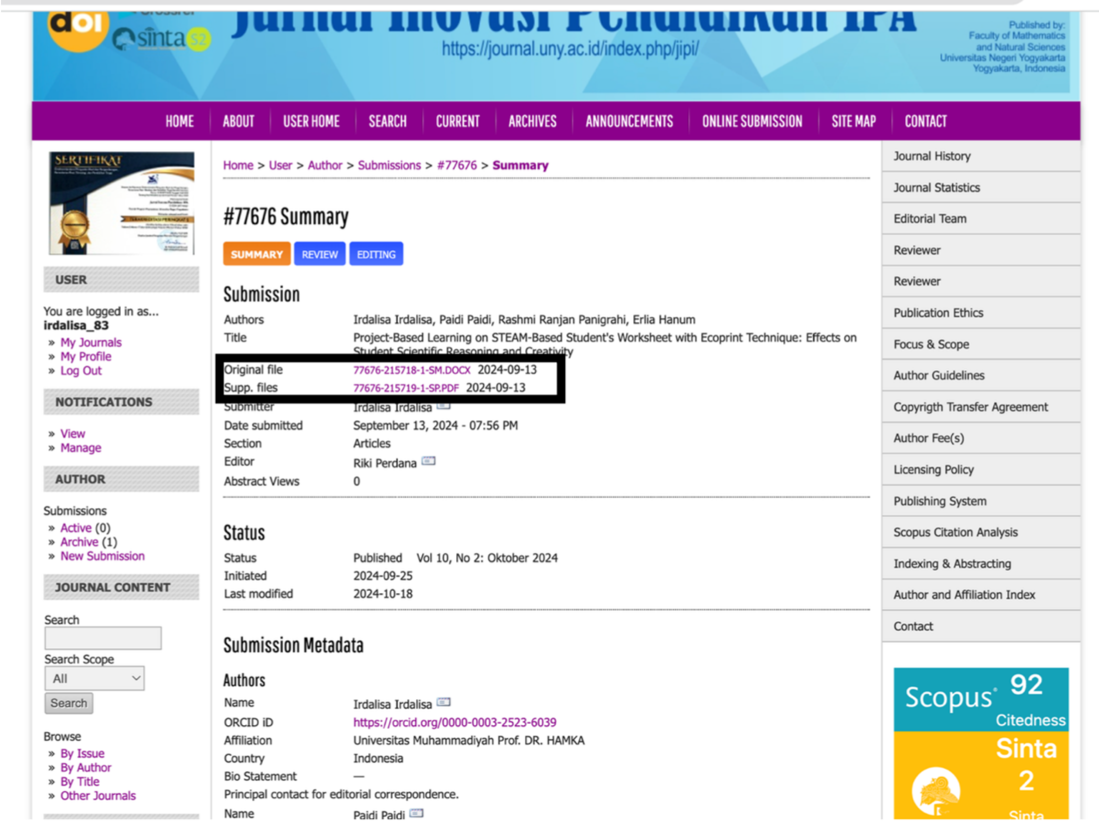

Laporan Akhir

Judul (Title) : Project-Based Learning On Steam-Based Student's Worksheet With Ecoprint Technique: Effects On Scientific Reasoning And Student Creativity

Latar Belakang (Background)

In the 21st century, education is tailored to emphasize skills relevant to the modern era, such as critical thinking, creative and innovative thinking, communication, and collaboration (Nurhasanah et al., 2024). In alignment with the 21st-century educational paradigm, students are encouraged to acquire the skills of critical thinking, inquiry, problem-solving, meaningful contextual understanding, and engaging pedagogical methodologies to achieve learning objectives (Puangpunsi, 2021). Teachers should endeavour to ascertain and explore the existing concepts held by learners and assist in integrating them with new knowledge to create meaningful learning experiences (Hsbollah & Hassan, 2022). The learning process implemented by teacher must be able to combine literacy skills, knowledge, skills, behavior and matery of technology. The learning process extends beyond memorising concepts or mere facts. It involves linking these concepts to real-world problems so that the acquired knowledge is well comprehended and less likely to be forgotten (Dixon & Brown, 2012).

Numerous studies indicate the positive impact of implementing various learning models, including requiring students to directly participate in constructing and organising knowledge, considering alternative answers, engaging directly in research and data analysis, and communicating directly with the community (Barron & Chen, 2008). One learning model that provides students with opportunities to explore meaningful content and collaborate experimentally is the Project-Based

Learning (PjBL) model (Belwal et al., 2020). PjBL forms a student-centric approach to teaching, marked by active student participation, constructive inquiry, goal establishment, collaboration, communication, and reflection within real-world practices (Zen et al., 2022) by presenting certain problem situations or problems to students and motivating students to identify and provide solutions (Anazifa & Djukri, 2017). In the PjBL model, the product design process empowers learners to integrate and reconstruct knowledge, enhance professional competencies, boost interest, and improve collaborative abilities among participants (Guo et al., 2020).

Project-based learning demonstrates suitability for integration with Science, Technology, Engineering, Arts, and Mathematics (STEAM). It has proven to be the most successful approach worldwide for incorporating artistic components into schools (Jantassova et al., 2023). The STEAM approach has been widely employed to create comprehensive learning experiences. Numerous studies have reported the varied impacts of STEAM, among which are its ability to drive multidisciplinary problem-solving and motivate students (Asrizal et al., 2023). However, STEAM does not influence learning outcomes, as seen from the lack of student interest (Min et al., 2021). Implementing STEAM in schools can be challenging due to its interdisciplinary nature and the need for adequate facilities and resources to support various knowledge domains (Jeong & Kim, 2015). The PjBL model and the STEAM approach have similar goals in directing students to solve problems with technological products (Herlita et al., 2023).

The utilisation of worksheets can facilitate knowledge acquisition, enhance students' fundamental competencies, and encourage the active involvement of both teachers and students in project-based activities (Suwarno & Hasanudin, 2020). However, only has a few school implemented the integrated STEAM worksheets (Sa'adah, Ullyatus., 2022). STEAM-based student worksheets are still rarely found, especially in Indonesian schools (Patresia et al., 2020). STEAM is highly significant for fostering scientific abilities and effectively addressing open-ended, real-world tasks within students' future careers, as it shapes their scientific reasoning. (Zulkipli et al., 2020).

The 21st century demands students to be able to think and reason scientifically. Scientific reasoning is on of the century skills that needs to be trained because it is the basis for the development of the other skills (Saad et al., 2017). Scientific reasoning strongly correlates with cognitive abilities, where effective scientific reasoning involves logic, justification, rational thinking, and decision-making (Bao et al., 2009). Scientific reasoning is defined as the search for knowledge and coordination between theory and evidence. It is synonymous with experimentation (Choowong & Worapun, 2021). It plays a role in decision-making in everyday life through scientific processes, as a construct or predictor of student learning outcomes (Firdaus, 2021).

Students' scientific reasoning is complicated to hone well if the learning process is inappropriate (Luzyawati et al., 2021). The lack of quality teachers in the learning process who train students' scientific reasoning makes students less accustomed to solving problems that require students to think convergently (Hasruddin & Aulia, 2023), so students lack a broad way of thinking (Shofiyah et al., 2013). Students' lack of scientific reasoning skills is also attributed to students' inadequate attention to teachers' explanations. Students tend to memorise scientific concepts without comprehending the underlying meaning (Daryanti et al., 2015). Forming students' scientific reasoning is challenging due to its perceived status as an indicator of the complexity of students' cognitive, psychological, and effective social frameworks. This is considered highly significant in influencing learning outcomes within the school environment (Bezci & Sungur, 2021).

Creative thinking could be predictive for scientific reasoning (Willemsen et al., 2023). Enhancing students' creativity is inextricably linked to the significance of scientific reasoning in connection to conceptual understanding. Creative thinking is a mental process that incorporates cognitive functions (Hargrove, 2013). Students are expected to have received creative thinking instruction in order to generate highly innovative products. The ability to think creatively is essential for answering multi safety issues both now and in the future (Leasa et al., 2023). To address global challenges, creativity and insight can drive innovation and better learning environments. (Evans, 2020).

Creativity is the primary skill that receives special attention in learning (Aguilera & Ortiz-Revilla, 2021). Creativity involves the combination of uniqueness and utility, merging interaction, talent, processes, and environment to generate novel and valuable products from something that did not previously exist. (Beghetto, 2005) (Pllana, 2019). Various findings claim that STEAM can enhance student creativity (Asrizal et al., 2023); the element of art in STEAM has an important role (Boy, 2013). Several studies show that learning by applying art more deeply can produce challenging work (Liu et al., 2023).

Art that can be associated with the learning process is the application of the ecoprint technique. It is a method of decorating fabric by using various plants to extract their natural colours (Fatmala & Hartati, 2020). It is considered applicable in learning due to its process involving techniques, art, technology, and mathematics (Widiantoro, 2020). The product creation process in the PjBL model empowers students to integrate and reconstruct student knowledge, strengthen professional competence, increase motivation and refine students' collaborative abilities (Guo et al., 2020). The integration of project-based learning with STEAM elements encourages students to explore innovative and imaginative ways to address challenges, present data, encourage innovation, and bridge multiple disciplines (Dyer, 2019). Project-based learning on STEAM-based student's worksheet with ecoprint technique is a crucial subject that has received less attentions and still rarely used in biology learning, so this research will help broaden the perspective to apply it in current learning. Hence, it can be utilised as project-based learning with STEAM elements so that students can acquire all fields of knowledge. Therefore, there is a need to design guidelines that integrate STEAM into project-based learning as an advanced organiser to assist students in activities and structure observations in the learning environment that do not confuse students (Lee, 2014). This research aims to determine the effectiveness of implementing project-based learning using STEAM-based worksheets alongside the ecoprint technique to enhance students' scientific reasoning and creativity. The research tries to address on research questions namely does the use project-based learning on STEAM-based student's worksheet with ecoprint technique have an effect on scientific reasoning and student creativity?

Tujuan Riset (Objective)

This research aims to determine the effectiveness of implementing project-based learning using STEAM-based worksheets alongside the ecoprint technique to enhance students' scientific reasoning and creativity.

Methodology

This study's quasi-experimental Nonrandomized Control Group Pretest-Posttest Design was to ascertain whether project-based learning could be applied to STEAM-based students' worksheet analysis using the ecoprint technique. Student creativity and scientific reasoning were the two dependent variables. Conversely, the learning model served as the study's independent variable. The study was carried out in a Jakartan public senior high school. Grade 10 MIPA students were included in the research sample. There were eighty students in each class, 35 female and 45 male. In the control class, students took lessons in the form of lectures, class discussions, and individual tasks, while in the experimental class, students followed learning through the project-based learning on STEAM.

Tabel 2. Research Design

Group	Pretest	Independent Variable	Posttest
Experiment	Y1	X	Y2
Control	Y1	-	Y2

Description:
Y1 : Dependent variable before treatment
X : Independent variable (Using a project-based learning course on STEAM-based worksheet analysis using the ecoprint technique)
Y2 : Dependent variable after treatment

Scientific reasoning data were collected using the Lawson Classroom Test of Scientific Reasoning (LCTSR), which is an essay-based tool with 18 items. In addition, student creativity was assessed through a questionnaire and observation sheets. According to the framework established by Lawson in the LCTSR, the indicators for evaluating scientific reasoning include conservation reasoning, proportional reasoning, control of variables reasoning, probability reasoning, correlation reasoning, and hypothesis-deductive reasoning (Handayani et al., 2020). For creativity assessment, the indicators involved ideation and development, exploration of product design, interdisciplinary knowledge, appropriate material selection, and tool usage.

Analytical procedures involved ANCOVA testing, This inferential statistical analysis is used to test the research hypothesis. The data to be analyzed in this study are the results of the Pre-Test (students' initial abilities) as accompanying variables or covariates and the results of the Post-Test (students' social skills and self-confidence) as dependent variables. ANCOVA is a combination of regression with variance analysis used as a statistical control technique. Before ANCOVA, the research data's normality and homogeneity assumptions were verified through Shapiro-Wilk and Levene tests. Quade's Rank Analysis of Covariance would be employed if the data fails to meet normality or homogeneity assumptions. Data analysis was executed using IBM Statistics 24 software, with a significance level set at 5%.

Result

The effectiveness of achieving these parameters can be impacted by the learning model used in the classroom. The results of the Shapiro-Wilk and Levene’s tests for the data in this study are shown in Table 3. The significance levels for scientific reasoning and student creativity from the Shapiro-Wilk test are 0.704 and 0.562, respectively. Additionally, the significance levels from Levene’s test are 0.454 and 0.622, respectively. This indicates that the data from this study meet the assumptions for normality and homogeneity.

Table 3. The Results of the Normality and Homogeneity Tests of the Research Data

Data	Statistical Tests	Sig.
scientific reasoning	Shapiro-Wilk test	0.704
	Levene’s test	0.562
student creativity	Shapiro-Wilk test	0.454
	Levene’s test	0.622

According to the hypothesis test results shown in Table 4, the F value was 39.586 with a significance level less than 0.05. This indicates that there was a significant difference in the levels of scientific reasoning and student creativity between the experimental class and the control class.

Table 4. The Results of the ANCOVA Test

Data	Degree of Freedom	F	Sig.
scientific reasoning	1	27.427	< 0.05
student creativity	1	16.327	< 0.05

The average scores of the adjusted results shown in Table 5 indicate that students in the experimental class achieved better learning outcomes than those in the control clas (84.743> 72.628). This result indicates that students who receive the integrated STEAM project-based learning and ecoprint worksheet show much better learning outcomes than those in other classes.

Table 5. The Comparison of Mean Scores of Corrected Results from Experimental and Control

Data	Classes	pretest	posttest	Increase (%)	Corrected Mean Scores
scientific reasoning	Experiment	54.683	84.246	53.584	84.743
	control	62.045	72.064	27.404	72.628
student creativity	Experiment	69.843	85.546	37.324	82.573

	control	59.118	69.474	31.284	70.398

One of the parameters examined in this study is scientific reasoning. The results of hypothesis testing using ANCOVA (Table 4) showed an F value of 27.427 for the scientific reasoning variable with a significance level of less than 0.05. This indicates that students who engaged in project-based learning with STEAM-based worksheets exhibited a significant difference in their creative thinking skills compared to those who did not participate in this type of learning. Additionally, as shown in Table 5, the average score for scientific reasoning skills in the experimental group (84.743) was higher than that of the control group (72.628).

Another parameter examined is creative thinking. The hypothesis testing using ANCOVA (Table 4) yielded an F value of 16.327 for the creative thinking skills variable, with a significance level less than 0.05. This indicates that students who participated in project-based learning with STEAM-based worksheets showed a significant improvement in creative thinking skills compared to those who did not receive this type of instruction. Additionally, the data analysis presented in Table 5 reveals that the average score for creative thinking skills in the experimental group (82.573) was higher than in the control group (70.398). These conclusions are based on the ANCOVA test results and the corresponding average scores.

DISCUSSION

The research findings exhibit a significant influence of project-based learning (PBL) on STEAM-based student worksheets with ecoprint techniques on learners' scientific reasoning and creativity. In project-based learning, students are guided in creating eco print projects using easily accessible materials relating to spermatophyte topics. This PBL project is group-assigned, with learners initiating the project by selecting a specific topic with scaffolding guidance from the teacher. Students design the arrangement of plant parts used in batik ecoprint results collaboratively based on their creativity. Within the PBL, students collaborate and take responsibility as team members, recognising the parallels between their learning and the surrounding environment. Engaging in this project allows students to enhance their abilities in discussing ideas, making predictions, and collecting, and analysing data to address challenges, thereby refining their scientific reasoning skills.

Scientific reasoning involves a logical thought process to draw conclusions based on information. It is a systematic and logical thinking ability to solve problems using scientific methods (Handayani et al., 2020). Adequate teaching strategies, learning tools, and teachers' ability to foster an active learning environment are essential in nurturing students' scientific reasoning abilities (Handayani et al., 2020). Patterns of scientific reasoning enable students to logically and systematically analyse facts or information (Hadi et al., 2021). This capacity is vital for students to apply their acquired knowledge in resolving various encountered issues (Yulianti & Zhafirah, 2020). The ability to reason scientifically affects students' ease in resolving problems ((Develaki, 2017); (Hejnová et al., 2018); (Fawaiz et al., 2020). Scientific reasoning skills involve cognitive abilities to plan and conduct investigations (Lazonder, 2023).

This study's scientific reasoning assessment indicators encompass conservation reasoning, proportional reasoning, variable control reasoning, probability reasoning, correlation reasoning, and hypothesis-deductive reasoning (Handayani et al., 2020). Conservation reasoning involves students' ability to comprehend that specific properties of objects remain unchanged (Handayani et al., 2020). Correlation reasoning pertains to students' capability to determine the relationship between the studied phenomena. It involves creative thinking to identify mutual relationships between variables that play a role in hypothesis formulation and data interpretation (Hadi et al., 2021). Probability reasoning involves understanding various possibilities in an event and interpreting observation data (Hadi et al., 2021). Probabilistic reasoning is used to decide if the drawn conclusions have a probability of being true or false (Handayani et al., 2020). Proportional reasoning relates to students' ability to compare problem situations by enhancing students' sensitivity to deal with comparative situations (Hadi et al., 2021). Correlation reasoning concerns students' ability to determine relationships within the investigated phenomena. It identifies and determines reciprocal relationships between variables

(Lawson, 2004). Variable control reasoning is students' ability to control certain variables in a given problem. Hypothesis-deductive reasoning involves students' ability to consider alternatives for specific situations. It encompasses the ability to form hypotheses from general theories followed by deduction to develop problem solutions (Han et al., 2016).

Integrating STEAM project-based learning is a facet of sound teaching practices (Sigit et al., 2022). The STEAM-PBL worksheets are crafted considering the steps of project-based learning and STEAM elements. These worksheets use projects as sources for students to discover knowledge and skills. Throughout the learning process, group discussion activities train students' scientific reasoning, enabling them to express their opinions among group members (Viyanti et al., 2023). Therefore, applying project-based learning on STEAM-based student worksheets with ecoprint techniques positively enhances students' scientific reasoning compared to direct instruction.

Creativity is thinking and using imagination to produce something novel with utility. It becomes an essential skill for problem-solving in the learning process (Yeh & Ting, 2023). Creativity is vital part of develop among students. The growth of student creativity relies on how teachers foster it in the learning environment (Herak & Hadung Lamanepa, 2019). Thus, teachers must implement learning strategies that nurture students' creative thinking (Prajoko et al., 2023). STEAM is an educational approach providing students with opportunities to develop creativity, a crucial skill for the 21st century (Katz-Buonincontro, 2018); (Blackley et al., 2018).

Throughout the learning process, there is an emphasis on the five critical elements of STEAM. The science aspect pertains to the learning topic's content, while the technology aspect involves technology to explore information from various sources and the equipment for creating ecoprint. The technical aspect relates to students' ability to utilise ecoprint techniques in designing products. The art aspect is crucial in fostering students' creativity in designing ecoprint products, while the mathematical element helps students' capacity to use mathematical skills to determine the quantity and size of materials needed to design products. Including the art aspect in STEAM education is paramount in eliciting students' creativity in solving complex problems in the 21st century. The integration of Art in STEAM fosters students' creativity and introduces interdisciplinary relationships through firsthand experiences gained during the learning process (Pearson, 2022).

STEAM makes learning more engaging and encourages students to express their creativity through visual arts, boosting their enthusiasm for science learning (Conradty & Bogner, 2020). Students achieve more relevant learning outcomes through the STEAM approach as they connect their learning with other fields of study, leading to a deeper understanding of the materials used in their projects (Herro et al., 2017). Leveraging technology has the potential to build learning interactions that prioritise active student participation in problem-solving activities (Irdalisa et al., 2020).

In addition to the STEAM approach, it is essential to integrate learning models with various disciplines and practical skills based on the needs of 21st-century education, where project-based learning (PjBL) emerges as a fitting model (Chiang & Lee, 2016); (Miller et al., 2019). Hence, PjBL on STEAM-based student worksheets can serve as a platform for students to generate ideas based on science and technology through thinking and exploration in problem-solving by integrating science, technology, engineering, arts, and mathematics. This integration renders the learning process more meaningful for students and encourages them to identify issues and devise inventive solutions through the projects they work on, thereby nurturing students' creativity. The results of Prajoko et al (2023) study show that the PjBL-STEM model influences students' creativity through problem-solving activities because they are directly involved in the learning process and produce creative products. The learning stages direct students to gain interesting and meaningful experiences where students construct their own knowledge through collaborative tasks and projects in producing authentic products.

STEAM has the potential to enhance students' creativity (Blackley et al., 2018); (Rahman et al., 2020); (Lu et al., 2022); (Nabila & Kamaludin, 2023). PjBL on STEAM-based student worksheets with ecoprint techniques focuses on ideation by linking various technological applications relevant to the subject matter with appropriate techniques, allowing students to create simple tools related to the lesson material (Irdalisa et al., 2023). Many straightforward projects undertaken by students enable them to learn more actively and solve everyday problems related to the studied topics (Deta & Widha, 2013). Using student worksheets as a support tool helps direct and enhance learning activities, leading to effective interaction between students and educators. These worksheets are designed according to models and approaches, which is relevant to the demands of 21st-century education.

Using these student worksheets can stimulate and develop students' abilities to generate creative ideas. Students can work creatively to develop ideas in creating a product within project-based learning (Viyanti et al., 2023). (Alkautsar et al., 2023) demonstrate that STEM-PjBL worksheets can enhance collaboration skills, creativity, and computational thinking through structured learning activities. In implementing project-based learning on STEAM-based student worksheets with ecoprint techniques, students are actively involved in the learning process and directed to learn through a project by following the instructional stages provided in the worksheets. Students collaborate with their group members regarding the design and completion of the ecoprint project, gathering project-related information seeking solutions to potential challenges encountered in project completion. These learning activities will hone students' creativity. Project-based learning allows students to learn and collaborate in solving problems. Thus, implementing project-based learning on STEAM-based student worksheets with eco print techniques has a positive and effective impact on enhancing students' creativity compared to direct instruction.

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