Effectiveness of Project-Based Learning on STEAM Based Student's Worksheet Analysis with Ecoprint Technique

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Effectiveness of Project-Based Learning on STEAM

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Authorship Contribution Statement

Irdalisa[1*]: Conceptualization and design. **Zulherman**[2]: Editing/reviewing, supervision. **Mega Elvianasti**[3]: analysis. **Sri Adi Widodo**[4]**:** critical revision of manuscript, **Erlia Hanum**[5]**:** data analysis

Abstract:

The objective of this research was to assess the efficacy of project-based learning in enhancing the analysis of student worksheets in the domains of Science, Technology, Engineering, Arts, and Mathematics (STEAM) with the integration of the ecoprint

technique, focusing on its influence on student motivation and creativity. This investigation was conducted as a quasi-experiment involving a sample size of 150 students selected through cluster sampling. Data collection was executed using standardized tests, with instrument validity ascertained through the Aiken index and instrument reliability determined via Cronbach's alpha coefficient. Data analysis was performed using multivariate analysis (MANOVA) and descriptive quantitative methods. The study's findings reveal a significant disparity in the mean scores of both learning motivation and student creativity. In conclusion, the implementation of project-based learning coupled with STEAM-based student worksheet analysis utilizing the ecoprint technique yields a substantial enhancement in learning motivation and student creativity. These findings underscore the success of employing STEAM-based worksheets in conjunction with the ecoprint method to foster students' motivation and creativity, as ecoprint inherently encompasses all STEAM components within the manufacturing process.

Keywords: *Motivation, STEAM, Student creativity, Worksheet*

Introduction

The education field constantly evolves due to advancements in knowledge and technological innovation. The 21st century emphasizes student-centered learning to enhance skills (Patresia et al., 2020). Creativity is a required skill, which involves the mental process of generating original ideas (Dinantika et al., 2019). Students are trained to possess high levels of creativity to develop, enrich, and elaborate on ideas and solve problems from different perspectives (Harizah et al., 2021). Improving the quality of education is always being improved so that students can have good skills to compete in the world of work. Efforts to develop learning models are always being developed to provide opportunities for teachers to provide effective learning. Project-based learning is one of the development models of learning that can be used in the learning process.

The progress in nurturing students' creativity has been hindered by their persistent reliance on teachers for guidance and support (Teacher Center) (Irdalisa et al., 2023). The facilitation of student creativity can be effectively fostered through the deliberate choice of pedagogical models that demonstrate adaptability to the evolving demands of the globalized era. 21st-century learning models are aimed at student-centered learning, emphasizing inquiry-based activities (Rumahlatu & Sangur, 2019). The transition to student-centered learning allows students to develop their independence, engage in active exploration, work together, and take part in research projects. Students' ability to think critically can also be enhanced by practicum activities that concretize project learning (Telekova & Lukacikova, 2023). The application of PjBL has been the subject of numerous studies. According to the findings, PjBL has a favourable impact on students' motivation, engagement, and self-confidence (Condliffe et al., 2017). Muskania and Wilujeng's (2017) research demonstrates that PjBL-based learning tools have a significant impact on students' scientific literacy.

Project-based learning facilitates student engagement in collaborative projects that encompass various subjects, offering them opportunities to delve into meaningful content exploration and collaborative experimentation (Belwal et al., 2020). The principles underpinning project-based learning underscore the development of students' problem-solving skills in authentic real-life scenarios (Zen et al., 2022). The process of creating products within Project-Based Learning (PjBL) models empowers students to integrate and reconstruct their knowledge, fortify their professional competencies, heighten their interest, and refine their collaborative capabilities (Guo et al., 2020). Project-Based Learning (PjBL) underscores the importance of contextual learning through intricate activities, affording students the autonomy to explore and plan learning initiatives, engage in collaborative project execution, and ultimately yield tangible results (Adriyawati et al., 2020). For

educators, project-based learning serves as a vehicle for refining their skills in meticulous project activity planning and preparation (Mansfield, 2023).

Project-Based Learning aligns seamlessly with the integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) education. STEAM has emerged as a globally recognized approach for incorporating artistic components into the educational landscape (Jantassova et al., 2023). The fusion of project-based learning with STEAM elements exhibits a strong alignment with the competencies demanded in the 21st century (Lu et al., 2022). These 21st-century skills encompass creativity, critical thinking, inquisitiveness, problem-solving, logical reasoning, collaboration, and self-assurance, all of which can be effectively nurtured through the STEAM framework (Allina, 2018). STEAM-oriented learning empowers students to explore innovative and imaginative avenues for addressing challenges, presenting data, fostering innovation, and bridging diverse disciplines (Dyer, 2019). Artistry harmonizes with students' creative capacities and their ability to envision and innovate through technology, enabling the production of tangible creations and nurturing an artistic sensibility in their comprehension of science (Liu et al., 2021).

Within the realm of the learning process, the Student Worksheet emerges as a crucial pedagogical tool that significantly enhances the effectiveness of teaching and learning. The integration of Student Worksheets aids students in constructing their knowledge autonomously (Sa'adah & Ellinawati, 2022). In the context of science project laboratories, Suwarno (2020) underscores the pivotal role of Student Worksheets in facilitating knowledge acquisition, reinforcing students' foundational competencies, and fostering active

participation by both educators and learners in project-based activities. Science education places a premium on context, emphasizing the application of knowledge and experiences in the real world (Martawijaya et al., 2023). Consequently, it becomes imperative for educators to craft Student Worksheets in science learning, drawing upon established models, approaches, and methods. These worksheets serve to provide structured and focused learning activities, guiding students in their exploration of novel concepts. The development of Student Worksheets not only heightens student engagement but also shifts the learning paradigm from teacher-centric to learner-centric (Melindawati, 2020). Therefore, in order to address the challenges of the 21st century, it becomes essential to redesign Student Worksheets that are thoughtfully tailored to incorporate biology concepts within the context of Science, Technology, Engineering, Arts, and Mathematics (STEAM).

Student Worksheets represent invaluable aids for facilitating and enriching learning experiences, fostering meaningful interactions between students and educators, and bolstering student motivation (Asnidar et al., 2016). Motivation constitutes a pivotal psychological factor within the realm of learning (Tasiwan et al., 2014). The presence of learning motivation holds paramount importance in the context of educational success, exerting a profound influence on students' educational progress and outcomes. Moreover, when educators opt for teaching models, they should take into account the characteristics inherent in the learning materials (Afriana et al., 2016). One particular area where students often encounter difficulties lies in their comprehension of spermatophytes, a topic encompassing the taxonomy and binomial nomenclature within the Plantae Kingdom. Students frequently struggle with memorizing the Latin language and navigating the hierarchical classification from Kingdom to Species. Furthermore, the vast array of plant types and species exacerbates the likelihood of errors in composing plant classifications and

employing scientific nomenclature.Field observations indicate that many Student Worksheets provided only contain material and tasks, making them appear dull and lacking in stimulating students' curiosity. Integrating student worksheets within the existing teaching models utilized in schools is not effectively implemented (Sa'adah & Ellinawati 2022)., motivation (Wandari et al., 2018). Teachers continue encountering difficulties in developing teaching materials, including creating Student Worksheets and assessment tools (Irdalisa et al., 2022). STEAM-based Student Worksheets are still rare, especially in Indonesian schools (Patresia et al., 2020).

One innovative and creative instructional medium based on STEAM that is relatively underutilized in education is Ecoprint. It is a method of decorating fabric using various plants to extract their natural colors (Setyaningrum & Purwanti, 2020). The ecoprint method can be used as an illustration of cross-disciplinary education that blends art instruction with knowledge of leaf structure and identification. This study aims to determine whether STEAM-based student worksheets that employ the ecoprint approach may increase student learning motivation and creativity.

Literature Review

Project Based Learning (PjBL)

The PjBL (Project-based Learning) model is an active learning approach that leverages real-world projects as a means of instruction. It is a practical and widely used innovation in education, where educators create learning experiences centered around everyday challenges to motivate students. By engaging in project-based learning, students are encouraged to explore, make choices, design, and ultimately produce a final product, thus enhancing their understanding and knowledge acquisition (Uziak, 2016). This learner-centered approach fosters meaningful learning as students seek relevant solutions and apply them in the context

of project work (Chiang & Lee, 2016). By relating their learning to actual events, the PjBL approach encourages students to acquire critical thinking skills, problem-solving techniques, and a deeper comprehension of subjects.

The PjBL model was developed by John Dewey, based on the concept of 'learning by doing,' which emphasizes direct experiential learning and student-centeredness (Maida, 2011). In the implementation of PjBL, students collectively organize their knowledge by exploring various solutions to solve problems, thereby fostering critical and creative thinking (Han et al., 2016; Darling-Hammond et al., 2020). According to Suradika (2023), there are several principles in the PjBL model: (1) students are at the center of the learning process; (2) the model enhances students' creativity; (3) it creates a challenging and enjoyable classroom environment; (4) the model incorporates values, aesthetics, ethics, sound reasoning, and kinesthetic learning; (5) it requires extended durations for sharing diverse learning experiences. These principles collectively contribute to the effectiveness of the PjBL model in promoting student engagement and holistic development.

Numerous research endeavors have delved into implementing Project-Based Learning (PjBL), yielding noteworthy discoveries. Mursid et al. (2022) uncovered that the blended project-based learning model positively influenced the creative thinking abilities and academic outcomes of engineering students. Payoungkiattikun et al. (2022) discerned that the PjBL approach bolstered the metacognitive skills of aspiring science educators. Syawaludin et al. (2022) unveiled that the PjBL model and online learning environments left an imprint on students' analytical proficiencies within discovery learning, interactive demonstrations, and inquiry-based lessons. Erviana et al. (2022) highlighted the impact of PjBL on the Technological Pedagogical Content Knowledge (TPACK) of elementary school instructors. Rahardjanto et al. (2019) showcased the substantial influence of the hybrid-PjBL

approach on academic achievement and creative thinking abilities. Suradika et al. (2023) ascertained that both project-based learning and problem-based learning models elevated students' critical thinking and creativity. Similarly, Suwarno et al. (2020) documented that the integration of PjBL, supported by well-structured worksheets, yielded positive outcomes for students' competencies, notably in the realms of creativity and applied science learning achievements.

Science, Technology, Engineering, Arts, and Mathematics (STEAM)

STEAM, an acronym representing Science, Technology, Engineering, Arts, and Mathematics, embodies an interdisciplinary educational methodology designed to furnish students with the proficiencies necessary for thriving in the 21st century. It constitutes a contextual learning paradigm that interweaves diverse academic domains, prompting students to nurture a spectrum of abilities encompassing problem-solving, critical thinking, and collaborative skills (Sigit et al., 2022).

The genesis of STEM (Science, Technology, Engineering, and Mathematics) in the United States was fundamentally driven by economic considerations, subsequently elevating STEM education as a focal point in both American and European contexts (Konkus & Topsakal, 2022). The incorporation of STEM into educational frameworks arises from the imperative need for individuals to acquire the knowledge and competencies requisite for success as innovators in the 21st-century labor force. The original conception of STEM, devised by the National Science Foundation, encompasses the amalgamation of Science (pertaining to the study of the natural world), Technology (centered on the examination of products designed to fulfill human needs), Engineering (involving the process of designing solutions to address problems), and Mathematics (serving as the language for comprehending shapes, numbers, and quantities) (DeCoito, 2014). Subsequently, STEM expanded into STEAM through the

inclusion of "Arts." This augmentation allows learners to showcase their creativity, effectiveness, fiscal acumen, and artistic prowess in the context of resolving real-world challenges (Razi & Zhou, 2022). Additionally, it enriches employability skills, fostering attributes such as teamwork, communication, and adaptability (Colucci et al., 2017).

Georgette Yakman's notion for STEAM first surfaced in the early 2000s, and it grew in acceptance by the mid-2000s (Pearson, 2022). It was first made available in the US in 2007 (Daugherty, 2013). The STEAM method stimulates student creativity and collaboration more than it does academic strategy (Belbase et al., 2022; Liao, 2019). It is a disruptive innovation in education. Students actively participate in the learning process and acquire 21st-century abilities when using the STEAM approach. Taylor (2016) highlights the following crucial STEAM components: 1) STEAM strengthens and broadens the scope of STEM; 2) STEAM enables science teachers to participate in the development of school-based curricula; 3) STEAM incorporates teachers in the process of building a student-centered vision of 21st-century education; and 4) STEAM offers a way to integrate the arts and humanities into STEM instruction.; 5) STEAM initiatives can be crafted and executed by individual educators on a manageable scale.; 6) Educators have the capacity to develop STEAM activities within the framework of project-based learning. In STEAM education, instructional models often incorporate collaborative or cooperative learning approaches, wherein students take on the role of subject matter experts and collaborate within groups to collectively complete tasks (Thompson et al., 2020; Edelen et al., 2023).

The integration of STEAM into education responds to the imperative of bolstering students' interest and proficiency in Science, Technology, Engineering, Arts, and Mathematics (STEM). In conjunction with the incorporation of STEAM, the adoption of appropriate

learning models becomes essential to bridge gaps in academic knowledge. Notably, the Project-Based Learning (PjBL) model proves particularly well-suited for integration with interdisciplinary frameworks like STEAM. Several research studies have delved into this amalgamation, with notable findings, including those by Winarni et al. (2022), who demonstrated that the integration of PjBL-STEM significantly impacted the science literacy and environmental awareness of elementary school students. Martawijaya et al. (2023) revealed that the ethno-STEM-PjBL model contributed to improved concept comprehension, characterized by enhanced higher-order thinking skills and reduced misconceptions. Konkus & Topsakal (2022) showcased that STEAM-based activities brought about enhancements in students' STEAM attitudes, cooperative work skills, and career choices. Siew & Ambo (2020) asserted that students' creativity witnessed a surge when employing the STEM-PjBL learning approach. Similarly, Sigit et al. (2022) provided evidence that the integration of PjBL with STEAM enriched students' mastery of ecological concepts. While numerous studies have explored the integration of PjBL and STEAM, a gap exists in the literature concerning PjBL-STEAM-based worksheets utilizing the ecoprint technique. Consequently, this study aims to adapt PjBL-STEAM-based worksheets incorporating the ecoprint technique to assess their impact on student motivation and creativity.

Ecoprint Technique

Ecoprint is a technique used to transfer patterns of flowers, leaves, and stems onto fabric. The process involves treating the plant material with a mordant to remove waxy layers and fine impurities, allowing the colors within the leaves and flowers to be absorbed by the fabric. Ecoprint can be performed using various methods, including boiling the fabric, pounding the plant material, or steaming the fabric (Pandasari et al., 2022). The ecoprint technique is commonly applied to natural fiber materials such as cotton, silk, canvas, and linen (Sedjati & Sari, 2019). Plants used for ecoprinting typically possess certain characteristics, including 1) a strong aroma; 2) easy color transfer when rubbed against fabric or skin; 3) changes in water color when leaves are immersed in hot water (Pandasari et al., 2022).

The learning process places a strong emphasis on fostering the exploration of ideas through the integration of various technologies, art, and engineering applications that align with the subject matter. This approach enables students to acquire the skills needed to create simple tools relevant to the lesson content. Given that the ecoprint technique can be harnessed to help students grasp and appreciate environmentally friendly art by utilizing the natural environment, it holds applicability not only in Indonesia but also on a global scale. Ecoprint employs uncomplicated and user-friendly tools that can assist students in studying topics related to the plant kingdom. Irdalisa et al.'s research (2023) demonstrates that the integration of the ecoprint technique into STEAM-based worksheets serves as a highly suitable method for developing innovative learning resources that align with the requisites of the 21st century, placing a premium on the 4C skills: Critical thinking, Collaboration, Communication, and Creativity. These studies collectively underscore the favorable impacts of Project-Based Learning (PjBL) in diverse educational contexts and its potential for

elevating students' learning outcomes and skillsets. Consequently, the central research question pertains to the effectiveness of Project-Based Learning in conjunction with STEAM-based Student's Worksheet Analysis utilizing the Ecoprint Technique on student motivation and creativity.

Methodology

Research Design

The primary objective of this research was to assess the effectiveness of Project-Based Learning when integrated with STEAM-based Student's Worksheet Analysis using the Ecoprint Technique in enhancing students' learning motivation and creativity. To achieve this, a quasi-experimental non-equivalent control group design was employed to compare the changes in Learning Motivation and Student Creativity between the experimental group and the control group. In the experimental group, students received instruction through Project-Based Learning within the context of STEAM-based Student's Worksheets, while the control group underwent conventional learning methods. The details of these instructional approaches are presented in Table 1 below.

Table 1. Project base learning syntax learning activities

Learning steps	**Activity**	
	Educator	**Students**
Asking physical questions in everyday life	- Lead the prayer - Apperception by giving questions that have been studied before. - Convey the theme and learning objectives - Provide instructions on how to use ecoprint	- Pray together - Give answers to the teacher's questions - Listening and paying attention
Develop project planning	- Provide teaching materials	Pay attention and carry out tasks

	- Provide assignments and instructions for group discussion activities.	
Doing independent learning	- - Provides an opportunity to seek - information	Access, manage, and communicate the information that has been obtained
Design in collaboration	- Provide opportunities to carry out activities - Controlling the course of activities	- Using engineering design - Solve the problem - Analyze ideas - Designing products
Test results	-Listening and assessing the presentation of the results of group activities - Reflecting on the results of the presentation of students - Provide opportunities for students to ask questions	- Testing and improving the results of the activities that have been carried out - Communicating results - Students actively ask questions about concepts they have not understood
Conduct an assessment	- Guiding students to conclude the learning that has been done - give post-test - provide post test results	- Summarize the material - Carrying out post tests

Sample and Data Collection

The research sample for this study comprised a total of 150 students, evenly divided into two groups with 75 students in each: the experimental group and the control group. Cluster sampling was employed as the sampling technique in this study. Cluster sampling was chosen because the sample members were drawn from a larger population, and the sampling process involved predetermined groups, as outlined in the methodology by Sugiyono (2015). The assessment indicators for learning motivation encompassed attention, relevance, confidence, and satisfaction, as per the framework established by Afjar et al. (2020). Meanwhile, the assessment indicators for student creativity encompassed idea planning and development, exploration in product design, interdisciplinary knowledge, appropriate material selection, and tool usage. These questionnaires and observation sheets underwent a

validation process conducted by experts in the field. To ascertain the validity of the research instrument, a panel of three educational experts conducted a validation process. This validation analysis aimed to determine the validity of the instrument items. The validation process involved assessing the level of expert agreement, as measured by the Aiken index (V). The results of this measurement are presented in Table 2.

Table 2. Results of the Aiken Index Coefficient of Instrument Validity

Instrument	V	Information
learning motivation	0.82	Valid
student creativity	0.85	Valid

The reliability of the research instruments was assessed using Cronbach's alpha coefficient. The results indicated a high level of reliability for both instruments. Specifically, the reliability coefficient for the learning motivation test instrument was 0.82, and for the student creativity instrument, it was 0.85. These reliability values fall within the high-reliability category, as defined by Taber (2013).

Analyzing of Data

The study's data were analyzed using descriptive quantitative methods in SPSS version 22 for Windows. The normality of the data was assessed through the One-Sample Kolmogorov-Smirnov test, and the Levene test was used to check for homogeneity. Additionally, the Manova test was conducted to identify any significant differences in mean scores between the experimental and control groups.

Result

This study seeks to assess the effectiveness of employing STEAM-based Student Worksheets alongside the ecoprint technique in enhancing students' learning motivation and creativity. The normality of the data was verified using the Kolmogorov-Smirnov test at a 5% significance level, confirming that the data followed a normal distribution.

Similarly, the homogeneity test conducted with the Barlett test indicated that the samples were drawn from populations with equal variances. Based on the outcomes of the Manova test employing Wilk's Lambda analysis, an F value of 1008.423 was obtained, signifying statistical significance with a p-value of 0.000, which is less than the threshold of 0.05.

Table 3. Marginal Means and Cell Means

Class	Student Worksheet	Dependent Variable	Low	High
Experiment	Student Worksheet based on STEAM with ecoprint technique	Learning Motivation	70.79	86.58
		Student Creativity	80.00	93.00
Control	Conventional Student Worksheet	Learning Motivation	61.87	61.87
		Student Creativity	53.00	69.65
	Marginal Mean	Learning Motivation	66.33	74.23
		Student Creativity	66.5	81.33

In terms of students' learning motivation, those who utilized the STEAM-based Student Worksheet in conjunction with the ecoprint technique achieved an average score of 86.58. In contrast, those who utilized the conventional Student Worksheet obtained a mean score of 61.83. Therefore, the mean score for students' learning motivation was higher when using the STEAM-based Student Worksheet with ecoprint technique compared to the conventional Student Worksheet (Table 3). As for students' creativity, the mean score for those who used the STEAM-based Student Worksheet with ecoprint technique was 93.00, while for those who used the conventional Student Worksheet was 69.65. Furthermore, the mean score for creativity was significantly greater when utilizing the STEAM-based Student Worksheet with the ecoprint technique compared to the conventional Student Worksheet. Based on these findings, it can be conclusively affirmed that using STEAM-based Student Worksheets in conjunction with the ecoprint technique enhances students' learning motivation and creativity compared to conventional Student Worksheets.

Subsequent analyses were conducted to assess the distinctions in each factor concerning the dependent variables (Table 4). The results indicated a significant disparity in values (p-value < .05), leading to the conclusion that there were substantial variations in both learning motivation (p = .000) and student creativity (p = .000) between the experimental class and the control class. In summary, the application of Project-Based Learning in conjunction with STEAM-based Student's Worksheet Analysis employing the Ecoprint Technique in the experimental class proved to be more effective in enhancing both Learning Motivation and Student Creativity compared to the conventional instructional model employed in the control class, as presented in Table 4.

Table 4. Test Result of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	F	Sig.
Corrected Model	learning motivation	1223.130[a]	1	248.808	.000
	student creativity	1472.667[b]	1	213.113	.000
Intercept	learning motivation	335278.241	1	68202.065	.000
	student creativity	339864.000	1	49182.545	.000
Group	learning motivation	1223.130	1	248.808	.000
	student creativity	1472.667	1	213.113	.000

Discussion

Students' learning motivation serves as a driving force for their learning activities. Student motivation can be enhanced by employing problem-solving techniques that establish a meaningful connection between the acquired knowledge and real-life circumstances. In project-based learning, students' motivation emerges through their experiences, collaboration, and authentic task construction. Students exhibit high perseverance in

project completion, possess a high level of curiosity, participate actively, and work independently. The development of students' motivation aligns with the problem-solving process. Projects assigned can stimulate students' motivation as they learn and evaluate their projects, thereby generating satisfaction in the learning process. Students' motivation in learning can be enhanced through various models and approaches (Tasiwan et al., 2014).

The integration of Project-Based Learning (PjBL) with STEM has demonstrated its capacity to enhance students' learning motivation, establish meaningful learning encounters, and facilitate effective problem-solving (Tseng et al., 2013). Furthermore, collaborative group work during project development fosters cooperative attitudes, courage, and an openness to accepting others' perspectives. Heightened student motivation contributes to a more engaging learning process. Student Worksheets serve as catalysts in the learning journey, underscoring the importance of adhering to criteria for graphic media as visual aids to captivate students' interest (Saputro et al., 2019). PjBL creates a conducive environment for applying skills, ultimately elevating the quality of the learning process and facilitating the attainment of higher cognitive levels by students (Yamin et al., 2017).

Creativity, defined as the capacity to generate something unique and innovative that holds practical value, represents a key facet of higher-level thinking, as highlighted by Dinantika et al. (2019). Throughout the learning process, students engage in project-based learning activities facilitated by teachers, with these projects aligning with the provided Student Worksheets. Student Worksheets play a pivotal role in fostering students' autonomy in the learning process and are meticulously crafted to align with specific learning competencies, as emphasized by Sari et al. (2019). Furthermore, Student

Worksheets serve as valuable tools for nurturing students' independence, literacy, creativity, and comprehension, as underscored by Febriani et al. (2017).

The utilization of STEAM-based Student Worksheets in conjunction with the ecoprint technique affords students invaluable experiences and opportunities to craft their projects, drawing from both their subject matter knowledge and creative abilities. Ecoprint, as elucidated by Saraswati et al. (2019), represents a method of embellishing fabric through the utilization of naturally derived pigments sourced directly from plants, resulting in the creation of intricate and captivating patterns or motifs. Within the learning process, teachers play a guiding role, directing students in their project work by furnishing instructions that are intricately tied to the attainment of specific learning objectives.

These objectives emphasize the five key elements of STEAM. Students will plan by seeking various information about the given project's solution. At this stage, students engage in discussions with their group members regarding the design and project completion stages, gather information about solutions and potential challenges in project implementation, determine the maximum time required for project completion, and integrate STEAM components into the project being undertaken. Therefore, in completing project-based learning, students need to follow the stages outlined in the instructional materials and integrate STEAM into the topic. The integration of arts within STEAM enables teachers to assist students in becoming creative and recognizing interdisciplinary connections through hands-on experiences (Pearson, 2022).

STEAM broadens students' outlook on the issues at hand and motivates them to seek resolutions (Pearson, 2022). The application of diverse critical and creative thinking techniques to pertinent curriculum content serves as a catalyst for motivating students to actively participate in critical and purposeful discussions regarding the subjects they are

studying. Students become better equipped to identify problems and devise inventive solutions through habitual application of these techniques. They also gain confidence in sharing their findings and concepts with others.

Implementing the STEAM-based Student Worksheet with the ecoprint technique demonstrates a substantial impact and effectiveness in enhancing students' creativity. This efficacy is attributed to the emphasis on creativity-enhancing learning within the PJBL-STEAM model. STEAM integrates two thinking models that cultivate talent by integrating interdisciplinary skills and creativity (Lu et al., 2022). PJBL integrated with the STEAM approach is applied in learning, resulting in the creation of a product by applying STEAM principles to project development (Adriyawati et al., 2015).

During the implementation phase, the utilization of STEAM-based Student Worksheets with the ecoprint technique promotes the seamless integration of content across diverse subjects encompassing science, technology, art, and mathematics. The science elements related to the learning content; the technological aspects of using the internet to browse information from numerous sources on the equipment and supplies required to create ecoprints; the scientific components related to the learning content; the technical component concerns how well students can use the ecoprint technique to design products; the artistic component concerns how well students can use their creativity to design ecoprints to produce interesting results; and the mathematical component focuses on how well students can use mathematical analysis to determine the quantity and size of materials required to create ecoprints. The presence and specifications of technology, along with its supportive applications, have the potential to establish novel learning interactions that prioritize active participation and offer direct learning encounters,

thereby stimulating student engagement in problem-solving, as highlighted by Irdalisa et al. (2020).

Within the sequence of Project-Based Learning (PJBL) integrated with STEAM, students are actively immersed in the learning process by amalgamating knowledge and skills. This integration serves as a conduit for students to acquire enriching learning experiences and refine their creative aptitude. As students embark on project-based activities, they are guided to exercise creativity in their planning and product design, drawing from the concepts they have assimilated. Creativity, as Dinantika et al. (2019) elucidate, represents an experiential journey through which individuals express themselves and generate valuable ideas, thoughts, and actions.

Past research has consistently demonstrated that the STEAM (Science, Technology, Engineering, Arts, and Mathematics) learning approach has a profound impact on students' knowledge competencies and significantly enhances their creativity, as evidenced by the studies conducted by Arsy and Syamsulrizal (2021). Furthermore, multiple research findings have underscored the capacity of STEAM to foster the development of advanced thinking skills, promote collaboration, encourage argumentation, and stimulate student creativity, as highlighted by Afriana et al. (2016). Leveraging Project-Based Learning (PjBL) serves as an effective strategy for involving students in STEAM learning, thereby affording them opportunities to cultivate and apply their creative abilities, as suggested by the research conducted by Siew and Ambo (2020).In the project planning phase, selecting activities by integrating various materials tailored to accessible tools and resources helps enhance student creativity compared to conventional learning. Elaboration, related to the ability to develop ideas and specify details of an object or concept, represents one characteristic of creativity. PJBL enhances

students' knowledge and skills (Ralph, 2015). PJBL emphasizes long-term and interdisciplinary learning (Hawari & Noor, 2020). Therefore, using STEAM-based Student Worksheets with ecoprint technique will engage students actively in learning by fostering innovation through group discussions that combine various elements of STEAM. This approach is effective in enhancing students' learning motivation and creativity.

Conclusion

Based on the research findings, it can be deduced that the utilization of STEAM-based Student Worksheets in conjunction with the ecoprint technique effectively enhances both students' learning motivation and creativity. Those students who were exposed to the STEAM-based Student Worksheets with the ecoprint technique demonstrated superior levels of learning motivation and creativity compared to their peers who relied on conventional Student Worksheets. Consequently, STEAM-based worksheets incorporating the ecoprint technique serve as a highly promising avenue for the creation of innovative learning resources that align seamlessly with the contemporary demands of the 21st century. Educators are encouraged to harness the potential of STEAM-based Student Worksheets integrated with the ecoprint technique as a pioneering tool in the realm of biology education, leveraging its capacity to nurture students' creativity and motivation. Acknowledging the diverse array of topics, learning motivations, and preferences among students, biology instructors should explore and implement various student-centric instructional models. It is important to note that this research possesses a limitation in that the development of Project-Based Learning (PjBL) and STEAM-based

worksheets with the ecoprint technique was restricted to the specific subject matter of Spermatophyta.

Recommendations

Researchers suggest that research using Project-Based Learning on STEAM Based Student's Worksheet Analysis with Ecoprint Technique can be carried out by involving a larger number of samples. In addition to the above, this study could be expanded to encompass other techniques or subjects, aligning with the subject-specific objectives. The researcher recommends that the impact of Project-Based Learning (PjBL) on STEAM-Based Student's Worksheet Analysis with the Ecoprint Technique be further explored through a qualitative approach, specifically employing post-teaching and learning sessions interviews with students who have experienced this method. For future research endeavors, it is imperative to emphasize the pursuit of meaningful investigations in alignment with the objectives of self-learning curricula. Moreover, there is a pressing need for additional studies focused on PjBL-STEAM-based worksheets, given their limited integration within teaching and learning contexts.

Limitations

This research is limited to increasing students' creative abilities and learning motivation. other than that it is limited to ecoprint material.

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