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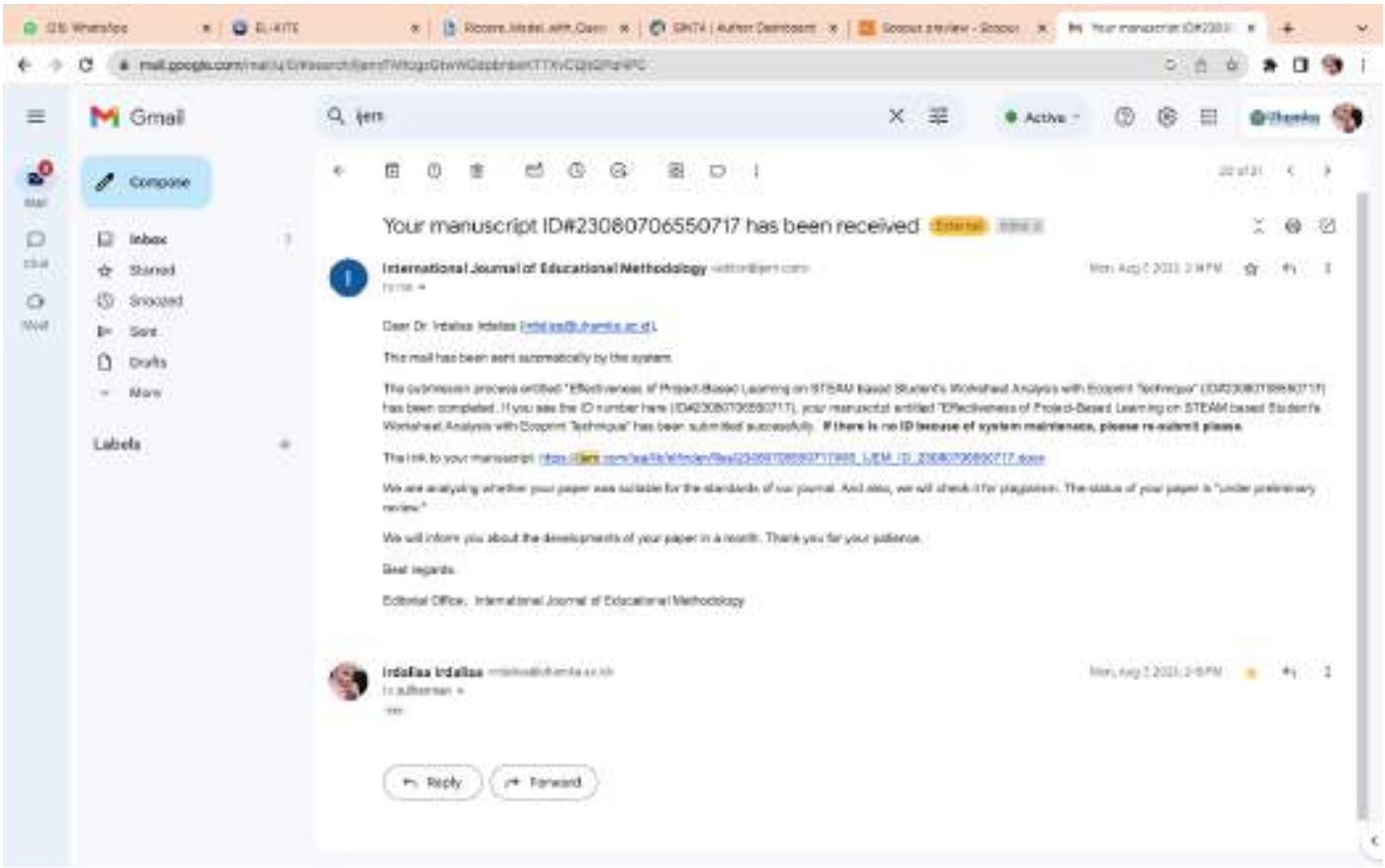
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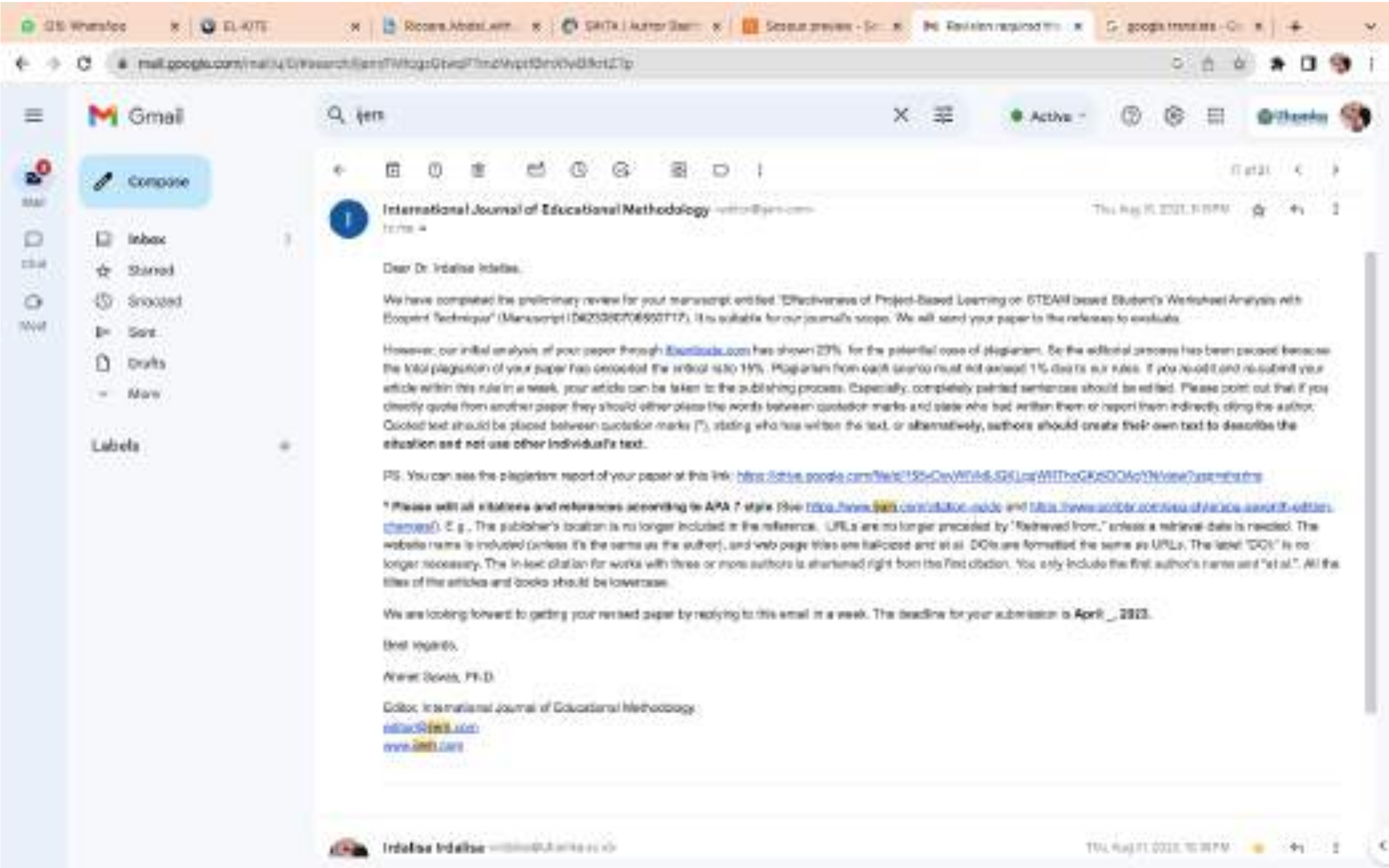

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Best regards,

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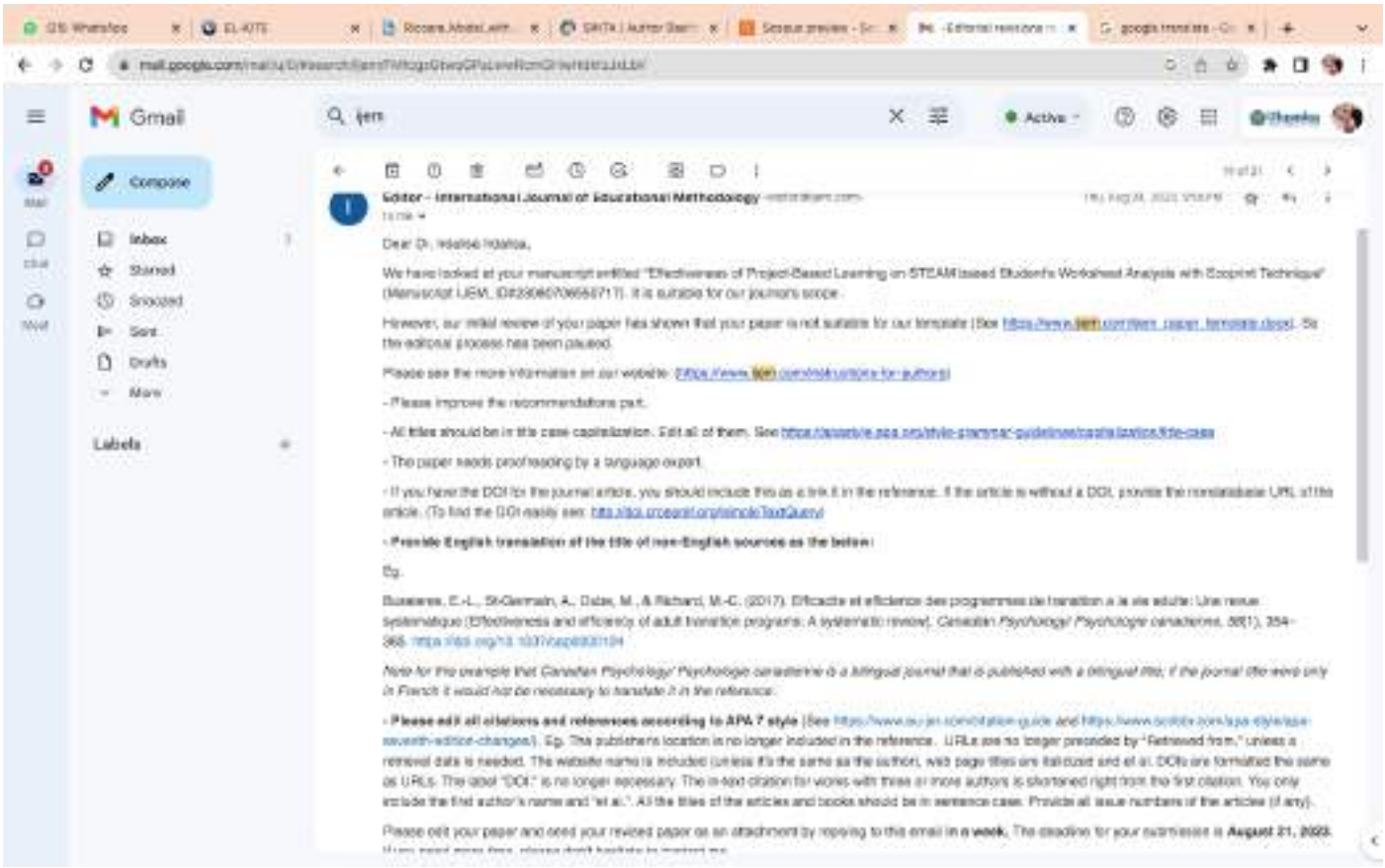
Irdalisa Irdalisa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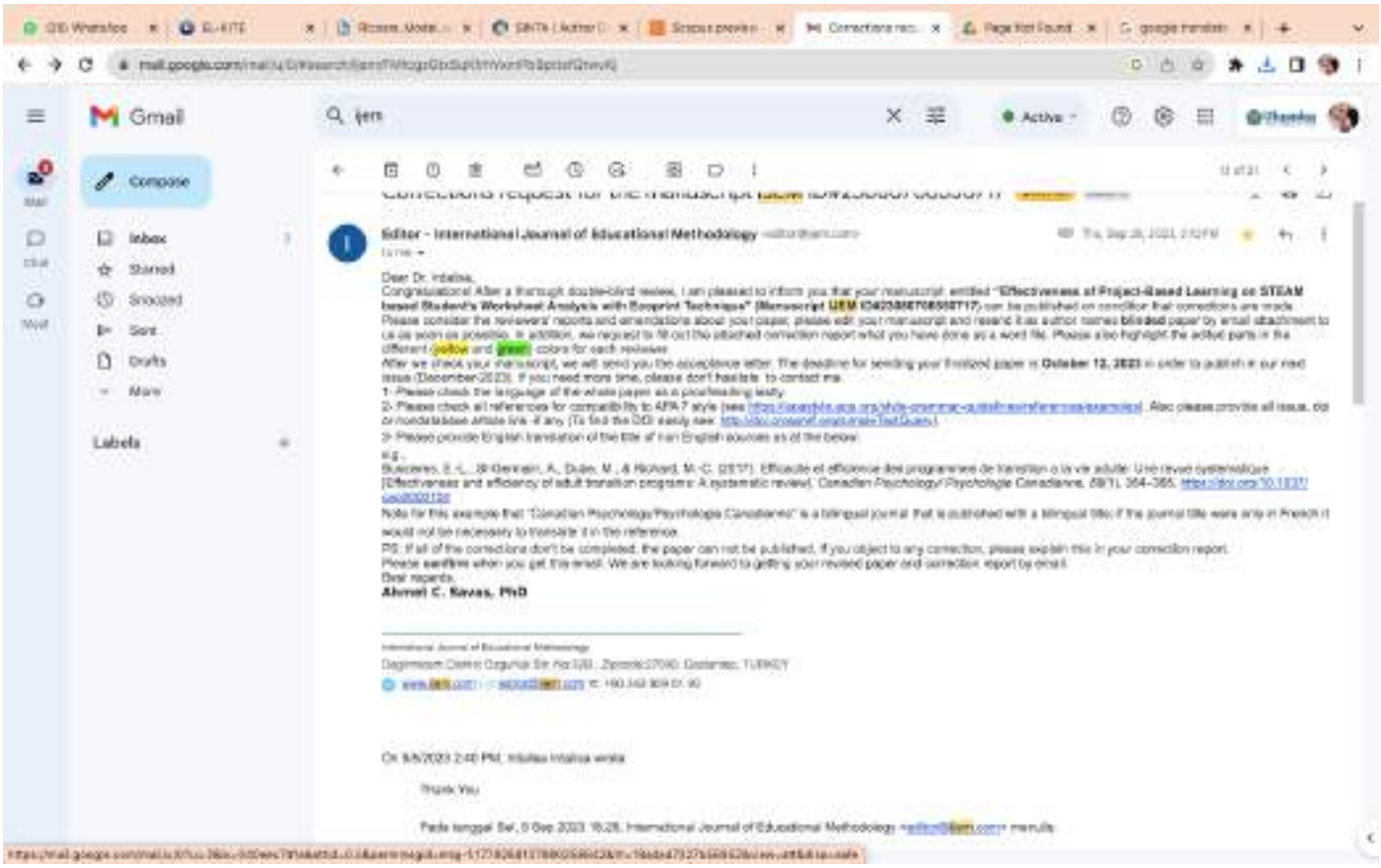
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Congratulations! After a thorough double-blind review, I am pleased to inform you that your manuscript entitled "Effectiveness of Project-Based Learning on STEAM Israel Student's Worksheet Analysis with Blueprint Technique" (Manuscript UEM ID4205887089887117) can be published on condition that corrections are made.
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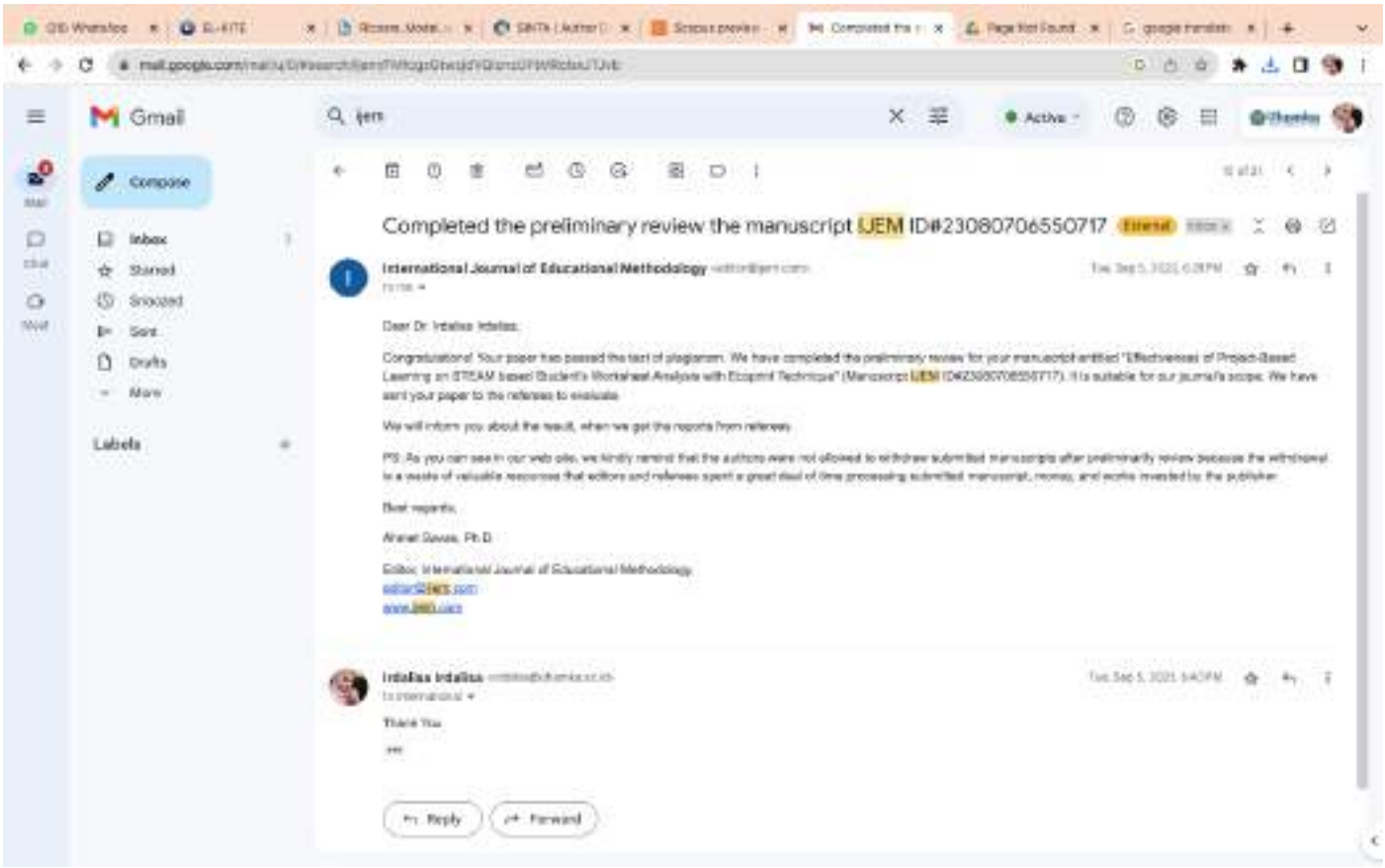
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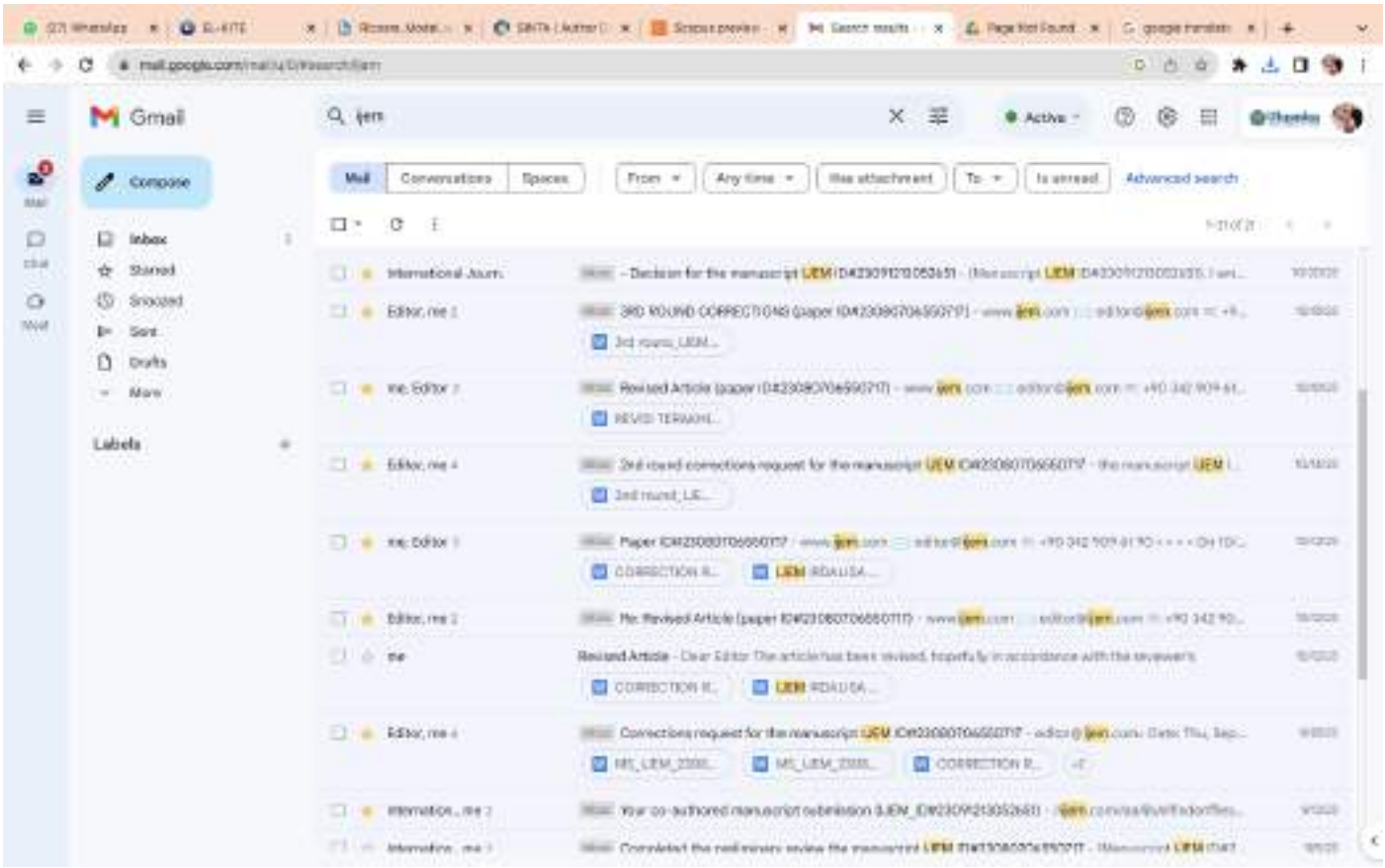
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HASIL REVIEW 1

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

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

Commented [MOU1]: - Provide more background on the specific gaps in motivation and creativity that the study aims to address.

- Elaborate on why the ecoprint technique was chosen and its relevance to STEAM education.

- Clarify earlier on that the study focuses specifically on the topic of Spermatophyta.

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

Commented [MOU2]: Synthesize the literature more concisely instead of summarizing each study individually. Focus on key themes and findings.
Provide more critical analysis of the literature - point out limitations, inconsistencies, or gaps in prior studies.

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.	- Pray together - Give answers to the teacher's questions

	- Convey the theme and learning objectives - Provide instructions on how to use ecoprint	- Listening and paying attention
Develop project planning	- Provide teaching materials - Provide assignments and instructions for group discussion activities.	Pay attention and carry out tasks
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.

Commented [MOU3]: Explain how the Aiken V values support validity and the thresholds for reliability.

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

Commented [MOU4]: - report descriptive statistics (means, standard deviations) for pretest and posttest scores.
-Provide more interpretation of the findings instead of just describing the results.

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.

Commented [MOU5]: Report effect sizes along with statistical significance values.

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

Commented [MOU6]: Tie the findings back to the original gaps identified in the introduction.
Discuss broader theoretical and practical implications. How do findings contribute new insights on motivating and engaging students in STEAM? How can teachers and schools implement these methods?

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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Conflict of Interest

The authors declare no conflict of interest.

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REVISI 1

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

Type of the research: research article

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Abstract: The aim of the research was to know effectiveness of project-based learning on Science, Technology, Engineering, Arts, and Mathematics (STEAM) based student's worksheet analysis with ecoprint technique on learning motivation student creativity. This study belongs to a quasi experiment. The sample of this research is 150 students.

The sampling technique in this study used a cluster sampling technique. Data collection using instrument test. Proving the validity of the instrument is measured based on the Aiken index, the reliability of the instrument is determined based on the Cronbach's alpha coefficient. The data were analyzed by using manova and deskriptif kuantitatif. The results of this study indicate that there is a significant difference in the average value of learning motivation and student creativity results. The conclusion of this study states that the application of project-based learning on STEAM based student's worksheet analysis with ecoprint technique has a significant impact on increasing learning motivation and student creativity. The findings showed that using STEAM-based students' worksheets along with the ecoprint method is successful in developing students' learning motivation and creativity. Ecoprint can help students develop a range of abilities because it incorporates all the STEAM components into 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. One of the development of learning models that can be applied to the learning process is a Project-based Learning model.

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). Shifting to student-centered learning encourages students to become independent, actively explore, collaborate, and participate in research projects. Practicum activities concreting project learning can also help students develop critical thinking skills (Telekova & Lukacikova, 2023). Several studies have been conducted related to the implementation of PjBL. The results showed that PjBL has a positive effect on student engagement, motivation, and students' confidence in their own abilities (Condliffe, et al., 2017). Research findings by Muskania and Wilujeng (2017) show that PjBL-based learning tools have a significant influence on students' scientific literacy.

Project-based learning facilitates students' engagement in collaborative projects integrating multiple subjects, providing opportunities for meaningful content exploration and collaborative experimentation (Belwal et al., 2020). The principles of project-based learning emphasize students' problem-solving skills in real-life situations (Zen et al., 2022). The product creation process within Project-Based Learning (PjBL) models enables students to integrate and reconstruct their knowledge, strengthen their professional skills, enhance their interest, and improve their ability for collaborative work (Guo et al., 2020). Project-Based Learning (PjBL) emphasizes the significance of contextual learning achieved through complex activities, granting students the autonomy to explore and strategize learning activities, execute collaborative projects, and ultimately generate tangible outcomes (Adriyawati et al., 2020). For teachers, project-based learning can train them in carefully planning and preparing project activities (Mansfield, 2023).

Project-Based Learning demonstrates suitability for integration with Science, Technology, Engineering, Arts, and Mathematics (STEAM). STEAM has shown to be the most successful way in the world for including art components in schooling (Jantassova et al., 2023). Project-based learning integrated with STEAM elements has synergy with the skills required in the 21st century (Lu et al., 2022). 21st-century skills include creativity and critical thinking skills, curiosity, problem-solving, reasoning, collaboration, and self-confidence, all of which can be accommodated through STEAM (Allina, 2018). STEAM-based learning allows students to explore novel and imaginative approaches to problem-solving, data presentation, innovation, and interconnecting diverse fields (Dyer, 2019). Art correlates with students' creativity and ability to imagine and innovate using technology, produce products, and develop an artistic sense in understanding science (Liu et al, 2021).

In the learning process, the Student Worksheet is imperative as a pedagogical instrument that facilitates the efficacy of teaching and learning. The use of Student Worksheet can assist students construct their knowledge independently (Sa'adah & Ellinawati, 2022). According to Suwarno (2020) In science project laboratories, utilizing Student Worksheets can facilitate knowledge acquisition, enhance students' fundamental competencies, and promote active engagement of both teachers and students in project-based activities. Science learning is more contextual, emphasizing knowledge and experiences in the real world (Martawijaya et al., 2023). Therefore, Student Worksheet in science learning needs to be developed by teachers based on models, approaches, and methods to provide more focused and structured learning activities and guide students in discovering new concepts. Developing Student Worksheets enhances student engagement and shifts the learning environment from teacher-centered to student-centered (Melindawati, 2020). Therefore, to meet the challenges of the 21st century, it is necessary to redesign a suitable Student Worksheet that is contextually

packaged with biology concepts related to science, technology, engineering, arts, and mathematics (STEAM).

Student Worksheets are valuable tools to assist and facilitate learning activities, fostering meaningful interaction between students and teachers and enhancing student motivation (Asnidar et al., 2016). Motivation is an important psychological factor in learning (Tasiwan et al., 2014). Learning motivation is crucial to learning success as it influences students' learning development and outcomes. Furthermore, the selection of teaching models by teachers should also consider the characteristics of the learning materials (Afriana et al., 2016). Students find the topic of spermatophyte difficult to understand as it involves the classification (taxonomy) and scientific nomenclature (binomial nomenclature) in the Plantae Kingdom (plants). Students often struggle to memorize the Latin language and the hierarchical classification from Kingdom to Species. Additionally, there are numerous types and species of plants, leading to frequent errors in writing plant classifications and 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). Monotonous and uninteresting Student Worksheets lead to a lack of student learning 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). Using the ecoprint technique can serve as an example of multidisciplinary learning that combines art education with learning about leaf structure and identification. This study aims to investigate the effectiveness of STEAM-based Student Worksheets using the ecoprint technique on 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). The PjBL model empowers students to develop critical thinking skills, problem-solving abilities, and a deeper understanding of concepts by connecting their learning to real-life situations.

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.

Several research studies have explored the implementation of Project-based Learning (PjBL) and have yielded significant findings. Mursid et al. (2022) found that the blended project-based learning model positively influenced the creative thinking skills and learning outcomes of engineering students. Payoungkiattikun et al. (2022) discovered that the PjBL approach enhanced the metacognitive skills of prospective science teachers. Syawaludin et al. (2022) revealed that both the PjBL model and online learning settings had an impact on students' analytical abilities in discovery learning, interactive demonstrations, and inquiry lessons. Erviana et al. (2022) indicated that PjBL influenced the Technological Pedagogical Content Knowledge (TPACK) of elementary school teachers. Rahardjanto et al. (2019) demonstrated that the hybrid-PjBL approach significantly affected learning achievement and creative thinking skills. Suradika et al. (2023) found that both project-based learning and problem-based learning models enhanced students' critical thinking and creativity. Similarly, Suwarno et al. (2020) reported that the use of PjBL, supported by worksheets, had a positive impact on students' competencies, particularly in terms of creativity and applied science learning outcomes.

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

STEAM (Science, Technology, Engineering, Arts, and Mathematics) is an interdisciplinary learning approach aimed at providing students with opportunities to develop the knowledge and skills required in the 21st century. It is a contextual learning approach that integrates

multiple disciplines, encouraging students to cultivate various skills such as problem-solving, critical thinking, and collaboration (Sigit et al., 2022).

Economic reasons primarily drove the emergence of STEM in America, and subsequently, STEM education became a priority in both America and Europe (Konkus & Topsakal, 2022). The integration of STEM in education is necessitated by the need for knowledge and skills to become successful innovators in the 21st-century workforce. The National Science Foundation originally designed STEM and encompasses the combination of Science (the study of the natural world), Technology (the study of products created to meet human needs), Engineering (the process of designing to solve problems), and Mathematics (the language of shapes, numbers, and quantities) (DeCoito, 2014). STEM later evolved into STEAM with the addition of "Arts." The inclusion of Arts allows learners to demonstrate their creativity, effectiveness, financial acumen, and artistic abilities in solving real-world problems (Razi & Zhou, 2022) and enhances employability skills such as teamwork, communication, and adaptability (Colucci et al., 2017).

STEAM emerged in the early 2000s as an idea conceptualized by Georgette Yakman and gained popularity throughout the mid-2000s (Pearson, 2022). It was introduced in the United States in 2007 (Daugherty, 2013). The STEAM approach is more than just an instructional strategy; it is a transformative innovation in education that fosters student creativity and collaboration (Belbase et al., 2022; Liao, 2019). In the STEAM approach, students are actively engaged in the learning process and develop 21st-century skills. Taylor (2016) emphasizes the following key aspects of STEAM: 1) STEAM enhances and expands upon the scope of STEM; 2) STEAM enables science teachers to engage in school-based curriculum development; 3) STEAM involves teachers in the process of developing a student-centered vision of 21st-century education; 4) STEAM provides creative design space

for educators to collaborate in creating integrated STEAM curricula; 5) STEAM activities can be designed and implemented by individual teachers on a moderate scale; 6) Educators can design STEAM activities within project-based learning. The models applied in STEAM can include collaborative or cooperative learning, where students play the role of experts and work together in groups to accomplish tasks (Thompson et al., 2020; Edelen et al., 2023). The integration of STEAM in education is a response to the need for enhancing students' interest and skills in Science, Technology, Engineering, Arts, and Mathematics. Along with the implementation of STEAM, appropriate learning models are required to bridge the gap in academic knowledge. The PjBL model is particularly suitable to be combined with interdisciplinary frameworks like STEAM. Several research studies have explored this connection, including the findings of Winarni et al. (2022), which showed that the integration of PjBL-STEM significantly influenced the science literacy and environmental concern of elementary school students. Martawijaya et al. (2023) found that the ethno-STEM-PjBL model had an impact on concept understanding, characterized by increased higher-order thinking skills and decreased misconceptions. Konkus & Topsakal (2022) demonstrated that STEAM-based activities led to improvements in students' STEAM attitudes, cooperative work skills, and career choices. Siew & Ambo (2020) stated that students' creativity increased when using the STEM-PjBL learning approach. Similarly, Sigit et al. (2022) showed that integrating PjBL with STEAM enhanced students' mastery of ecological concepts. Various studies have been conducted on PjBL-STEAM integration. However, there is currently no report on PjBL-STEAM-based worksheets using the ecoprint technique. Therefore, the researchers aim to modify PjBL-STEAM-based worksheets with 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 emphasizes discovering ideas by connecting various technology, art, and engineering applications that align with the subject matter. This allows students to learn how to create simple tools related to the lesson content. As the ecoprint technique can be applied to assist students in understanding and appreciating environmentally friendly art by utilizing the surrounding environment, it can be utilized in Indonesia and worldwide. Ecoprint employs simple and user-friendly tools that can aid students in studying subjects related to the plant world. The research conducted by Irdalisa et al. (2023) demonstrates that integrating the ecoprint technique into STEAM-based worksheets is highly suitable for implementing innovative learning media that align with the demands of the 21st century, which prioritize the 4C skills (Critical thinking, Collaboration, Communication, and Creativity). These studies collectively emphasize the beneficial effects of PjBL in various educational contexts and its potential for enhancing students' learning outcomes and skills. Thus the research question is how effective is the effectiveness of Project-Based Learning

on STEAM Based Student's Worksheet Analysis with Ecoprint Technique on Learning Motivation Student Creativity.

Methodology

Research Design

The aim of the research was to know the effectiveness of Project-Based Learning on STEAM Based Student's WorkSheet Analysis with Ecoprint Technique on Learning Motivation Student Creativity. This study used a quasi-experimental non-equivalent control group design to compare the increase in Learning Motivation Student Creativity between the experimental class and the control class. The experimental class was given treatment using Project-Based Learning on STEAM Based Student's Worksheet while the control class was given treatment using conventional learning models, the syntax is 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 - Provide assignments and instructions for group discussion activities.	Pay attention and carry out tasks
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 sample of this research is 150 students. There were 75 students in each experimental and control group. The sampling technique in this study used cluster sampling, because the sample members are from a larger population, so the sampling is based on predetermined groups (Sugiyono, 2015).

The assessment indicators for learning motivation included attention, relevance, confidence, and satisfaction (Afjar et al., 2020). The assessment indicators for student creativity included idea planning and development, exploration in product design, interdisciplinary knowledge, appropriate material selection, and tool usage. Experts validated both the questionnaires and observation sheets. The data on learning motivation and student creativity were used to test the hypothesis that the use of STEAM-based Student Worksheets with the ecoprint technique is effective in improving learning motivation and student creativity. This research instrument is valid because it has been validated by three educational experts. Validity analysis is used to determine whether the instrument items are valid or not. Proving the validity of the instrument is done by measuring the expert agreement index based on the Aiken index (V). The measurement results are presented in Table 2 below:

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

Instrumen	V	Information
learning motivation	0.82	Valid
student creativity	0.85	Valid

Instrument reliability was determined based on Cronbach's alpha coefficient. The reliability of the learning motivation test instrument was 0.87, while the reliability of the student creativity instrument was 0.88, thus the reliability value of the instrument was in a high category (Taber, 2013).

Analyzing of Data

The results of this study were analyzed using descriptive quantitative with the Statistical Package for Social Sciences (SPSS) for Windows version 22. To find out the normality of the data with the One-Sample Kolmogorov-Smirnov test and to check homogeneity, the Levene test was carried out. Furthermore, the Manova test was carried out to determine significant differences in the mean scores of the experimental class and the applied control class.

Result

This study aims to examine the effectiveness of STEAM-based Student Worksheets with the ecoprint technique in enhancing students' learning motivation and creativity. The normality test results using the Kolmogorov-Smirnov test at a significance level of 5% indicated that the data were normally distributed. Similarly, the results of the homogeneity test using the Barlett test showed that the samples used were from populations with equal variances. Based on the results of the Manova test with Wilk's Lambda analysis, an F value of 1008.423 was obtained with a significance value of $0.000 < 0.05$.

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

Regarding students' learning motivation, those who utilized the STEAM-based Student Worksheet with the ecoprint technique achieved a mean score of 78.46. In contrast, those who utilized the conventional Student Worksheet obtained a mean score of 63.94. 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 86.67, while for those who used the conventional Student Worksheet was 63.94. Moreover, the mean score for creativity was higher when using the STEAM-based Student Worksheet with ecoprint technique than the conventional Student Worksheet. Based on these findings, it can be concluded that students' learning motivation and creativity are enhanced when using STEAM-based Student Worksheets with ecoprint technique compared to the conventional Student Worksheet.

Furthermore, Subsequent analysis based on differences in each factor to the dependent variable (see table 4). The results showed that there was a significant difference in value (p value < .05) so it could be concluded that there was a significant difference in the values of learning motivation (p = .000) and student creativity (p = .000) between the experimental class and the control class. Based on the explanation above, it can be seen

that the application of Project-Based Learning on STEAM Based Student's WorkSheet Analysis with Ecoprint Technique in the experimental class is more effective in increasing Learning Motivation and Student Creativity than the conventional model in the control class presented in Table 4.

Tabel 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).

PjBL integrated with STEM can improve students' learning motivation, create meaningful learning experiences, and assist students in problem-solving (Tseng et al., 2013). Furthermore, group collaboration during project development can foster cooperative attitudes, courage, and the acceptance of others' opinions. Increased student motivation can make the learning process more engaging. Student Worksheet acts as a stimulus in learning, thus the criteria for graphic media as visual aids need to be considered to capture students' interest (Saputro et al., 2019). PjBL provides an appropriate environment for applying skills to enhance the quality of students' learning process towards achieving higher cognitive levels (Yamin et al., 2017).

Creativity is the ability to produce something different and novel that has utility. Creativity is one of the indicators of higher-level thinking (Dinantika et al., 2019). During the learning process, students learn through projects assigned by teachers according to the given Student Worksheet. Student Worksheet promotes students' independence in learning and is designed according to learning competencies (Sari et al., 2019). Student Worksheet is useful for developing students' independence, literacy, creativity, and understanding (Febriani et al., 2017).

The STEAM-based Student Worksheet with ecoprint technique provides students with experiences and opportunities to design their projects based on their subject matter and creativity. Ecoprint is a technique of decorating fabric by utilizing natural colors extracted directly from plants to create beautiful patterns or motifs (Saraswati et al., 2019). In the learning process, the teacher guides students to work on a project by providing instructions related to the achievement of the 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). When various critical and creative thinking techniques are applied to relevant curriculum content, students are encouraged to engage in critical and meaningful deliberation about the subjects they study. 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).

At the implementation stage, the STEAM-based student's workSheet with the ecoprint technique facilitates the integration of content from various subjects referring to 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 existence and specifications of technology and its supporting applications can create new learning interactions that prioritize activities and provide direct learning experiences to stimulate student engagement in problem-solving (Irdalisa et al., 2020). In the sequence of PJBL-STEAM learning activities, students are directly involved by integrating knowledge and skills, which serves as a means for students to gain learning experiences and sharpen their creativity. When completing a project, students are guided to be creative in planning and designing a product based on the concepts they have learned. Creativity is an experiential process to express oneself and generate valuable ideas, thoughts, and actions (Dinantika et al., 2019).

Previous studies have shown that the STEAM learning approach influences students' knowledge competencies and impacts their creativity (Arsy & Syamsulrizal, 2021). Several research findings indicate that STEAM can develop high-level thinking skills, collaboration, argumentation, and student creativity (Afriana et al., 2016). Utilizing PjBL can be an effective way to involve students in STEAM learning which can provide opportunities to practice creativity (Siew & 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 findings derived from the research, it can be concluded that using the STEAM-based Student Worksheet with the ecoprint technique effectively enhances students' learning motivation and creativity. Students who used the STEAM-based Student Worksheet with ecoprint technique exhibited better learning motivation and creativity than those who used the conventional Student Worksheet. STEAM-based worksheets with the ecoprint technique are highly suitable for implementing innovative learning media that align with the demands of the 21st century. Therefore, educators can utilize the STEAM-based Student Worksheet with ecoprint technique as an innovative tool in biology education to cultivate students' creativity and motivation. Considering the different topics, learning motivations, and learning preferences, biology teachers should implement various student-centered instructional models. One limitation of this research is that the learning content included in developing PjBL-STEAM-based worksheets with the ecoprint technique is limited to Spermatophyta material.

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. besides that the study can be extended to other techniques or other lessons in accordance with the objectives of the subject. The researcher suggests that the effect of Project-Based Learning on STEAM Based Student's Worksheet Analysis with Ecoprint Technique is also determined through a qualitative approach, namely by using the interview method with students after they have undergone a teaching and learning session using this method. For future research, it is important to focus on meaningful research based on the target of a self-learning curriculum and the need for further studies on PjBL-STEAM-based worksheets due to their limited implementation in 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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Conflict of Interest

The authors declare no conflict of interest.

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REVIEW 2

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

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.

Creativity has become a focal point in the 21st century because it is highly needed to adapt to the advancements in science and technology. Learners who possess creativity can think critically and see problems from various angles, enabling them to have an open mindset when solving issues. Therefore, effective learning in schools occurs when there is a reciprocal communication between teachers and students. However, students often lack motivation, and their creativity remains undeveloped. They struggle to create something new and tend to imitate what they see. Many students also lack the initiative to solve problems. The creative potential an individual possesses represents a form of thinking that involves finding connections among existing elements or discovering new approaches to personal challenges. This is driven by a strong desire and motivation to create. The development of students' creativity tends to be slow due to their continued dependence on teachers.

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 Project Based Learning (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 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 et al. (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

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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 & Ellianawati, 2022; 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 technique is employed in the study of Spermatophyta material. Ecoprint serves as an illustration of interdisciplinary education that combines art instruction with knowledge of leaf structure and identification. Therefore, this technique is well-suited for studying Spermatophyta material, which encompasses topics such as Classification (Taxonomy) and Scientific Nomenclature (Binomial Nomenclature) within the Kingdom Plantae (Plants). Ecoprint, as a learning medium, can enhance various skills possessed by students. During its creation process, ecoprint integrates all the elements of STEAM (Science, Technology, Engineering, Arts, and Mathematics). The ecoprint technique is relevant for integration with STEAM education because STEAM offers learners the opportunity to develop knowledge and skills through a series of activities that combine science, technology, engineering, art, and mathematics. 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 model was developed by John Dewey, based on the concept of 'learning by doing,' which emphasizes direct experiential learning and student-centeredness (Maida, 2011). The analysis of previous research provides insights into the application of PjBL (Project-Based Learning) in education. Mursid et al. (2022) conducted research on the blended project-based learning model's impact on creative thinking abilities. The findings suggest that creative thinking abilities need enhancement to ensure the effective implementation of the PjBL

model. Furthermore, this research focused on teaching engineering drawing, indicating the need for further studies on PjBL in different subject areas. Syawaludin et al. (2022), in their study of the PjBL model in an online learning setting, explored its influence on students' analytical skills. The results indicate that in online learning design, the choice of project-based learning models can be effective when combined with the appropriate online learning settings, involving a combination of synchronous and asynchronous elements. Rahardjanto et al. (2019) conducted research on hybrid-PjBL and its impact on learning outcomes and creative thinking skills. Their findings showed a significant influence on learning outcomes and creative thinking skills. However, there was no significant difference in learning motivation between the control group and the experimental group. Therefore, further research is needed to comprehensively understand the overall positive impact of this model. Suwarno et al. (2020) investigated the PjBL model based on Student Worksheets (LKPD) and its influence on student competencies, especially creativity and applied science learning outcomes. The results demonstrated the impact of the PjBL model based on LKPD on students' creativity and learning outcomes. However, effective planning, alignment of content, and time management are crucial. These results should be further developed in future research to gain insights into individual activities and their long-term effects.

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 integration of STEAM into education has emerged as a response to the increasing need to enhance students' interest and competence across these diverse fields. Alongside the implementation of STEAM, there arises a pressing need for an effective teaching model that can effectively bridge the gaps in academic knowledge. One particularly promising teaching model is Project-Based Learning (PjBL). It offers a dynamic and immersive approach to education, where students engage in real-world projects that require them to apply knowledge and skills from various disciplines. This makes PjBL an ideal candidate for integration with interdisciplinary frameworks like STEAM. Several research studies have shed light on the potential of this integration. For instance. Konkus and Topsakal (2022) conducted a study focused on the effects of STEAM-based activities on gifted students. Their research yielded encouraging results, indicating a noticeable improvement in students' attitudes towards STEAM, their cooperative working skills, and even their career choices. However, it's worth noting that this study was conducted with a single sample group, prompting the need for further research that includes a control group. Another study by Martawijaya et al. (2023) explored the ethno-STEM-PjBL model and its impact on students' conceptual understanding. Their findings highlighted significant progress, marked by an enhancement in high-level thinking and a reduction in misconceptions among students. Siew and Ambo (2020) reported that students' creativity saw a marked increase when a STEM-PjBL learning approach was employed. This aligns with the idea that the hands-on, inquiry-based nature of PjBL can nurture creativity. Furthermore, Sigit et al. (2022) provided

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insights into how the integration of PjBL with STEAM can significantly improve students' mastery of complex concepts, such as those found in ecology. While these studies have enriched our understanding of PjBL and its potential within a STEAM framework, there remains an unexplored area PjBL-STEAM-based worksheets with the ecoprint technique. Hence, the researcher's intent is to adapt and assess the impact of worksheets based on PjBL-STEAM, incorporating the ecoprint technique to evaluate its influence on student motivation and creativity. In light of the limited research available on worksheets based on PjBL-STEAM and its effects on student motivation and creativity, this study seeks to address this gap, contributing to the growing body of knowledge in STEAM education.

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Ecoprint Technique

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). 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. This study, up to this point, has primarily focused on assessing the validity, feasibility, and practicality of the STEAM-based worksheets developed using the ecoprint technique. However, it's important to acknowledge the scope of this research. Further investigation is warranted to comprehensively gauge the effectiveness of these STEAM-based worksheets with the ecoprint technique on student creativity and motivation. 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.

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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 Based 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	- Pray together - Give answers to the teacher's questions

	- Provide instructions on how to use ecoprint	- Listening and paying attention
Develop project planning	- Provide teaching materials - Provide assignments and instructions for group discussion activities.	Pay attention and carry out tasks
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 empirical investigation of item validity can be conducted based on the measurement's objectives. In this research, the empirical investigation of items is carried out in the context of a formative test, making its validation follow the criteria-referenced test principles. Therefore, the test items can identify learning success, which is expressed in the formula for the item sensitivity index. When empirically investigating the item reliability of criterion-referenced tests, it should be expressed using the kappa index formula, as outlined by Subali (2019). The results of this measurement are presented in Table 2.

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

Instrument	V	Information
learning motivation	.82	Valid
student creativity	.85	Valid

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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 .82, and for the student creativity instrument, it was .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

The effectiveness of the implementation of the STEAM-based Student Worksheets is determined based on the impact of applying on enhancing students' learning motivation and creativity. The difference in the average score between the experimental and the control classes presented in Table 3 shows the average student's learning motivation and creativity. Both are higher than the average value in the control class.

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Table 3 The comparison of the Average Value of students' learning motivation and creativity *in Control and Experimental Class*

Group	Aspect	Mean	Std. Deviation	N
Experimental Class	students' motivation	85.73	4.794	75
	creativity	83.93	2.448	75
Control Class	students' motivation	66.30	3.843	75
	creativity	68.93	2.196	75

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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.

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Table 4. 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 4). 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. It may occur because the structure of the learning activities involving STEAM-based worksheets and the ecoprint technique places a strong emphasis on active participation. It encourages students to connect various aspects of knowledge, scientific skills, technology, engineering, art, and mathematics within the context of project-based work. Consequently, students become actively involved in

exploration and collaboration throughout the project, which significantly influences their motivation and creativity.

Subsequent analyses were conducted to assess the distinctions in each factor concerning the dependent variables (Table 5). 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 5.

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Table 5. Test Result of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	*df*	*F*	Sig.
Corrected Model	learning motivation	1223.130	1	248.808	.000
	student creativity	1472.667	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

Effect sizes along with statistical significance values That the significance value of students' learning motivation and creativity is 0.000 < α (0.05) which means that H0 is rejected and Ha which states that there is a difference in students' learning motivation and creativity scores simultaneously between the classes studied. with the STEAM-based Student Worksheet with the ecoprint technique compared to the conventional Student Worksheet is accepted. The effectiveness of applying Project-Based Learning alongside

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STEAM-based Student's Worksheets, utilizing the Ecoprint Technique in the experimental class, is attributed to the various stages of learning in which students engage. They are involved in project planning, self-directed learning, active exploration, and collaborative work. These learning activities provide students with opportunities to seek, manage, and communicate information acquired during the project's execution. Creative students, in particular, can produce intriguing and innovative products as a result.

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 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.

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 et al. (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.

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).

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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).

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-Gray 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: (a) STEAM strengthens and broadens the scope of STEM; (b) STEAM enables science teachers to participate in the development of school-based curricula; (c) STEAM incorporates teachers in the process of building a student-centered vision of 21st-century education; and (d) STEAM offers a way to integrate the arts and humanities into STEM instruction.; (e) STEAM initiatives can be crafted and executed

by individual educators on a manageable scale.; (f) 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 (Edelen et al., 2023; Thompson et al., 2020).

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., 2020).

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.

Thus, the results of this research represent an innovation in designing Student's Worksheets that are tailored to the needs of students, thereby enhancing their engagement and learning activities through project-based assignments. This, in turn, contributes to their mastery of competencies. These worksheets are designed in accordance with a model and approach that aligns with the 21st-century learning paradigm. The development of STEAM-based LKPDs with the ecoprint technique can serve as a benchmark for educators when redesigning their own worksheets, fostering creativity and innovation. Moreover, utilising worksheets must

consider the characteristics of the subject matter to meet the diverse learning needs of students. Given the infrequent use of STEAM-based worksheets like this, they can be valuable in teaching and learning.

The implementation of STEAM-based Student's Worksheets with the ecoprint technique in biology education represents an innovative approach to enhancing student creativity and motivation. The theoretical findings from this research can serve as a reference and source of knowledge for educators and educational practitioners, especially in the development of innovative worksheets. Teachers can employ these worksheets as alternative learning media in their teaching process. For students, using these worksheets helps nurture creativity and motivation in the learning process. STEAM-based Student's Worksheets with the ecoprint technique sharpen and develop students' skills in generating creative ideas and concepts, particularly during ecoprint-related projects. Students are guided and supported throughout the project, emphasising the five key elements of STEAM. Teachers can utilize these worksheets as supportive tools in the teaching and learning process, fostering optimal interaction between educators and students.

Previous 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 using 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 promising avenue for creating 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 involve 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. The results of this research can be used by teachers to help design innovative student worksheets as a means to facilitate the learning process and enhance student engagement, particularly in biology education, thereby improving students' competence.

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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Conflict of Interest

The authors declare no conflict of interest.

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REVIEW 2

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

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.

Creativity has become a focal point in the 21st century because it is highly needed to adapt to the advancements in science and technology. Learners who possess creativity can think critically and see problems from various angles, enabling them to have an open mindset when solving issues. Therefore, effective learning in schools occurs when there is a reciprocal communication between teachers and students. However, students often lack motivation, and their creativity remains undeveloped. They struggle to create something new and tend to imitate what they see. Many students also lack the initiative to solve problems. The creative potential an individual possesses represents a form of thinking that involves finding connections among existing elements or discovering new approaches to personal challenges. This is driven by a strong desire and motivation to create. The development of students' creativity tends to be slow due to their continued dependence on teachers.

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 Project Based Learning (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 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 et al. (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

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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 & Ellianawati, 2022; 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 technique is employed in the study of Spermatophyta material. Ecoprint serves as an illustration of interdisciplinary education that combines art instruction with knowledge of leaf structure and identification. Therefore, this technique is well-suited for studying Spermatophyta material, which encompasses topics such as Classification (Taxonomy) and Scientific Nomenclature (Binomial Nomenclature) within the Kingdom Plantae (Plants). Ecoprint, as a learning medium, can enhance various skills possessed by students. During its creation process, ecoprint integrates all the elements of STEAM (Science, Technology, Engineering, Arts, and Mathematics). The ecoprint technique is relevant for integration with STEAM education because STEAM offers learners the opportunity to develop knowledge and skills through a series of activities that combine science, technology, engineering, art, and mathematics. 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 model was developed by John Dewey, based on the concept of 'learning by doing,' which emphasizes direct experiential learning and student-centeredness (Maida, 2011). The analysis of previous research provides insights into the application of PjBL (Project-Based Learning) in education. Mursid et al. (2022) conducted research on the blended project-based learning model's impact on creative thinking abilities. The findings suggest that creative thinking abilities need enhancement to ensure the effective implementation of the PjBL

model. Furthermore, this research focused on teaching engineering drawing, indicating the need for further studies on PjBL in different subject areas. Syawaludin et al. (2022), in their study of the PjBL model in an online learning setting, explored its influence on students' analytical skills. The results indicate that in online learning design, the choice of project-based learning models can be effective when combined with the appropriate online learning settings, involving a combination of synchronous and asynchronous elements. Rahardjanto et al. (2019) conducted research on hybrid-PjBL and its impact on learning outcomes and creative thinking skills. Their findings showed a significant influence on learning outcomes and creative thinking skills. However, there was no significant difference in learning motivation between the control group and the experimental group. Therefore, further research is needed to comprehensively understand the overall positive impact of this model. Suwarno et al. (2020) investigated the PjBL model based on Student Worksheets (LKPD) and its influence on student competencies, especially creativity and applied science learning outcomes. The results demonstrated the impact of the PjBL model based on LKPD on students' creativity and learning outcomes. However, effective planning, alignment of content, and time management are crucial. These results should be further developed in future research to gain insights into individual activities and their long-term effects.

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 integration of STEAM into education has emerged as a response to the increasing need to enhance students' interest and competence across these diverse fields. Alongside the implementation of STEAM, there arises a pressing need for an effective teaching model that can effectively bridge the gaps in academic knowledge. One particularly promising teaching model is Project-Based Learning (PjBL). It offers a dynamic and immersive approach to education, where students engage in real-world projects that require them to apply knowledge and skills from various disciplines. This makes PjBL an ideal candidate for integration with interdisciplinary frameworks like STEAM. Several research studies have shed light on the potential of this integration. For instance. Konkus and Topsakal (2022) conducted a study focused on the effects of STEAM-based activities on gifted students. Their research yielded encouraging results, indicating a noticeable improvement in students' attitudes towards STEAM, their cooperative working skills, and even their career choices. However, it's worth noting that this study was conducted with a single sample group, prompting the need for further research that includes a control group. Another study by Martawijaya et al. (2023) explored the ethno-STEM-PjBL model and its impact on students' conceptual understanding. Their findings highlighted significant progress, marked by an enhancement in high-level thinking and a reduction in misconceptions among students. Siew and Ambo (2020) reported that students' creativity saw a marked increase when a STEM-PjBL learning approach was employed. This aligns with the idea that the hands-on, inquiry-based nature of PjBL can nurture creativity. Furthermore, Sigit et al. (2022) provided

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insights into how the integration of PjBL with STEAM can significantly improve students' mastery of complex concepts, such as those found in ecology. While these studies have enriched our understanding of PjBL and its potential within a STEAM framework, there remains an unexplored area PjBL-STEAM-based worksheets with the ecoprint technique. Hence, the researcher's intent is to adapt and assess the impact of worksheets based on PjBL-STEAM, incorporating the ecoprint technique to evaluate its influence on student motivation and creativity. In light of the limited research available on worksheets based on PjBL-STEAM and its effects on student motivation and creativity, this study seeks to address this gap, contributing to the growing body of knowledge in STEAM education.

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Ecoprint Technique

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). 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. This study, up to this point, has primarily focused on assessing the validity, feasibility, and practicality of the STEAM-based worksheets developed using the ecoprint technique. However, it's important to acknowledge the scope of this research. Further investigation is warranted to comprehensively gauge the effectiveness of these STEAM-based worksheets with the ecoprint technique on student creativity and motivation. 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.

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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 Based 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	- Pray together - Give answers to the teacher's questions

	- Provide instructions on how to use ecoprint	- Listening and paying attention
Develop project planning	- Provide teaching materials - Provide assignments and instructions for group discussion activities.	Pay attention and carry out tasks
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 empirical investigation of item validity can be conducted based on the measurement's objectives. In this research, the empirical investigation of items is carried out in the context of a formative test, making its validation follow the criteria-referenced test principles. Therefore, the test items can identify learning success, which is expressed in the formula for the item sensitivity index. When empirically investigating the item reliability of criterion-referenced tests, it should be expressed using the kappa index formula, as outlined by Subali (2019). The results of this measurement are presented in Table 2.

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

Instrument	V	Information
learning motivation	.82	Valid
student creativity	.85	Valid

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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 .82, and for the student creativity instrument, it was .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

The effectiveness of the implementation of the STEAM-based Student Worksheets is determined based on the impact of applying on enhancing students' learning motivation and creativity. The difference in the average score between the experimental and the control classes presented in Table 3 shows the average student's learning motivation and creativity. Both are higher than the average value in the control class.

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Table 3 The comparison of the Average Value of students' learning motivation and creativity *in Control and Experimental Class*

Group	Aspect	Mean	Std. Deviation	N
Experimental Class	students' motivation	85.73	4.794	75
	creativity	83.93	2.448	75
Control Class	students' motivation	66.30	3.843	75
	creativity	68.93	2.196	75

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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.

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Table 4. 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 4). 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. It may occur because the structure of the learning activities involving STEAM-based worksheets and the ecoprint technique places a strong emphasis on active participation. It encourages students to connect various aspects of knowledge, scientific skills, technology, engineering, art, and mathematics within the context of project-based work. Consequently, students become actively involved in

exploration and collaboration throughout the project, which significantly influences their motivation and creativity.

Subsequent analyses were conducted to assess the distinctions in each factor concerning the dependent variables (Table 5). 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 5.

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Table 5. Test Result of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	*df*	*F*	Sig.
Corrected Model	learning motivation	1223.130	1	248.808	.000
	student creativity	1472.667	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

Effect sizes along with statistical significance values That the significance value of students' learning motivation and creativity is 0.000 < α (0.05) which means that H0 is rejected and Ha which states that there is a difference in students' learning motivation and creativity scores simultaneously between the classes studied. with the STEAM-based Student Worksheet with the ecoprint technique compared to the conventional Student Worksheet is accepted. The effectiveness of applying Project-Based Learning alongside

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STEAM-based Student's Worksheets, utilizing the Ecoprint Technique in the experimental class, is attributed to the various stages of learning in which students engage. They are involved in project planning, self-directed learning, active exploration, and collaborative work. These learning activities provide students with opportunities to seek, manage, and communicate information acquired during the project's execution. Creative students, in particular, can produce intriguing and innovative products as a result.

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 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.

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 et al. (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.

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).

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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).

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-Gray 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: (a) STEAM strengthens and broadens the scope of STEM; (b) STEAM enables science teachers to participate in the development of school-based curricula; (c) STEAM incorporates teachers in the process of building a student-centered vision of 21st-century education; and (d) STEAM offers a way to integrate the arts and humanities into STEM instruction.; (e) STEAM initiatives can be crafted and executed

by individual educators on a manageable scale.; (f) 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 (Edelen et al., 2023; Thompson et al., 2020).

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., 2020).

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.

Thus, the results of this research represent an innovation in designing Student's Worksheets that are tailored to the needs of students, thereby enhancing their engagement and learning activities through project-based assignments. This, in turn, contributes to their mastery of competencies. These worksheets are designed in accordance with a model and approach that aligns with the 21st-century learning paradigm. The development of STEAM-based LKPDs with the ecoprint technique can serve as a benchmark for educators when redesigning their own worksheets, fostering creativity and innovation. Moreover, utilising worksheets must

consider the characteristics of the subject matter to meet the diverse learning needs of students. Given the infrequent use of STEAM-based worksheets like this, they can be valuable in teaching and learning.

The implementation of STEAM-based Student's Worksheets with the ecoprint technique in biology education represents an innovative approach to enhancing student creativity and motivation. The theoretical findings from this research can serve as a reference and source of knowledge for educators and educational practitioners, especially in the development of innovative worksheets. Teachers can employ these worksheets as alternative learning media in their teaching process. For students, using these worksheets helps nurture creativity and motivation in the learning process. STEAM-based Student's Worksheets with the ecoprint technique sharpen and develop students' skills in generating creative ideas and concepts, particularly during ecoprint-related projects. Students are guided and supported throughout the project, emphasising the five key elements of STEAM. Teachers can utilize these worksheets as supportive tools in the teaching and learning process, fostering optimal interaction between educators and students.

Previous 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 using 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 promising avenue for creating 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 involve 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. The results of this research can be used by teachers to help design innovative student worksheets as a means to facilitate the learning process and enhance student engagement, particularly in biology education, thereby improving students' competence.

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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Conflict of Interest

The authors declare no conflict of interest.

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

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.

Creativity has become a focal point in the 21st century because it is highly needed to adapt to the advancements in science and technology. Learners who possess creativity can think critically and see problems from various angles, enabling them to have an open mindset when solving issues. Therefore, effective learning in schools occurs when there is a reciprocal communication between teachers and students. However, students often lack motivation, and their creativity remains undeveloped. They struggle to create something new and tend to imitate what they see. Many students also lack the initiative to solve problems. The creative potential an individual possesses represents a form of thinking that involves finding connections among existing elements or discovering new approaches to personal challenges. This is driven by a strong desire and motivation to create. The development of students' creativity tends to be slow due to their continued dependence on teachers.

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 Project Based Learning (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 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 & Ellianawati, 2022). In the context of science project laboratories, Suwarno et al. (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 & Ellianawati, 2022; 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 technique is employed in the study of Spermatophyta material. Ecoprint serves as an illustration of interdisciplinary education that combines art instruction with knowledge of leaf structure and identification. Therefore, this technique is well-suited for studying Spermatophyta material, which encompasses topics such as Classification (Taxonomy) and Scientific Nomenclature (Binomial Nomenclature) within the Kingdom Plantae (Plants). Ecoprint, as a learning medium, can enhance various skills possessed by students. During its creation process, ecoprint integrates all the elements of STEAM (Science, Technology, Engineering, Arts, and Mathematics). The ecoprint technique is relevant for integration with STEAM education because STEAM offers learners the opportunity to develop knowledge and skills through a series of activities that combine science, technology, engineering, art, and mathematics. 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 model was developed by John Dewey, based on the concept of 'learning by doing,' which emphasizes direct experiential learning and student-centeredness (Maida, 2011). The analysis of previous research provides insights into the application of PjBL

(Project-Based Learning) in education. Mursid et al. (2022) conducted research on the blended project-based learning model's impact on creative thinking abilities. The findings suggest that creative thinking abilities need enhancement to ensure the effective implementation of the PjBL model. Furthermore, this research focused on teaching engineering drawing, indicating the need for further studies on PjBL in different subject areas. Syawaludin et al. (2022), in their study of the PjBL model in an online learning setting, explored its influence on students' analytical skills. The results indicate that in online learning design, the choice of project-based learning models can be effective when combined with the appropriate online learning settings, involving a combination of synchronous and asynchronous elements. Rahardjanto et al. (2019) conducted research on hybrid-PjBL and its impact on learning outcomes and creative thinking skills. Their findings showed a significant influence on learning outcomes and creative thinking skills. However, there was no significant difference in learning motivation between the control group and the experimental group. Therefore, further research is needed to comprehensively understand the overall positive impact of this model. Suwarno et al. (2020) investigated the PjBL model based on Student Worksheets (LKPD) and its influence on student competencies, especially creativity and applied science learning outcomes. The results demonstrated the impact of the PjBL model based on LKPD on students' creativity and learning outcomes. However, effective planning, alignment of content, and time management are crucial. These results should be further developed in future research to gain insights into individual activities and their long-term effects.

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 integration of STEAM into education has emerged as a response to the increasing need to enhance students' interest and competence across these diverse fields. Alongside the implementation of STEAM, there arises a pressing need for an effective teaching model that can effectively bridge the gaps in academic knowledge. One particularly promising teaching model is Project Based Learning (PjBL). It offers a dynamic and immersive approach to education, where students engage in real-world projects that require them to apply knowledge and skills from various disciplines. This makes PjBL an ideal candidate for integration with interdisciplinary frameworks like STEAM. Several research studies have shed light on the potential of this integration. For instance. Konkus and Topsakal (2022) conducted a study focused on the effects of STEAM-based activities on gifted students. Their research yielded encouraging results, indicating a noticeable improvement in students' attitudes towards STEAM, their cooperative working skills, and even their career choices. However, it's worth noting that this study was conducted with a single sample group, prompting the need for further research that includes a control group.

Another study by Martawijaya et al. (2023) explored the ethno STEM PjBL model and its impact on students' conceptual understanding. Their findings highlighted significant progress, marked by an enhancement in high level thinking and a reduction in misconceptions among students. Siew and Ambo (2020) reported that students' creativity saw a marked increase when a STEM PjBL learning approach was employed. This aligns with the idea that the hands on, inquiry based nature of PjBL can nurture creativity. Furthermore, Sigit et al. (2022) provided insights into how the integration of PjBL with STEAM can significantly improve students' mastery of complex concepts, such as those found in ecology. While these studies have enriched our understanding of PjBL and its potential within a STEAM framework, there remains an unexplored area PjBL STEAM based worksheets with the ecoprint technique. Hence, the researcher's intent is to adapt and assess the impact of worksheets based on PjBL STEAM, incorporating the ecoprint technique to evaluate its influence on student motivation and creativity. In light of the limited research available on worksheets based on PjBL STEAM and its effects on student motivation and creativity, this study seeks to address this gap, contributing to the growing body of knowledge in STEAM education.

Ecoprint Technique

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). 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. This study, up to this point, has primarily focused on assessing the validity, feasibility, and practicality of the STEAM-based worksheets developed using the ecoprint technique. However, it's important to acknowledge the scope of this research. Further investigation is warranted to comprehensively gauge the effectiveness of these STEAM-based worksheets with the ecoprint technique on student creativity and motivation. 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 Based 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 - Provide assignments and instructions for group discussion activities.	Pay attention and carry out tasks
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 empirical investigation of item validity can be conducted based on the measurement's objectives. In this research, the empirical investigation of items is carried out in the context of a formative test, making its validation follow the criteria-referenced test principles. Therefore, the test items can identify learning success, which is expressed in the formula for the item sensitivity index. When empirically investigating the item reliability of criterion-referenced tests, it should be expressed using the kappa index

formula, as outlined by Subali (2019). 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	.82	Valid
student creativity	.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 .82, and for the student creativity instrument, it was .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

The effectiveness of the implementation of the STEAM based Student Worksheets is determined based on the impact of applying on enhancing students' learning motivation and creativity. The difference in the average score between the experimental and the control class presented in Table 3 shows the average student's learning motivation and creativity. Both are higher than the average value in the control class.

Table 3 The comparison of the Average Value of students' learning motivation and creativity *in Control and Experimental Class*

Group	Aspect	Mean	Std. Deviation	*N*
Experimental Class	students' motivation	85.73	4.794	75
	creativity	83.93	2.448	75
Control Class	students' motivation	66.30	3.843	75
	creativity	68.93	2.196	75

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 < .05 which is less than the threshold of 0.05.

Table 4. 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 4). 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. It may occur because the structure of the learning activities involving STEAM based worksheets and the ecoprint technique places a strong emphasis on active participation. It encourages students to connect various aspects of knowledge, scientific skills, technology, engineering, art, and mathematics within the context of project based work. Consequently, students become actively involved in exploration and collaboration throughout the project, which significantly influences their motivation and creativity.

Subsequent analyses were conducted to assess the distinctions in each factor concerning the dependent variables (Table 5). 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-value $< .05$) and student creativity (p-value $< .05$) 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 5.

Table 5. Test Result of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	*df*	*F*	Sig.
Corrected Model	learning motivation	1223.130	1	248.808	.000
	student creativity	1472.667	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

Effect sizes along with statistical significance values That the significance value of students' learning motivation and creativity p-value < .001 ($p < 0.05$) hich means that H0 is rejected and Ha which states that there is a difference in students' learning motivation and creativity scores simultaneously between the classes studied. with the STEAM based Student Worksheet with the ecoprint technique compared to the conventional Student Worksheet is accepted. The effectiveness of applying Project Based Learning alongside STEAM based Student's Worksheets, utilizing the Ecoprint Technique in the experimental class, is attributed to the various stages of learning in which students engage. They are involved in project planning, self directed learning, active exploration, and collaborative work. These learning activities provide students with opportunities to seek, manage, and communicate information acquired during the project's execution. Creative students, in particular, can produce intriguing and innovative products as a result.

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 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.

In the implementation of PjBL, students collectively organize their knowledge by exploring various solutions to solve problems, there by fostering critical and creative thinking (Darling-Hammond et al., 2020; Han et al., 2016). According to Suradika et al. (2023), there are several principles in the PjBL model: (a) students are at the center of the

learning process; (b) the model enhances students' creativity; (c) it creates a challenging and enjoyable classroom environment; (d) the model incorporates values, aesthetics, ethics, sound reasoning, and kinesthetic learning; (e) 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.

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).

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-Gray 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: (a) STEAM strengthens and broadens the scope of STEM; (b) STEAM enables science teachers to participate in the development of school-based curricula; (c) STEAM incorporates teachers in the process of building a student-centered vision of 21st-century education; and (d) STEAM offers a way to integrate the arts and humanities into STEM instruction.; (e) STEAM initiatives can be crafted and executed by individual educators on a manageable scale.; (f) 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 (Edelen et al., 2023; Thompson et al., 2020).

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., 2020).

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.

Thus, the results of this research represent an innovation in designing Student's Worksheets that are tailored to the needs of students, thereby enhancing their engagement and learning activities through project-based assignments. This, in turn, contributes to their mastery of competencies. These worksheets are designed in accordance with a model and approach that aligns with the 21st-century learning paradigm. The development of STEAM based LKPDs with the ecoprint technique can serve as a benchmark for educators when redesigning their own worksheets, fostering creativity and innovation. Moreover, utilising worksheets must consider the characteristics of the subject matter to meet the diverse learning needs of students. Given the infrequent use of STEAM based worksheets like this, they can be valuable in teaching and learning.

The implementation of STEAM based Student's Worksheets with the ecoprint technique in biology education represents an innovative approach to enhancing student creativity and motivation. The theoretical findings from this research can serve as a reference and source of knowledge for educators and educational practitioners, especially in the development of innovative worksheets. Teachers can employ these worksheets as alternative learning media in their teaching process. For students, using these worksheets helps nurture

creativity and motivation in the learning process. STEAM based Student's Worksheets with the ecoprint technique sharpen and develop students' skills in generating creative ideas and concepts, particularly during ecoprint-related projects. Students are guided and supported throughout the project, emphasising the five key elements of STEAM. Teachers can utilize these worksheets as supportive tools in the teaching and learning process, fostering optimal interaction between educators and students.

Previous 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 using 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 promising avenue for creating 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 involve 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. The results of this research can be used by teachers to help design innovative student worksheets as a means to facilitate the learning process and enhance student engagement, particularly in biology education, thereby improving students' competence.

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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Conflict of Interest

The authors declare no conflict of interest.

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REVIEW KE 3

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

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.

Creativity has become a focal point in the 21st century because it is highly needed to adapt to the advancements in science and technology. Learners who possess creativity can think critically and see problems from various angles, enabling them to have an open mindset when solving issues. Therefore, effective learning in schools occurs when there is a reciprocal communication between teachers and students. However, students often lack motivation, and their creativity remains undeveloped. They struggle to create something new and tend to imitate what they see. Many students also lack the initiative to solve problems. The creative potential an individual possesses represents a form of thinking that involves finding connections among existing elements or discovering new approaches to personal challenges. This is driven by a strong desire and motivation to create. The development of students' creativity tends to be slow due to their continued dependence on teachers.

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 Project Based Learning (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 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 & Ellianawati, 2022). In the context of science project laboratories, Suwarno et al. (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 & Ellianawati, 2022; 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 technique is employed in the study of Spermatophyta material. Ecoprint serves as an illustration of interdisciplinary education that combines art instruction with knowledge of leaf structure and identification. Therefore, this technique is well-suited for studying Spermatophyta material, which encompasses topics such as Classification (Taxonomy) and Scientific Nomenclature (Binomial Nomenclature) within the Kingdom Plantae (Plants). Ecoprint, as a learning medium, can enhance various skills possessed by students. During its creation process, ecoprint integrates all the elements of STEAM (Science, Technology, Engineering, Arts, and Mathematics). The ecoprint technique is relevant for integration with STEAM education because STEAM offers learners the opportunity to develop knowledge and skills through a series of activities that combine science, technology, engineering, art, and mathematics. 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 model was developed by John Dewey, based on the concept of 'learning by doing,' which emphasizes direct experiential learning and student-centeredness (Maida, 2011). The analysis of previous research provides insights into the application of PjBL

(Project-Based Learning) in education. Mursid et al. (2022) conducted research on the blended project-based learning model's impact on creative thinking abilities. The findings suggest that creative thinking abilities need enhancement to ensure the effective implementation of the PjBL model. Furthermore, this research focused on teaching engineering drawing, indicating the need for further studies on PjBL in different subject areas. Syawaludin et al. (2022), in their study of the PjBL model in an online learning setting, explored its influence on students' analytical skills. The results indicate that in online learning design, the choice of project-based learning models can be effective when combined with the appropriate online learning settings, involving a combination of synchronous and asynchronous elements. Rahardjanto et al. (2019) conducted research on hybrid-PjBL and its impact on learning outcomes and creative thinking skills. Their findings showed a significant influence on learning outcomes and creative thinking skills. However, there was no significant difference in learning motivation between the control group and the experimental group. Therefore, further research is needed to comprehensively understand the overall positive impact of this model. Suwarno et al. (2020) investigated the PjBL model based on Student Worksheets (LKPD) and its influence on student competencies, especially creativity and applied science learning outcomes. The results demonstrated the impact of the PjBL model based on LKPD on students' creativity and learning outcomes. However, effective planning, alignment of content, and time management are crucial. These results should be further developed in future research to gain insights into individual activities and their long-term effects.

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).

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The integration of STEAM into education has emerged as a response to the increasing need to enhance students' interest and competence across these diverse fields. Alongside the implementation of STEAM, there arises a pressing need for an effective teaching model that can effectively bridge the gaps in academic knowledge. One particularly promising teaching model is Project Based Learning (PjBL). It offers a dynamic and immersive approach to education, where students engage in real-world projects that require them to apply knowledge and skills from various disciplines. This makes PjBL an ideal candidate for integration with interdisciplinary frameworks like STEAM. Several research studies have shed light on the potential of this integration. For instance. Konkus and Topsakal (2022) conducted a study focused on the effects of STEAM-based activities on gifted students. Their research yielded encouraging results, indicating a noticeable improvement in students' attitudes towards STEAM, their cooperative working skills, and even their career choices. However, it's worth noting that this study was conducted with a single sample group, prompting the need for further research that includes a control group.

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Another study by Martawijaya et al. (2023) explored the ethno STEM PjBL model and its impact on students' conceptual understanding. Their findings highlighted significant progress, marked by an enhancement in high level thinking and a reduction in misconceptions among students. Siew and Ambo (2020) reported that students' creativity saw a marked increase when a STEM PjBL learning approach was employed. This aligns with the idea that the hands on, inquiry based nature of PjBL can nurture creativity. Furthermore, Sigit et al. (2022) provided insights into how the integration of PjBL with STEAM can significantly improve students' mastery of complex concepts, such as those found in ecology. While these studies have enriched our understanding of PjBL and its potential within a STEAM framework, there remains an unexplored area PjBL STEAM based worksheets with the ecoprint technique. Hence, the researcher's intent is to adapt and assess the impact of worksheets based on PjBL STEAM, incorporating the ecoprint technique to evaluate its influence on student motivation and creativity. In light of the limited research available on worksheets based on PjBL STEAM and its effects on student motivation and creativity, this study seeks to address this gap, contributing to the growing body of knowledge in STEAM education.

Ecoprint Technique

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). 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. This study, up to this point, has primarily focused on assessing the validity, feasibility, and practicality of the STEAM-based worksheets developed using the ecoprint technique. However, it's important to acknowledge the scope of this research. Further investigation is warranted to comprehensively gauge the effectiveness of these STEAM-based worksheets with the ecoprint technique on student creativity and motivation. 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 Based 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 - Provide assignments and instructions for group discussion activities.	Pay attention and carry out tasks
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 empirical investigation of item validity can be conducted based on the measurement's objectives. In this research, the empirical investigation of items is carried out in the context of a formative test, making its validation follow the criteria-referenced test principles. Therefore, the test items can identify learning success, which is expressed in the formula for the item sensitivity index. When empirically investigating the item reliability of criterion-referenced tests, it should be expressed using the kappa index

formula, as outlined by Subali (2019). 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	.82	Valid
student creativity	.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 .82, and for the student creativity instrument, it was .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

The effectiveness of the implementation of the STEAM based Student Worksheets is determined based on the impact of applying on enhancing students' learning motivation and creativity. The difference in the average score between the experimental and the control class presented in Table 3 shows the average student's learning motivation and creativity. Both are higher than the average value in the control class.

Table 3 The comparison of the Average Value of students' learning motivation and creativity *in Control and Experimental Class*

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Group	Aspect	Mean	Std. Deviation	*N*
Experimental Class	students' motivation	85.73	4.794	75
	creativity	83.93	2.448	75
Control Class	students' motivation	66.30	3.843	75
	creativity	68.93	2.196	75

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 < .05 which is less than the threshold of 0.05.

Table 4. 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 4). 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. It may occur because the structure of the learning activities involving STEAM based worksheets and the ecoprint technique places a strong emphasis on active participation. It encourages students to connect various aspects of knowledge, scientific skills, technology, engineering, art, and mathematics within the context of project based work. Consequently, students become actively involved in exploration and collaboration throughout the project, which significantly influences their motivation and creativity.

Subsequent analyses were conducted to assess the distinctions in each factor concerning the dependent variables (Table 5). 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-value < .05) and student creativity (p-value < .05) 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 5.

Table 5. Test Result of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	*df*	*F*	Sig.
Corrected Model	learning motivation	1223.130	1	248.808	.000
	student creativity	1472.667	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

Effect sizes along with statistical significance values That the significance value of students' learning motivation and creativity *p*-value < .001 ($p < 0.05$) hich means that H0 is rejected and Ha which states that there is a difference in students' learning motivation and creativity scores simultaneously between the classes studied. with the STEAM based Student Worksheet with the ecoprint technique compared to the conventional Student Worksheet is accepted. The effectiveness of applying Project Based Learning alongside STEAM based Student's Worksheets, utilizing the Ecoprint Technique in the experimental class, is attributed to the various stages of learning in which students engage. They are involved in project planning, self directed learning, active exploration, and collaborative work. These learning activities provide students with opportunities to seek, manage, and communicate information acquired during the project's execution. Creative students, in particular, can produce intriguing and innovative products as a result.

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 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.

In the implementation of PjBL, students collectively organize their knowledge by exploring various solutions to solve problems, there by fostering critical and creative thinking (Darling-Hammond et al., 2020; Han et al., 2016). According to Suradika et al. (2023), there are several principles in the PjBL model: (a) students are at the center of the

learning process; (b) the model enhances students' creativity; (c) it creates a challenging and enjoyable classroom environment; (d) the model incorporates values, aesthetics, ethics, sound reasoning, and kinesthetic learning; (e) 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.

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).

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-Gray 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: (a) STEAM strengthens and broadens the scope of STEM; (b) STEAM enables science teachers to participate in the development of school-based curricula; (c) STEAM incorporates teachers in the process of building a student-centered vision of 21st-century education; and (d) STEAM offers a way to integrate the arts and humanities into STEM instruction.; (e) STEAM initiatives can be crafted and executed by individual educators on a manageable scale.; (f) 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 (Edelen et al., 2023; Thompson et al., 2020).

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., 2020).

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.

Thus, the results of this research represent an innovation in designing Student's Worksheets that are tailored to the needs of students, thereby enhancing their engagement and learning activities through project-based assignments. This, in turn, contributes to their mastery of competencies. These worksheets are designed in accordance with a model and approach that aligns with the 21st-century learning paradigm. The development of STEAM based LKPDs with the ecoprint technique can serve as a benchmark for educators when redesigning their own worksheets, fostering creativity and innovation. Moreover, utilising worksheets must consider the characteristics of the subject matter to meet the diverse learning needs of students. Given the infrequent use of STEAM based worksheets like this, they can be valuable in teaching and learning.

The implementation of STEAM based Student's Worksheets with the ecoprint technique in biology education represents an innovative approach to enhancing student creativity and motivation. The theoretical findings from this research can serve as a reference and source of knowledge for educators and educational practitioners, especially in the development of innovative worksheets. Teachers can employ these worksheets as alternative learning media in their teaching process. For students, using these worksheets helps nurture

creativity and motivation in the learning process. STEAM based Student's Worksheets with the ecoprint technique sharpen and develop students' skills in generating creative ideas and concepts, particularly during ecoprint-related projects. Students are guided and supported throughout the project, emphasising the five key elements of STEAM. Teachers can utilize these worksheets as supportive tools in the teaching and learning process, fostering optimal interaction between educators and students.

Previous 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 using 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 promising avenue for creating 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 involve 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. The results of this research can be used by teachers to help design innovative student worksheets as a means to facilitate the learning process and enhance student engagement, particularly in biology education, thereby improving students' competence.

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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Conflict of Interest

The authors declare no conflict of interest.

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Bussieres, E.-L., St-Germain, A., Dube, M., & Richard, M.-C. (2017). Efficacite et efficience des programmes de transition a la vie adulte: Une revue systematique [Effectiveness and efficiency of adult transition programs: A systematic review]. *Canadian Psychology/ Psychologie canadienne, 58*(1), 354–365. https://doi.org/10.1037/cap0000104
Note for this example that Canadian Psychology/Psychologie canadienne is a bilingual journal that is published with a bilingual title; if the journal title were only in French it would not be necessary to translate it in the reference.

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

Effectiveness of Project-Based Learning on STEAM

Type of the research: research article

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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.

Creativity has become a focal point in the 21st century because it is highly needed to adapt to the advancements in science and technology. Learners who possess creativity can think critically and see problems from various angles, enabling them to have an open mindset when solving issues. Therefore, effective learning in schools occurs when there is a reciprocal communication between teachers and students. However, students often lack motivation, and their creativity remains undeveloped. They struggle to create something new and tend to imitate what they see. Many students also lack the initiative to solve problems. The creative potential an individual possesses represents a form of thinking that involves finding connections among existing elements or discovering new approaches to personal challenges. This is driven by a strong desire and motivation to create. The development of students' creativity tends to be slow due to their continued dependence on teachers.

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 Project Based Learning (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 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 et al. (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 & Ellianawati, 2022; 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 technique is employed in the study of Spermatophyta material. Ecoprint serves as an illustration of interdisciplinary education that combines art instruction with knowledge of leaf structure

and identification. Therefore, this technique is well-suited for studying Spermatophyta material, which encompasses topics such as Classification (Taxonomy) and Scientific Nomenclature (Binomial Nomenclature) within the Kingdom Plantae (Plants). Ecoprint, as a learning medium, can enhance various skills possessed by students. During its creation process, ecoprint integrates all the elements of STEAM (Science, Technology, Engineering, Arts, and Mathematics). The ecoprint technique is relevant for integration with STEAM education because STEAM offers learners the opportunity to develop knowledge and skills through a series of activities that combine science, technology, engineering, art, and mathematics. 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 model was developed by John Dewey, based on the concept of 'learning by doing,' which emphasizes direct experiential learning and student-centeredness (Maida, 2011). The analysis of previous research provides insights into the application of PjBL (Project-Based Learning) in education. Mursid et al. (2022) conducted research on the blended project-based learning model's impact on creative thinking abilities. The findings suggest that creative thinking abilities need enhancement to ensure the effective implementation of the PjBL model. Furthermore, this research focused on teaching engineering drawing, indicating the need for further studies on PjBL in different subject areas. Syawaludin et al. (2022), in their study of the PjBL model in an online learning setting, explored its influence on students' analytical skills. The results indicate that in online learning design, the choice of project-based learning models can be effective when combined with the appropriate online learning

settings, involving a combination of synchronous and asynchronous elements. Rahardjanto et al. (2019) conducted research on hybrid-PjBL and its impact on learning outcomes and creative thinking skills. Their findings showed a significant influence on learning outcomes and creative thinking skills. However, there was no significant difference in learning motivation between the control group and the experimental group. Therefore, further research is needed to comprehensively understand the overall positive impact of this model. Suwarno et al. (2020) investigated the PjBL model based on Student Worksheets (LKPD) and its influence on student competencies, especially creativity and applied science learning outcomes. The results demonstrated the impact of the PjBL model based on LKPD on students' creativity and learning outcomes. However, effective planning, alignment of content, and time management are crucial. These results should be further developed in future research to gain insights into individual activities and their long-term effects.

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 integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) into education has emerged as a response to the increasing need to enhance students' interest and competence across these diverse fields. Alongside the implementation of STEAM, there arises a pressing need for an effective teaching model that can effectively bridge the gaps in academic knowledge. One particularly promising teaching model is Project-Based Learning (PjBL). It offers a dynamic and immersive approach to education, where students engage in real-world projects that require them to apply knowledge and skills from various disciplines. This makes PjBL an ideal candidate for integration with interdisciplinary frameworks like STEAM. Several research studies have shed light on the potential of this integration. For instance, Konkus and Topsakal (2022) conducted a study focused on the effects of STEAM-based activities on gifted students. Their research yielded encouraging results, indicating a noticeable improvement in students' attitudes towards STEAM, their cooperative working skills, and even their career choices. However, it's worth noting that this study was conducted with a single sample group, prompting the need for further research that includes a control group. Another study by Martawijaya et al. (2023) explored the ethno-STEM-PjBL model and its impact on students' conceptual understanding. Their findings highlighted significant progress, marked by an enhancement in high-level thinking and a reduction in misconceptions among students. Siew and Ambo (2020) reported that students' creativity saw a marked increase when a STEM-PjBL learning approach was employed. This aligns with the idea that the hands-on, inquiry-based nature of PjBL can nurture creativity. Furthermore, Sigit et al. (2022) provided insights into how the integration of PjBL with STEAM can significantly improve students' mastery of complex concepts, such as those found in ecology. While these studies have enriched our understanding of PjBL and its potential within a STEAM framework, there remains an unexplored area—PjBL-STEAM-

based worksheets (LKPD) with the ecoprint technique. Hence, the researcher's intent is to adapt and assess the impact of LKPD based on PjBL-STEAM, incorporating the ecoprint technique to evaluate its influence on student motivation and creativity. In light of the limited research available on LKPD based on PjBL-STEAM and its effects on student motivation and creativity, this study seeks to address this gap, contributing to the growing body of knowledge in STEAM education.

Ecoprint Technique

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). 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. This study, up to this point, has primarily focused on assessing the validity, feasibility, and practicality of the STEAM-based worksheets developed using the ecoprint technique. However, it's important to acknowledge the scope

of this research. Further investigation is warranted to comprehensively gauge the effectiveness of these STEAM-based worksheets with the ecoprint technique on student creativity and motivation. 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 Based 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 empirical investigation of item validity can be conducted based on the measurement's objectives. In this research, the empirical investigation of items is carried out in the context of a formative test, making its validation follow the criteria-referenced test principles. Therefore, the test items can identify learning success, which is expressed in the formula for the item sensitivity index. When empirically investigating the item reliability of criterion-referenced tests, it should be expressed using the kappa index formula, as outlined by Subali (2019). 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	.82	Valid
student creativity	.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 .82, and for the student creativity instrument, it was .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

The effectiveness of the implementation of the STEAM-based Student Worksheets is determined based on the impact of applying on enhancing students' learning motivation and creativity. The difference in the average score between the experimental and the control class presented in Table 3 shows the average student's learning motivation and creativity. Both are higher than the average value in the control class.

Table 3 The comparison of Average Value of students' learning motivation and creativity *in Control and Experimental Class*

Group	**Aspect**	**Mean**	**Std. Deviation**	**N**
Experimental Class	students' motivation	85.73	4.794	75
	creativity	83.93	2.448	75
Control Class	students' motivation	66.30	3.843	75
	creativity	68.93	2.196	75

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 4. 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 4). 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. It may occur because the structure of the learning activities involving STEAM-based worksheets and the ecoprint technique places a strong emphasis on active participation. It encourages students to connect various aspects of knowledge, scientific skills, technology, engineering, art, and mathematics within the context of project-based work. Consequently, students become actively involved in

exploration and collaboration throughout the project, which significantly influences their motivation and creativity.

Subsequent analyses were conducted to assess the distinctions in each factor concerning the dependent variables (Table 5). 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 5.

Table 5. Test Result of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	*df*	*F*	Sig.
Corrected Model	learning motivation	1223.130	1	248.808	.000
	student creativity	1472.667	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

Effect sizes along with statistical significance values That the significance value of students' learning motivation and creativity is 0.000 < α (0.05) which means that H0 is rejected and Ha which states that there is a difference in students' learning motivation and creativity scores simultaneously between the classes studied. with the STEAM-based Student Worksheet with the ecoprint technique compared to the conventional Student Worksheet is accepted. The effectiveness of applying Project-Based Learning alongside

STEAM-based Student's Worksheets, utilizing the Ecoprint Technique in the experimental class, is attributed to the various stages of learning in which students engage. They are involved in project planning, self-directed learning, active exploration, and collaborative work. These learning activities provide students with opportunities to seek, manage, and communicate information acquired during the project's execution. Creative students, in particular, can produce intriguing and innovative products as a result.

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 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.

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 et al. (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.

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).

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-Gray 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: (a) STEAM strengthens and broadens the scope of STEM; (b) STEAM enables science teachers to participate in the development of school-based curricula; (c) STEAM incorporates teachers in the process of building a student-centered vision of 21st-century education; and (d) STEAM offers a way to integrate the arts and humanities into STEM instruction.; (e) STEAM initiatives can be crafted and executed

by individual educators on a manageable scale.; (f) 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 (Edelen et al., 2023; Thompson et al., 2020).

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., 2020).

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.

Thus, the results of this research represent an innovation in designing Student's Worksheets that are tailored to the needs of students, thereby enhancing their engagement and learning activities through project-based assignments. This, in turn, contributes to their mastery of competencies. These worksheets are designed in accordance with a model and approach that aligns with the 21st-century learning paradigm. The development of STEAM-based LKPDs with the ecoprint technique can serve as a benchmark for educators when redesigning their own worksheets, fostering creativity and innovation. Moreover, utilising worksheets must

consider the characteristics of the subject matter to meet the diverse learning needs of students. Given the infrequent use of STEAM-based worksheets like this, they can be valuable in teaching and learning.

The implementation of STEAM-based Student's Worksheets with the ecoprint technique in biology education represents an innovative approach to enhancing student creativity and motivation. The theoretical findings from this research can serve as a reference and source of knowledge for educators and educational practitioners, especially in the development of innovative worksheets. Teachers can employ these worksheets as alternative learning media in their teaching process. For students, using these worksheets helps nurture creativity and motivation in the learning process. STEAM-based Student's Worksheets with the ecoprint technique sharpen and develop students' skills in generating creative ideas and concepts, particularly during ecoprint-related projects. Students are guided and supported throughout the project, emphasising the five key elements of STEAM. Teachers can utilize these worksheets as supportive tools in the teaching and learning process, fostering optimal interaction between educators and students.

Previous 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 using 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 promising avenue for creating 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 involve 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. The results of this research can be used by teachers to help design innovative student worksheets as a means to facilitate the learning process and enhance student engagement, particularly in biology education, thereby improving students' competence.

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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Conflict of Interest

The authors declare no conflict of interest.

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Review Form

Manuscript ID:	IJEM_ID# 23080706550717	**Date:**	September 28, 2023
Manuscript Title:	Effectiveness of Project-Based Learning on STEAM-Based Student's Worksheet Analysis with Ecoprint Technique		

ABOUT MANUSCRIPT (Mark with "X" one of the options)	Accept	Weak	Refuse	Not Available
Language is clear and correct	x			
Literature is well written		x		
References are cited as directed by APA	x			
The research topic is significant to the field	x			
The article is complete, well organized and clearly written		x		
Research design and method is appropriate		x		
Analyses are appropriate to the research question	x			
Results are clearly presented		x		
A reasonable discussion of the results is presented		x		
Conclusions are clearly stated	x			
Recommendations are clearly stated	x			

GENERAL REMARKS AND RECOMMENDATIONS TO THE AUTHOR

The manuscript is related to assess the effectiveness of Project-Based Learning (PjBL) integrated with STEAM-based Student's Worksheet Analysis utilizing the Ecoprint Technique in enhancing students' learning motivation and creativity in the specific topic area of Spermatophyta. It has some methodological and structural deficits. The following recommendations are presented:

1- Provide more background on the specific gaps in motivation and creativity that the study aims to address.
2- Elaborate on why the ecoprint technique was chosen and its relevance to STEAM education.
3- Clarify earlier on that the study focuses specifically on the topic of Spermatophyta.
4-Synthesize the literature more concisely instead of summarizing each study individually. Focus on key themes and findings.
5- Provide more critical analysis of the literature - point out limitations, inconsistencies, or gaps in prior studies.
6- Explain how the Aiken V values support validity and the thresholds for reliability.
7- Report descriptive statistics (means, standard deviations) for pretest and posttest scores.
8- Provide more interpretation of the findings instead of just describing the results.
9- Report effect sizes along with statistical significance values.
10- Tie the findings back to the original gaps identified in the introduction.
11- Discuss broader theoretical and practical implications. How do findings contribute new insights on motivating and engaging students in STEAM? How can teachers and schools implement these methods?

THE DECISION (Mark with "X" one of the options)

Accepted: Correction not required	
Accepted: Minor correction required	
Conditionally Accepted: Major Correction Required **(Need second review after corrections)**	x
Refused	

Reviewer Code: R2611 (The name of referee is hidden because of blind review)

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Review Form

Manuscript ID:	IJEM_ID# 23080706550717	**Date:**	10th September 2023
Manuscript Title:	Effectiveness of Project-Based Learning on STEAM-Based Student's Worksheet Analysis with Ecoprint Technique		

ABOUT MANUSCRIPT (Mark with "X" one of the options)	Accept	Weak	Refuse	Not Available
Language is clear and correct	X			
Literature is well written		X		
References are cited as directed by APA		X		
The research topic is significant to the field	X			
The article is complete, well organized and clearly written	X			
Research design and method is appropriate	X			
Analyses are appropriate to the research question	X			
Results are clearly presented	X			
A reasonable discussion of the results is presented		X		
Conclusions are clearly stated	X			
Recommendations are clearly stated		X		

GENERAL REMARKS AND RECOMMENDATIONS TO THE AUTHOR

Non-Greek symbols (*p, F, df, M,* etc.) in statistics should be in italics. See for a complete list https://www.jcu.edu.sg/__data/assets/pdf_file/0003/1027227/Common-Statistical-Abbreviations-and-Symbols-in-APA-7th-italics.pdf

In Recommendations section, in addition to recommendations for further research, please provide recommendations for practitioners such as how this study contributes to teaching and learning, how teachers benefit from those results, etc.

Please fix style errors indicated in the manuscript.

Please improve the literature review and discussion parts with recent studies.

Please cite to this study in order to improve your paper:

Rahmawati, D. F., & Fadhilah, R. (2022). The effectiveness of the STEM approach on science process skills in studying reaction rate. *European Journal of Mathematics and Science Education, 3(*2), 135-143. https://doi.org/10.12973/ejmse.3.2.135

THE DECISION (Mark with "X" one of the options)

Accepted: Correction not required	
Accepted: Minor correction required	X
Conditionally Accepted: Major Correction Required **(Need second review after corrections)**	
Refused	

Reviewer Code: R2613 (The name of referee is hidden because of blind review)

CORRECTION REPORT

No	Reviewer Code	Reviews	Corrections made by the author
1	Reviewer 1	• Provide more background on the specific gaps in motivation and creativity that the study aims to address.	• Creativity has become a focal point in the 21st century because it is highly needed to adapt to the advancements in science and technology. Learners who possess creativity can think critically and see problems from various angles, enabling them to have an open mindset when solving issues. Therefore, effective learning in schools occurs when there is a reciprocal communication between teachers and students. However, students often lack motivation, and their creativity remains undeveloped. They struggle to create something new and tend to imitate what they see. Many students also lack the initiative to solve problems. The creative potential an individual possesses represents a form of thinking that involves finding connections among existing elements or discovering new approaches to personal challenges. This is driven by a strong desire and motivation to create. The development of students' creativity tends to be slow due to their continued dependence on teachers.
		• Elaborate on why the ecoprint technique was chosen and its relevance to STEAM education.	• The ecoprint technique is employed in the study of Spermatophyta material. Ecoprint serves as an illustration of interdisciplinary education that combines art instruction with knowledge of leaf structure and identification. Therefore, this technique is well-suited for studying Spermatophyta material, which encompasses topics such as Classification (Taxonomy) and Scientific Nomenclature (Binomial Nomenclature) within the Kingdom Plantae (Plants).
		• Clarify earlier on that the study focuses specifically on the topic of Spermatophyta.	• Ecoprint, as a learning medium, can enhance various skills possessed by students. During its creation process, ecoprint integrates all the elements of STEAM (Science, Technology, Engineering, Arts, and Mathematics). The ecoprint technique is relevant for integration with STEAM education because STEAM offers learners the opportunity to develop knowledge and skills through a series of activities that combine science, technology, engineering, art, and mathematics.
2	Reviewer 1	• Synthesize the literature more concisely instead of summarizing each study individually. Focus on key themes and findings. Provide more critical analysis of the literature - point out limitations, inconsistencies, or gaps in prior studies.	• The analysis of previous research provides insights into the application of PjBL (Project-Based Learning) in education. Mursid et al. (2022) conducted research on the blended project-based learning model's impact on creative thinking abilities. The findings suggest that creative thinking abilities need enhancement to ensure the effective implementation of the PjBL model. Furthermore, this research focused on teaching engineering drawing, indicating the need for further studies on PjBL in different subject areas. Syawaludin et al. (2022), in their study of the PjBL model in an online learning setting, explored its influence on students' analytical skills. The results indicate that in online learning design, the choice of project-based learning models can be effective when combined with

			the appropriate online learning settings, involving a combination of synchronous and asynchronous elements. Rahardjanto et al. (2019) conducted research on hybrid-PjBL and its impact on learning outcomes and creative thinking skills. Their findings showed a significant influence on learning outcomes and creative thinking skills. However, there was no significant difference in learning motivation between the control group and the experimental group. Therefore, further research is needed to comprehensively understand the overall positive impact of this model. Suwarno et al. (2020) investigated the PjBL model based on Student Worksheets (LKPD) and its influence on student competencies, especially creativity and applied science learning outcomes. The results demonstrated the impact of the PjBL model based on LKPD on students' creativity and learning outcomes. However, effective planning, alignment of content, and time management are crucial. These results should be further developed in future research to gain insights into individual activities and their long-term effects. • The integration of STEAM (Science, Technology, Engineering, Arts, and Mathematics) into education has emerged as a response to the increasing need to enhance students' interest and competence across these diverse fields. Alongside the implementation of STEAM, there arises a pressing need for an effective teaching model that can effectively bridge the gaps in academic knowledge. One particularly promising teaching model is Project-Based Learning (PjBL). It offers a dynamic and immersive approach to education, where students engage in real-world projects that require them to apply knowledge and skills from various disciplines. This makes PjBL an ideal candidate for integration with interdisciplinary frameworks like STEAM. Several research studies have shed light on the potential of this integration. For instance, Konkus and Topsakal (2022) conducted a study focused on the effects of STEAM-based activities on gifted students. Their research yielded encouraging results, indicating a noticeable improvement in students' attitudes towards STEAM, their cooperative working skills, and even their career choices. However, it's worth noting that this study was conducted with a single sample group, prompting the need for further research that includes a control group. Another study by Martawijaya et al. (2023) explored the ethno-STEM-PjBL model and its impact on students' conceptual understanding. Their findings highlighted significant progress, marked by an enhancement in high-level thinking and a reduction in misconceptions among students. Siew and Ambo (2020) reported that students' creativity saw a marked increase when a STEM-PjBL learning approach was employed. This aligns with the idea that the hands-on, inquiry-based nature of PjBL can nurture creativity. Furthermore, Sigit et al. (2022) provided insights into how the integration of PjBL with STEAM can significantly improve students' mastery of complex concepts, such as those found in ecology. While these studies have enriched our

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<td>understanding of PjBL and its potential within a STEAM framework, there remains an unexplored area—PjBL-STEAM-based worksheets (LKPD) with the ecoprint technique. Hence, the researcher's intent is to adapt and assess the impact of LKPD based on PjBL-STEAM, incorporating the ecoprint technique to evaluate its influence on student motivation and creativity. In light of the limited research available on LKPD based on PjBL-STEAM and its effects on student motivation and creativity, this study seeks to address this gap, contributing to the growing body of knowledge in STEAM education.

• This study, up to this point, has primarily focused on assessing the validity, feasibility, and practicality of the STEAM-based worksheets (LKPD) developed using the ecoprint technique. However, it's important to acknowledge the scope of this research. Further investigation is warranted to comprehensively gauge the effectiveness of these STEAM-based LKPD with the ecoprint technique on student creativity and motivation. 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.</td>
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<tr>
<td>3</td>
<td>Reviewer 1</td>
<td>• Explain how the Aiken V values support validity and the thresholds for reliability.</td>
<td>The empirical investigation of item validity can be conducted based on the measurement's objectives. In this research, the empirical investigation of items is carried out in the context of a formative test, making its validation follow the criteria-referenced test principles. Therefore, the test items can identify learning success, which is expressed in the formula for the item sensitivity index. When empirically investigating the item reliability of criterion-referenced tests, it should be expressed using the kappa index formula, as outlined by Subali (2019).</td>
</tr>
<tr>
<td>4</td>
<td>Reviewer 1</td>
<td>• Report descriptive statistics (means, standard deviations) for pretest and posttest scores.

• Provide more interpretation of the findings instead of just describing</td>
<td>• The effectiveness of the implementation of the STEAM-based Student Worksheets is determined based on the impact of applying on enhancing students' learning motivation and creativity. The difference in the average score between the experimental and the control class presented in Table 3 shows the average student's learning motivation and creativity. Both are higher than the average value in the control class.

Table 3 The comparison of Average Value of students' learning motivation and creativity *in Control and Experimental Class*
<table>
<tr><th>Group</th><th>Aspect</th><th>Mean</th><th>Std. Deviation</th><th>N</th></tr>
<tr><td rowspan="2">Experimental Class</td><td>students' motivation</td><td>85.73</td><td>4.794</td><td>75</td></tr>
<tr><td>creativity</td><td>83.93</td><td>2.448</td><td>75</td></tr>
<tr><td rowspan="2">Control Class</td><td>students' motivation</td><td>66.30</td><td>3.843</td><td>75</td></tr>
<tr><td>creativity</td><td>68.93</td><td>2.196</td><td>75</td></tr>
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</table>

		the results.	• It may occur because the structure of the learning activities involving STEAM-based worksheets and the ecoprint technique places a strong emphasis on active participation. It encourages students to connect various aspects of knowledge, scientific skills, technology, engineering, art, and mathematics within the context of project-based work. Consequently, students become actively involved in exploration and collaboration throughout the project, which significantly influences their motivation and creativity. The effectiveness of applying Project-Based Learning alongside STEAM-based Student's Worksheets, utilizing the Ecoprint Technique in the experimental class, is attributed to the various stages of learning in which students engage. They are involved in project planning, self-directed learning, active exploration, and collaborative work. These learning activities provide students with opportunities to seek, manage, and communicate information acquired during the project's execution. Creative students, in particular, can produce intriguing and innovative products as a result.
5	Reviewer 1	• Report effect sizes along with statistical significance values.	Effect sizes along with statistical significance values That the significance value of students' learning motivation and creativity is 0.000 < α (0.05) which means that H0 is rejected and Ha which states that there is a difference in students' learning motivation and creativity scores simultaneously between the classes studied. with the STEAM-based Student Worksheet with the ecoprint technique compared to the conventional Student Worksheet is accepted
6	Reviewer 2	"With" in the title	Effectiveness of Project-Based Learning on STEAM-Based Student's Worksheet Analysis With Ecoprint Technique
7	Reviewer 2	When you first use a term that you want to abbreviate in the text, present both the full version of the term and the abbreviation in parentheses after it.	The application of Project Based Learning (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).
8	Reviewer 2	PjBL tools	Muskania and Wilujeng's (2017) research demonstrates that PjBL tools have a significant impact on students' scientific literacy.
9	Reviewer 2	et al	Suwarno et al. (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).
10	Reviewer 2	Asnidar et al. (2016) Not found in the reference list	Asnidar, Hala, Y., & Yaiyeb, A. M. (2016). Pengaruh penggunaan lembar kerja peserta didik berbasis peta konsep terhadap motivasi dan hasil belajar peserta didik

			kelas VII SMPN 1 Awangpone. Jurnal Bionature, 17(2), 102-106. https://doi.org/10.35580/bionature.v17i2.2839
11	Reviewer 2	Space needed in nomenclature.Field	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.
12	Reviewer 2	• Expecting comma after surname (Sa'adah & Ellinawati 2022).	Integrating student worksheets within the existing teaching models utilized in schools is not effectively implemented (Sa'adah & Ellianawati, 2022; Wandari et al., 2018).
13	Reviewer 2	• Incomplete setence 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).	Integrating student worksheets within the existing teaching models utilized in schools is not effectively implemented (Sa'adah & Ellianawati, 2022; Wandari et al., 2018).
14	Reviewer 2	Author mismatch Is this an "et al."? (Han et al., 2016; Darling-Hammond et al., 2020). According to Suradika (2023),	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 et al. (2023),
15	Reviewer 2	Author mismatch Syawaludin et al. (2022)	Syawaludin et al. (2022), in their study of the PjBL model in an online learning setting, explored its influence on students' analytical skills. The results indicate that in online learning design, the choice of project-based learning models.
16	Reviewer 2	Author has two surname with hyphen. (Colucci et al., 2017).	Additionally, it enriches employability skills, fostering attributes such as teamwork, communication, and adaptability (Colucci-Gray et al., 2017).
17	Reviewer 2	Use lettered list "(a) …, (b) …." for phrases and incomplete sentences in a paragraph or sentence	Taylor (2016) highlights the following crucial STEAM components: (a) STEAM strengthens and broadens the scope of STEM; (b) STEAM enables science teachers to participate in the development of school-based curricula; (c) STEAM incorporates teachers in the process of building a student-centered vision of 21st-century education; and (d) STEAM offers a way to integrate the arts and humanities into STEM instruction.; (e) STEAM initiatives can be crafted and executed by individual educators on a manageable scale.; (f) Educators have the capacity to develop STEAM activities within the framework of project-based learning.
18	Reviewer 2	Multiple citations should be in	(Edelen et al., 2023; Thompson et al., 2020).

<table>
<tr><td></td><td></td><td>correct alphabetical order

(Thompson et al., 2020; Edelen et al., 2023).</td><td></td></tr>
<tr><td>19</td><td>Reviewer 2</td><td>In title case

Table 1. Project base learning syntax learning activities</td><td>Table 1. Project Based Learning Syntax Learning Activities</td></tr>
<tr><td>20</td><td>Reviewer 2</td><td>Do not use a zero before a decimal fraction when the statistic cannot be greater than 1 (e.g., correlations, proportions, levels of statistical significance, etc.).</td><td>Table 2. Results of the Aiken Index Coefficient of Instrument Validity
<table><tr><th>Instrument</th><th>V</th><th>Information</th></tr><tr><td>learning motivation</td><td>.82</td><td>Valid</td></tr><tr><td>student creativity</td><td>.85</td><td>Valid</td></tr></table></td></tr>
<tr><td>21</td><td>Reviewer 2</td><td>MANOVA (please change to all uppercase)</td><td>Additionally, the MANOVA test was conducted to identify any significant differences in mean scores between the experimental and control groups.</td></tr>
<tr><td>22</td><td>Reviewer 2</td><td>p should be in italics</td><td>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.</td></tr>
<tr><td>23</td><td>Reviewer 2</td><td>Year mismatch (check reference list)

(Adriyawati et al., 2015).</td><td>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., 2020).</td></tr>
<tr><td>24</td><td>Reviewer 2</td><td>In addition to recommendations for further research, please provide recommendations for practitioners such as how this study contributes to teaching and learning, how teachers benefit from those results, etc.</td><td>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. The results of this research can be used by teachers to help design innovative student worksheets as a means to facilitate the learning process and enhance student engagement, particularly in biology education, thereby improving students' competence.</td></tr>
<tr><td>25</td><td>Reviewer 2</td><td>• Provide volume and issue numbers

Belwal, R., Belwal, S., Sufian, A., & Badi, A. (2020). Project-based learning (PBL): Outcomes of students' engagement in a external consultancy project in Oman. Education and Training a head-of-print, 336-359. https://doi.org/10.1108/ET-01-2020-0006</td><td>• Belwal, R., Belwal, S., Sufian, A., & Badi, A. (2020). Project-based learning (PBL): Outcomes of students' engagement in a external consultancy project in Oman. Education and Training, 63(3), 336-359. https://doi.org/10.1108/ET-01-2020-0006

• Colucci-Gray, L., Trowsdale, J., Cooke, C. F., Davies,</td></tr>
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		• Need space between initials, need space between initials Colucci-Gray, L., Trowsdale, J., Cooke, C.F., Davies, R., Burnard, P., & Gray, D.S. (2017). Reviewing the potential and challenges of developing STEAM education through creative pedagogies for 21 st learning: How can school curricula be broadened towards a more responsive, dynamic and inclusive form of education. *British Educational Research Assosiation*. • Working paper is included when there is a number. This one has no number so delete it. Publisher location is not needed. Condliffe, B., Quint, J., Visher, M. G., Bangser, M. R., Drohojowska, S., Saco, L., & Nelson, E. (2017). Project-based learning a literature review. Working paper. New York: MDRC. • Fix authors (Missing author, missing initials, etc.) and Invalid DOI link. If no DOI available then provide URL link. Han, S., Rosli, & Capraro, R. (2016). The effect of science, technology, engineering, and mathematics (STEM) project-based learning (PBL) on students' achievement in four mathematics topics. *Journal of Turkish Science Education*, 13, 3-30. https://doi.org/10.12973/tused.10168a • If a source is in another language, write the original title then add its English translation. See https://www.ijem.com/ijem_paper_template.docx Harizah, D. T. D., Sumarni, & Bachri, S. (2021). Pengaruh model pembelajaran project based learning terhadap kreativitas dan hasil belajar geografi siswa. *Journal of Education: Theory, Research, and Development /Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan, 6*(5), 767-771.	R., Burnard, P., & Gray, D. S. (2017). *Reviewing the potential and challenges of developing STEAM education through creative pedagogies for 21 st learning: How can school curricula be broadened towards a more responsive, dynamic and inclusive form of education*. British Educational Research Association. • Condliffe, B., Quint, J., Visher, M. G., Bangser, M. R., Drohojowska, S., Saco, L., & Nelson, E. (2017). *Project-based learning a literature review*. MDRC. • Han, S., Rosli, R., & Capraro, M. M., & Capraro, R. M. (2016). The effect of science, technology, engineering, and mathematics (STEM) project-based learning (PBL) on students' achievement in four mathematics topics. *Journal of Turkish Science Education*, *13*, 3-30. DOI: 10.12973/tused.10168a • Harizah, D. T. D., Sumarni, & Bachri, S. (2021). Pengaruh model pembelajaran project based learning terhadap kreativitas dan hasil belajar geografi siswa [The influence of the project-based learning model on students' creativity and geography learning outcomes]. *Journal of Education: Theory, Research, and Development /Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan, 6*(5), 767-771. • Mansfield, J. (2023). Supporting the development of pre-service teachers' pedagogical knowledge about planning for practical work. *Journal of Science*

			Teacher Education, 34(3), 225-247. https://doi.org/10.1080/1046560X.2022.2042979
		• In sentence case Mansfield, J. (2023). Supporting the Development of Pre-service Teachers' Pedagogical Knowledge about Planning for Practical Work. *Journal of Science Teacher Education, 34*(3), 225-247. https://doi.org/10.1080/1046560X.2022.2042979	• Razi, A., & Zhou, G. (2022). STEM, iSTEM, and STEAM: What is next?. *International of Technology in Education*, *5*(1), 1-29. https://doi.org/10.46328/ijte.119
		• In title case Razi, A., & Zhou, G. (2022). STEM, iSTEM, and STEAM: What is next?. *International of technology in education*, *5*(1), 1-29. https://doi.org/10.46328/ijte.119	• Syawaludin, A., Prasetyo, Z. K., Jabar, C. S. A., & Retnawati, H. (2022). The effect of project-based learning model and online learning setting on analytical skills of discovery learning, interactive demonstrations and inquiry lessons. *Journal of Turkish Science Education*, *19*(2), 608-621 https://www.tused.org/index.php/tused/article/view/1615
		• Need space between initials. Provide DOI link, not Author's ORCID ID link, if not, provide URL link. Syawaluddin, A., Prasetyo, Z.K., Jabar, C.S.A., & Retnawati, H. (2022). The effect of project-based learning model and online learning setting on analytical skills of discovery learning, interactive demonstrations and inquiry lessons. *Journal of Turkish Science Education*, *19*(2), 608-621. https://orcid.org/0000-0003-1876-2866	• Thompson, K., Chapman, S. N., & Kanasa, H. (2020). Tools to mediate learning and self-assessment in a STEAM unit of work. In K. Tomas, & D. Huffman (Eds.), *Challenges and opportunities for transforming from STEM to STEAM education* (pp. 24-50). IGI Global. DOI: 10.4018/978-1-7998-2517-3.ch002
		• Use edited book chapter format. See https://apastyle.apa.org/style-grammar-guidelines/references/examples/edited-book-chapter-references Thompson, K., Chapman, S. N., & Kanasa, H. (2020). Tools to mediate learning and self-assessment in a STEAM unit of work. *In Challenges and Opportunities for Transforming from STEM to STEAM Education*, 24-50. IGI Global.	• Zen, Z., Reflianto, Syamsuar, & Ariani, F. (2022). Academic achievement: the effect of project-based learning method and student engagement. *Heliyon*, 8, 1-13. https://doi.org/10.1016/j.heliyon.2022.e11509
		• Use "&" to separate last two authors	

		Zen, Z., Reflianto, Syamsuar, Ariani, F. (2022). Academic achievement: the effect of project-based learning method and student engagement. *Heliyon*, 8, 1-13. https://doi.org/10.1016/j.heliyon.2022.e11509	