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Developing High School Students' Creativity Through Practical Work on Utilizing Durian Peel Waste in Project-Based Learning

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ABSTRACT

This study aims to develop a practical work design for creating briquettes from durian peel waste and to identify the development of high school students' creativity through this practical work in the context of project-based learning on petroleum. Adopting a mixed-methods approach, this research involved 48 eleventh-grade students from a high school in South Sumatra. The practical work design encompassed six critical stages: raw material preparation, carbonization, pulverization, mixing, molding, and drying durian peel waste into briquettes. The research comprehensively assessed students' creativity across three dimensions: creative thinking skills, creative attitudes, and creative actions. The results demonstrated significant improvements: creative thinking skills showed an n-gain of 0.59, creative attitudes an n-gain of 0.68, and creative actions an impressive n-gain of 0.84. This approach facilitates a deeper understanding of chemical concepts and aligns with the Merdeka Curriculum's principles of developing 21st-century skills. By integrating contextual learning, environmental awareness, and practical innovation, the study provides a meaningful approach to chemistry education that encourages student creativity, problem-solving, and entrepreneurial thinking while addressing waste management and alternative energy challenges. The research implications underscore the importance of implementing project-based, contextually relevant learning strategies in high school chemistry education to enhance student engagement and skill development.

INTRODUCTION

In the era of modern education, developing students' creativity has become one of the primary focuses in the learning process. This is increasingly relevant with the implementation of the Merdeka Curriculum in Indonesia, which emphasizes the importance of developing 21st-century competencies and skills, including creativity. Creativity in chemistry education represents a critical educational strategy that transforms traditional learning from passive knowledge acquisition to active, innovative problem-solving (Aidoo et al., 2016; Konopka et al., 2015; Lombardi et al., 2021; Marchak, Shvarts-serebro, et al., 2021; Veerasinghan et al., 2021). By fostering creative thinking, students are not merely learning chemical concepts, but developing the cognitive flexibility necessary to address complex real-world challenges. The Merdeka Curriculum specifically recognizes this imperative, positioning creativity as a fundamental competency that transcends disciplinary boundaries. In chemistry, creativity manifests through students' abilities to design experimental approaches, develop novel solutions to scientific problems, and connect theoretical knowledge with practical applications (Heller, 2007; Holmes, 1985; Jang, 2009; Marfu'ah & Meristin, 2022; Rees & Newton, 2020; Vázquez-Villegas et al., 2023; Yang et al., 2022; Zhu et al., 2024). This approach aligns perfectly with the curriculum's goal of developing holistic learners who can think critically, adapt to changing

contexts, and contribute meaningfully to societal development through scientific innovation. Chemistry education, as a subject closely related to everyday life (Ananda et al., 2023; Atkins & Paula, 2005; Chi et al., 2024; Harris, 1980; Marfu'ah et al., 2022, 2024; Marfu'ah & Anwar, 2018; Marfu'ah & Meristin, 2022; Meristin et al., 2022; Orosz et al., 2022; Winkelmann et al., 2020), has great potential to facilitate the development of students' creativity through innovative and contextual learning approaches (Karamustafaoğlu & Pektaş, 2023; Kwangmuang et al., 2021; Marchak, Shvarts-Serebro, et al., 2021; Nuswowati & Taufiq, 2015; Samsudin & Raharjo, 2023; Sener et al., 2015; Tomasevic & Trivic, 2014; Veerasinghan et al., 2021; Yoon et al., 2015).

The growing concern over environmental sustainability and energy security has led to increased interest in converting waste materials into valuable resources. Durian peel waste, which constitutes about 60-75% of the total fruit weight and is often discarded, presents a significant environmental challenge in Indonesia and other Southeast Asian countries. However, this waste material possesses characteristics that make it an excellent candidate for conversion into briquettes - it has high cellulose content, good calorific value, and is abundantly available (Manmeen et al., 2023). Converting durian peel waste into briquettes not only addresses waste management issues but also provides a sustainable alternative to fossil fuels (Chua et al., 2023), making it an ideal context for teaching chemistry concepts related to petroleum.

One approach that aligns with the principles of the Merdeka Curriculum is project-based learning (PBL) (Abdul et al., 2022; Risqi et al., 2023; Roberts & Nurkhamidah, 2024; Wulandari & Nawangsari, 2024). PBL allows students to actively engage in the learning process (Almulla, 2020; Hmelo-Silver, 2004; Zhao & Wang, 2022), apply their knowledge in real-world contexts (de la Puente Pacheco et al., 2022; Smith et al., 2022; Varadarajan & Ladage, 2024; Zhao & Wang, 2022), and develop higher-order thinking skills (Darwis & Patimbangi, 2024; Luchang & Nasri, 2023; Tambak & Siregar, 2023). In the context of chemistry education, practical work on making briquettes from durian peel waste offers a unique opportunity to combine chemical concepts with relevant environmental and alternative energy issues (Brunerová et al., 2017; Gamay et al., 2024a; Ly et al., 2024; Rimantho et al., 2024; Sanchez et al., 2022).

The utilization of durian peel waste as a raw material for briquette production not only provides an innovative solution to waste management problems but also opens up opportunities to explore chemical concepts such as carbonization, calorific value, and combustion reactions in a meaningful context for students (Chua et al., 2023; Gamay et al., 2024b; Leesing et al., 2021; Leong & Chang, 2022). Furthermore, this project has the potential to develop students' environmental awareness and entrepreneurship, which are important aspects of the Pancasila Student Profile as outlined in the Merdeka Curriculum.

Based on this background, this study aims to: (1) Develop a practical work design for creating briquettes from durian peel waste that aligns with the principles of the Merdeka Curriculum, and (2) Identify the development of high school students' creativity through this practical work in the context of project-based learning on the topic of petroleum. The results of this study are expected to provide a significant contribution to the development of innovative and relevant chemistry teaching methods that align with the objectives of the Merdeka Curriculum.

METHODS

Research Design

This study adopts a mixed-methods approach, combining qualitative and quantitative methods to obtain a comprehensive understanding of the phenomenon under study (Creswell & Plano Clark, 2023). In the initial stage, descriptive research was conducted to design the

practical work for making briquettes from durian peel waste. This design was then implemented using a Quasi-Experimental method with a non-equivalent control group design.

Research Target

The research subjects consisted of 48 eleventh-grade students from a high school in South Sumatra, divided into control and experimental groups, each consisting of 24 students. Sample selection was carried out using purposive sampling technique, considering the equivalence of students' initial abilities based on their average chemistry scores from the previous semester.

Research Data

Data was collected through observation sheets, questionnaires and tests. Observation sheets, designed to evaluate students' creative thinking, attitudes, and actions. Written tests measuring concept understanding and creative thinking. The questionnaire was used to see students' responses to the practice of making briquettes from durian skin waste.

Research Instruments

The data collection instruments were comprehensive and rigorously validated through various methods to ensure reliability and accuracy. Observation sheets, designed to evaluate students' creative thinking, attitudes, and actions, were validated using the Aiken's V method and reviewed by three experienced chemistry education experts. Written tests measuring concept understanding and creative thinking were validated through expert judgment, item analysis, and Cronbach's alpha for reliability. Questionnaires assessing students' responses underwent face validity checks, pilot testing, and statistical reliability analysis. All instruments met psychometric standards, ensuring they were both theoretically and empirically robust for the study.

Data Analysis

Data analysis was conducted descriptively and inferentially. An independent t-test was used to test the significance of differences between the control and experimental classes, while n-gain calculations were used to measure the magnitude of increase in students' creativity. Qualitative analysis was carried out on observation results and student responses to obtain a deeper understanding of the creativity development process in the context of project-based learning.

RESULTS AND DISCUSSION

Practical Work Design for Making Briquettes from Durian Peel Waste

The research results at the planning stage produced a practical work design for making briquettes from durian peel waste, consisting of six main stages (Table 1): raw material preparation, carbonization, pulverization, mixing, molding, and drying. This design was developed considering the principles of the Merdeka Curriculum, especially in terms of creativity development, problem-solving, and contextual learning.

Table 1. Process of Making Briquettes from Durian Peel: Steps, Tools, Materials, and Quantities

No.	Step	Description	Tools and Materials	Quantity
1	Raw material preparation	Durian peel is cleaned, dried, and chopped into smaller sizes.	Durian peel, water, knife, and cutting board.	• 2 kg durian peel • 2 liters of water • 1 knife • 1 cutting board
2	Carbonization	The chopped durian peel is carbonized at 400°C for 2.5 hours.	Electric oven	1 electric oven

3	Pulverization	Durian peel charcoal is ground into powder.	Blender and sieve	• 1 blender • 1 sieve
4	Mixing	Charcoal powder is mixed with a binder (tapioca flour) in a 1:10 ratio.	Large bowl, spoon, spatula, tapioca flour.	• 1 large bowl • 1 spoon • 1 spatula • 100 grams of tapioca flour
5	Molding	The mixture is molded into the desired briquette shape.	Simple briquette mold (can be plastic or metal), pressing tool (can be by hand)	1 simple briquette mold
6	Drying	Briquettes are dried using an oven at 100°C for 6 hours	Drying rack, electric oven	• 1 drying rack • 1 electric oven

This practical work design is intended to be carried out with simple equipment available in school laboratories, making it easy to implement in learning. The main innovation in this practical work design is the integration of chemical concepts with environmental and renewable energy issues. Students not only learn about carbonization and combustion processes theoretically but also apply them in the real context of waste utilization. This approach aligns with the principles of contextual and problem-based learning promoted by the Merdeka Curriculum.

Development of Students' Creativity

The analysis results show that the creativity of students in the experimental class who conducted the practical work of making briquettes from durian peel waste experienced significant development compared to the control class. This improvement is evident in three main aspects of creativity:

1. Creative Thinking Skills

Students' creative thinking skills were measured through indicators of fluent, flexible, and evaluative thinking. The analysis results show development in the medium category, with an average n-gain of 0.59.

Table 2. Average N-Gain Scores for Creative Thinking Skills

Indicator	Experimental Class	Control Class
Fluent Thinking	0.62	0.31
Flexible Thinking	0.58	0.28
Evaluative Thinking	0.57	0.30
Average	0.59	0.30

The improvement in creative thinking skills can be attributed to the characteristics of project-based learning that provide students with opportunities to explore various solutions in making briquettes. Students are required to think fluently in identifying problems and proposing ideas, think flexibly in adapting procedures to existing conditions, and think evaluatively in assessing the quality of the produced briquettes.

2. Creative Attitudes

The development of students' creative attitudes shows a medium category with an average n-gain of 0.68. The measured indicators include curiosity, appreciation, and risk-taking attitude, as shown in Table 3.

Table 3. Average N-Gain Scores for Creative Attitudes

Indicator	Experimental Class	Control Class
Curiosity	0.71	0.35
Appreciation	0.67	0.33
Risk-Taking	0.66	0.32
Average	0.68	0.33

The improvement in creative attitudes can be associated with the project-based learning process that encourages students to actively seek information, appreciate opinions of peers in the group, and dare to try new methods in making briquettes.

3. Creative Actions

Students' creative actions show development in the high category, with an average n-gain of 0.84. The measured indicators include preparing, conducting, and communicating practical work results, as shown in Table 4.

Table 4. Average N-Gain Scores for Creative Actions

Indicator	Experimental Class	Control Class
Preparing	0.86	0.42
Conducting	0.83	0.40
Communicating	0.83	0.41
Average	0.84	0.41

The high increase in creative actions indicates that the practical work of making briquettes from durian peel waste provides students with opportunities to apply their knowledge directly. Students not only understand concepts theoretically but are also able to design, implement, and communicate their experimental results. The results of this study indicate that the practical work of making briquettes from durian peel waste in project-based learning is effective in developing students' creativity. This aligns with previous research conducted by Adawiyah (2020), Andini & Rusmini (2022), Ekaputra (2024), Ling et al. (2024), Simangunsong et al. (2024), Suradika et al. (2023), and Wijayati et al. (2019), which demonstrated the effectiveness of project-based learning in enhancing student creativity.

Students' Response to the Practical Work

The questionnaire results show that the majority of students (92%) gave positive responses to the practical work of making briquettes from durian peel waste. Students felt that this practical work was interesting, relevant to daily life, and helped them better understand the concept of petroleum. Some students also expressed that this project opened their perspectives on waste-based entrepreneurship potential, which aligns with the independence aspect of the Pancasila Student Profile. This research has significant implications for the implementation of the Merdeka Curriculum in high school chemistry education. First, the project-based learning approach used in this study demonstrates how the principles of the Merdeka Curriculum, such as contextual learning and 21st-century skills development, can be effectively integrated into the chemistry curriculum. Second, the practical work of making briquettes from durian peel waste provides a concrete example of how chemistry learning can be linked to environmental and renewable energy issues, in line with the Merdeka Curriculum's focus on sustainable development. This opens up opportunities for the development of similar learning modules that integrate various disciplines. Third, the significant increase in students' creativity demonstrates that this approach is effective in developing one of the key competencies emphasized in the Pancasila Student Profile. This affirms the importance of adopting learning methods that provide space for students to explore, experiment, and innovate. Nevertheless, this study also has some limitations. First, the relatively small sample size limits the generalization of results. Second, the short duration of the study may not be sufficient to observe long-term creativity development.

CONCLUSION AND RECOMMENDATIONS

Based on the research results and analysis, the practical work design for creating briquettes from durian peel waste has been successfully developed and effectively implemented in high school chemistry education. The design, which incorporates six systematic stages (raw material preparation, carbonization, pulverization, mixing, molding, and drying), proved to be feasible using basic laboratory equipment while effectively integrating chemical concepts with real-world environmental and renewable energy issues. This alignment with Merdeka Curriculum principles was demonstrated through its practical applicability and contextual learning approach. The study showed significant development in students' creativity through this project-based learning approach. Quantitative analysis revealed improvements across three key dimensions: creative thinking skills (n-gain 0.59), creative attitudes (n-gain 0.68), and creative actions (n-gain 0.84). The notably high improvement in creative actions particularly indicates the effectiveness of hands-on, project-based learning in developing practical creativity skills. Furthermore, the overwhelmingly positive student response (92%) suggests that this approach successfully engages students while making chemistry learning more relevant to their daily lives. This research demonstrates that utilizing durian peel waste for briquette production in project-based learning not only serves as an effective method for teaching petroleum-related concepts but also successfully develops students' creativity and environmental awareness. The approach proves particularly valuable in the context of the Merdeka Curriculum, as it simultaneously addresses content knowledge, practical skills, and 21st-century competencies. These findings suggest that integrating similar contextual, project-based learning approaches into chemistry education could enhance both subject understanding and creative capability development among high school students. The implications of this research highlight the importance of integrating contextual and project-based learning into the high school chemistry curriculum. This approach has the potential to enhance the relevance of chemistry learning for students while developing key competencies such as creativity, problem-solving, and environmental awareness.

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