

Development of Green Chemistry-Oriented Student Worksheets for Home Industry Product Manufacturing

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ABSTRAK

Penelitian ini bertujuan untuk mengembangkan Lembar Kerja Mahasiswa (LKM) berwawasan *green chemistry* yang dapat digunakan dalam kegiatan praktik pembuatan produk *home industry*, khususnya sabun cuci piring ramah lingkungan. Metode yang digunakan adalah *Research and Development (R&D)* dengan model pengembangan 4-D, yang meliputi tahap *Define*, *Design*, dan *Develop*. Validasi dilakukan oleh tiga ahli terhadap aspek isi, bahasa, prinsip *green chemistry*, dan penyajian. Uji coba terbatas dilakukan kepada 35 mahasiswa dari berbagai program studi. Hasil validasi menunjukkan bahwa LKM sangat valid, dengan skor rata-rata keseluruhan 4,55 dari skala 5. Praktikalitas LKM juga dinilai sangat baik oleh mahasiswa, dengan skor rata-rata 4,64. LKM ini tidak hanya membantu mahasiswa memahami prinsip kimia hijau dan melakukan praktik yang kontekstual, tetapi juga menumbuhkan semangat kewirausahaan melalui pembuatan produk yang ramah lingkungan. Hasil penelitian menunjukkan bahwa pengembangan LKM berbasis *green chemistry* efektif meningkatkan literasi kimia, kesadaran lingkungan, dan keterampilan abad ke-21 mahasiswa. Oleh karena itu, LKM ini direkomendasikan untuk digunakan dalam pembelajaran kimia yang berorientasi pada keberlanjutan dan pengembangan *soft skills*.

Keyword: Lembar Kerja Siswa; Kimia Hijau; Industri Rumah Tangga; Kewirausahaan

ABSTRACT

This study aims to develop a green chemistry-based Student Worksheet (LKM) that can be used in practical activities for making home industry products, specifically environmentally friendly dishwashing soap. The method used is Research and Development (R&D) with a 4-D development model, which includes the Define, Design, and Develop stages. Validation was carried out by three experts on aspects of content, language, green chemistry principles, and presentation. A limited trial was conducted on 35 students from various study programs. The validation results showed that the LKM was highly valid, with an overall average score of 4.55 on a scale of 5. The practicality of the LKM was also rated very well by students, with an average score of 4.64. This LKM not only helps students understand the principles of green chemistry and carry out contextual practices, but also fosters an entrepreneurial spirit through the creation of environmentally friendly products. The results of the study indicate that the development of a green chemistry-based LKM is effective in improving students' chemical literacy, environmental awareness, and 21st-century skills. Therefore, this LKM is recommended for use in chemistry learning oriented towards sustainability and soft skills development.

Keyword: Student Worksheets; Green Chemistry; Home Industry; Entrepreneurship

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1. INTRODUCTION

Environmental pollution issues caused by the use of synthetic chemicals in daily life have become a serious concern in many countries, including Indonesia. Various household products such as detergents, dishwashing liquids, and laundry perfumes commonly used by the public generally contain chemical substances that have the potential to pollute the environment. Therefore, efforts to educate the public—

particularly the younger generation—about the importance of using environmentally friendly materials are increasingly relevant and urgent. In this context, higher education institutions have a strategic role in instilling values of sustainability and *green chemistry* through various innovations in learning.

Sunan Doe Institute of Islamic Studies, as one of the higher education institutions with a vision to produce professional and environmentally conscious educators and entrepreneurs, organizes a *home industry* program as part of students' *soft skill* development. This program encourages students to create and market small-scale industrial products that are safe, economical, and eco-friendly. To ensure that this activity runs optimally and is pedagogically guided, there is a need for an applicative and contextual learning medium, such as a Student Worksheet (*LKM*) integrated with *green chemistry* principles.

Research on the development of student worksheets has been widely conducted. Sari & Wulanda (2019) demonstrated that project-based worksheets can enhance students' creative potential. Ramadhona and Izzati (2018) emphasized the importance of effectiveness and practicality in worksheet development. Meriani et al. (2023) developed scientific approach-based worksheets to improve students' scientific thinking skills. On the other hand, the *green chemistry* approach has begun to be applied in the development of learning media by Muzdalifah (2023), Zai and Ulianas (2023), as well as Wiranti and Sholeh (2023), although their studies were still limited to laboratory practices without reinforcing entrepreneurial aspects.

The scientific novelty of this research lies in the development of a *green chemistry*-oriented Student Worksheet that not only functions as a practicum guide but also serves as a tool to strengthen students' entrepreneurial spirit through *home industry* activities. This worksheet is designed to ensure that students not only understand the principles of *green chemistry* but are also able to practice making environmentally friendly household products, such as dishwashing soap from natural ingredients. This approach integrates cognitive, psychomotor, and affective aspects in a contextual and meaningful learning process (Febriana et al., n.d.).

The main problem in this study is how to develop a *green chemistry*-oriented Student Worksheet that is valid and practical for use by students of the Sunan Doe Institute of Islamic Studies in *home industry* activities. In addition, this research seeks to answer questions regarding the characteristics and quality of the worksheet in terms of content validity, language, *green chemistry* principles, and presentation, as well as the level of practicality of its use in the field (Zulfa & Anwar, n.d.). Therefore, the purpose of this study is to develop a *green chemistry*-oriented Student Worksheet for the production of *home industry* products that is valid and practical, while also contributing to the improvement of chemical literacy, environmental awareness, and students' entrepreneurial skills within the context of 21st-century learning.

2. RESEARCH METHOD

This study is development research (Research and Development) aimed at producing a product in the form of a *green chemistry*-oriented Student Worksheet (*LKM*) that is valid and practical for use in *home industry* activities. The development model employed in this study is the 4-D (*Four-D*) Model, which consists of four stages: *Define*, *Design*, *Develop*, and *Disseminate* (Al Idrus et al., 2020). However, this research was conducted only up to the *Develop* stage.

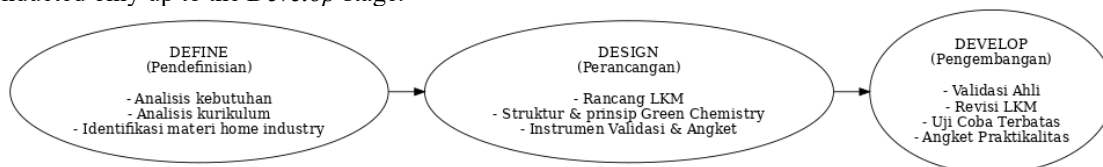


Figure 1. Flowchart Research

A. Research Phases

1) Define

At this stage, several activities were carried out, including: analyzing students' needs for practical and contextual chemistry practicum learning media; analyzing the curriculum and materials relevant to the practice of making *home industry* products; and identifying the principles of *green chemistry* that can be applied in practicum activities.

2) Design

The development process involved several key steps. First, the Student Worksheet (*LKM*) was designed based on the results of the needs analysis and relevant subject matter. Then, the structure of the *LKM* was arranged to include learning objectives, step-by-step work instructions, integration of *green chemistry* principles, and activity reflection. Additionally, research instruments were prepared, including a validation sheet and a practicality questionnaire.

3) Develop

The validation of the Student Worksheet (*LKM*) was carried out by three experts, covering aspects of content, language, *green chemistry* principles, and presentation. Based on the suggestions provided by the

validators, revisions were made to improve the *LKM*. A limited trial was then conducted involving 35 students from the Science Education (*Tadris IPA*), Chemistry Education (*Tadris Kimia*), and Social Studies Education (*Tadris IPS*) programs. Data on the practicality of the *LKM* were collected through questionnaires completed by the students after the practicum.

4) Data Collection Methods

The data in this study were collected using two main techniques. First, expert validation was conducted using a validation sheet to assess the feasibility of the Student Worksheet (*LKM*) in terms of content, presentation, language, and integration of *green chemistry* principles. Second, a practicality questionnaire was employed to gather students' responses to the developed worksheet. The scores were obtained based on four indicators: content comprehensibility, clarity of procedural steps, student interest, and relevance to entrepreneurship.

3. RESULTS AND DISCUSSION

This research resulted in a product in the form of a *green chemistry*-oriented Student Worksheet (*LKM*), which was used in practical activities for producing dishwashing soap—one of the *home industry* products at the Sunan Doe Institute of Islamic Studies. The results of validation and testing indicated that the developed *LKM* was feasible to use and effective in improving the quality of learning, while also shaping students' entrepreneurial character and environmental awareness.

A. Validity of the Worksheet: Integration of Content, Environment, and Entrepreneurship

Based on validation by three experts, the *LKM* was declared highly valid with average scores in the following aspects: content (4.6), language (4.4), *green chemistry* principles (4.7), and presentation (4.5). This shows that the worksheet meets academic content standards, readability, and relevance to contextual learning needs. Scientifically, these findings demonstrate that chemistry material can be contextualized into simple yet meaningful practices without losing its scientific value. The worksheet includes activities that not only provide practicum procedures but also encourage students to think critically about the processes, materials used, and their environmental impact. This positions the worksheet as a constructivist learning medium, allowing knowledge to be built through direct experience.

Table 1. Validation Results of the Student Worksheet

Assessed Aspect	Average Score	Category
Content	4.6 / 5	Very Good
Language	4.4 / 5	Good
Green Chemistry Principles	4.7 / 5	Very Good
Presentation	4.5 / 5	Good
Overall Average	4.55 / 5	Very Good

This research expands on Sari's (2019) findings, which focused only on student creativity in project-based worksheets, by adding sustainability and environmental literacy components that are increasingly crucial in the modern era.

B. Practicality of the Worksheet: High Engagement and Procedural Accessibility

Findings from the trial with 35 students revealed that the worksheet was highly practical, with scores in content comprehension (4.6), clarity of procedures (4.7), content interest (4.5), and suitability as an entrepreneurship tool (4.8). Overall, students were able to understand the worksheet content well, follow the procedures easily, and showed high enthusiasm during practice. This indicates active student engagement in the learning process. According to Vygotsky's theory (1978), collaborative and contextual learning can significantly enhance meaningful understanding. The worksheet developed not only includes step-by-step instructions but also reflective and evaluative components that allow students to engage in metacognition about their learning process.

Table 2. Practicality Results Based on Student Responses

Practicality Indicator	Average Score (1–5)	Category
Content Comprehension	4.6	Very Practical
Procedural Clarity	4.7	Very Practical
Content Interest	4.5	Practical
Relevance to Student Needs	4.6	Very Practical
Suitability for Entrepreneurship	4.8	Very Practical
Overall Average	4.64 / 5	Very Practical

This high level of practicality also indicates that contextual, project-based learning can bridge the gap between theory and practice. These findings support Ramadhona & Izzati (2018), who argued that effective worksheets can increase student engagement and understanding in learning.

C. Conceptual Transformation Through Green Chemistry Principles

One of the key aspects of this worksheet's development is the application of *green chemistry* principles, including the use of renewable materials (e.g., lime extract, natural bar soap), avoidance of synthetic chemicals, energy efficiency (no excessive heating), and waste minimization. These findings show a conceptual transformation in students—from simply producing soap to understanding sustainability principles in chemistry. Students are encouraged to question material choices, consider environmental impacts, and evaluate product safety.

In modern science education, this ability is referred to as the environmental dimension of scientific literacy, meaning an understanding of science within the context of environmental issues. This approach is supported by Patmawati (2021) and Muzdalifah (2023), who argue that chemistry education should aim to develop critical thinking about the impact of chemistry in real life.

D. Development of Soft Skills: Entrepreneurship, Collaboration, and Creativity

The worksheet is also designed to enhance students' non-academic competencies, particularly entrepreneurial spirit. After completing the practice session, some students expressed interest in producing the dishwashing soap independently. This indicates that the worksheet fosters entrepreneurship and innovative skills essential for future graduates. Collaborative elements also emerged during the practice sessions, with students working in teams to plan production strategies and assign roles. This aligns with 21st-century skill demands, including communication, collaboration, problem-solving, and digital literacy.

These findings support the study by Permestisari et al. (2022), which concluded that learning media integrated with entrepreneurship practices can shape students into independent and innovative individuals. In this context, the worksheet functions not only as a learning tool but also as a medium for character building and *soft skill* development.

4. CONCLUSION

Based on the research results and discussion concerning the numeracy literacy skills of eighth-grade students at MTs NW Aik Anyer on the topic of data presentation in the *Merdeka Belajar* era, it is known that achievement across all numeracy literacy indicators is not yet optimal. This indicates that, in general, the students' numeracy literacy level is still considered low. Of the 20 students who were subjects of the study, the results showed that for the first indicator—the ability to use various types of numbers and symbols related to basic mathematical operations to solve everyday problems—the percentage was in the “Low” category. Similarly, the second indicator—the ability to analyze information in visual formats such as graphs, tables, charts, and diagrams—also showed low achievement. Meanwhile, for the third indicator—the ability to interpret the results of an analysis to make predictions, formulate conclusions, and make decisions—the results also fell into the “Low” category.

Overall, the findings of this study address the research questions and support the hypothesis that the developed *green chemistry*-oriented Student Worksheet (*LKM*):

- Is valid and feasible for use in practicum activities based on *home industry* practices.
- Is practical and capable of facilitating active, reflective, and contextual learning.
- Fosters environmental awareness through the integration of *green chemistry* principles.
- Promotes students' *soft skills* in terms of collaboration, entrepreneurship, and innovation.

These findings not only enrich the body of research on instructional media development but also contribute to the advancement of chemistry learning models that support the formation of environmentally conscious and productive character in the global era.

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