ORBITAL: JURNAL PENDIDIKAN KIMIA
Website : jurnal.radenfatah.ac.id/index.php/orbital
ISSN 2580-1856 (print) ISSN 2598-0858 (online)

Analysis of Student Worksheet Needs in Green Chemistry Based Physics Chemistry Practicum

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ARTICLE INFO

Article History:
Received 01 November 2025
Revised 22 November 2025
Accepted 08 December 2025
Published 21 December 2025

Keywords:
Green chemistry;
Physics chemistry practicum;
Student worksheets.

ABSTRACT

Sustainability issues in chemistry laboratories are increasingly important to address, particularly because practicum activities often generate hazardous waste that can negatively affect both health and the environment. One approach that can be applied in chemistry education to reduce such risks is the implementation of green chemistry principles. In this context, the availability of learning materials that align with environmentally friendly practices is essential, including Student Worksheets used in Physical Chemistry practicum activities. This study aims to analyze students' needs for green chemistry-based Student Worksheets to support Physical Chemistry practicum learning. The research employed a descriptive method with a qualitative approach, collecting data through questionnaires and interviews distributed via Google Form. The analysis process included data reduction, data presentation, and conclusion drawing, ensuring that the findings accurately reflected students' needs for the development of Green Chemistry–based Student WorksheetsThe results indicate that students require worksheets that not only facilitate conceptual understanding but also promote independent learning through safer, more efficient, and environmentally responsible laboratory practices. The findings further show that integrating green chemistry principles into the worksheets has the potential to enhance learning effectiveness and create more sustainable practicum experiences. Therefore, the development of green chemistry-based Student Worksheets is considered crucial for providing valid, practical, and effective learning media that support sustainability-oriented chemistry education in laboratory settings.

INTRODUCTION

Higher education plays an essential role in preparing quality human resources who are capable of addressing major global challenges such as climate change, environmental degradation, and resource scarcity (Rahmawati, 2019). Therefore, universities are required to design innovative and sustainability-oriented learning approaches (Darsyah, 2023). In the field of chemistry education, efforts toward sustainability are increasingly emphasized because chemical processes and laboratory practices often involve hazardous materials that may negatively impact the environment (Dayrit & Enriquez, 2023) These challenges highlight the importance of integrating environmentally responsible approaches one of which is green chemistry into learning activities, especially in laboratory-based courses (Mitarlis et al., 2023)

Chemistry as a discipline is closely related to human life and is inseparable from experimental activities carried out through practicum sessions (Nurmilawati et al., 2021). However, many laboratory activities still rely on conventional methods that generate hazardous waste, making practicum sessions a potential source of environmental pollution (Purwanti et al., 2023) To address this issue, green chemistry has emerged as a relevant concept that promotes safer and more sustainable chemical practices (Ratri & Verina, 2024). Green chemistry introduces twelve fundamental principles that aim to minimize environmental impact, reduce toxicity, and encourage efficient use of materials and energi (Najih, 2019) These principles can be integrated into laboratory learning to provide safer, more sustainable, and impactful practicum experiences for students (Al Idrus et al., 2020).

In the Chemistry Education Study Program of Sriwijaya University, the Physical Chemistry Practicum is one of the courses that inherently involves chemical usage and laboratory processes. Although some practicum materials already apply certain green chemistry principles such as reducing reagent concentrations, they still generate hazardous waste and lack structured guidance that explicitly embeds sustainability-oriented practices. This indicates a gap between the sustainability principles promoted in literature and their actual implementation in practicum activities. Therefore, appropriate teaching materials are required to support safer and environmentally responsible laboratory learning.

Student Worksheets (LKM) serve as one of the learning resources that can guide students through practicum activities in a structured and comprehensible manner(Al-Idrus et al., 2020). Previous studies have explored the development of green chemistry–based practicum modules and electronic guide (Ilma et al., 2022). Showing that integrating green chemistry enhances environmental literacy, safety awareness, and scientific reasoning skills (López et al., 2025). However, most existing research focuses on high school modules, environmental chemistry practicums, or specific laboratory activities (Syam, 2020). Very limited studies have examined the need for green chemistry–based Student Worksheets specifically in the Physical Chemistry Practicum at the university level to the concept of green chemistry and the SDGs (Ilma et al., 2022).

To address this gap, the present study aims to analyze student needs regarding the development of Student Worksheets based on green chemistry principles for the Physical Chemistry Practicum. Operationally, this study seeks to (1) identify students' perceptions of existing practicum teaching materials, (2) assess their understanding and awareness of green chemistry principles, (3) determine the necessity for integrating green chemistry into practicum worksheets, and (4) map specific aspects required in developing environmentally responsible and pedagogically effective LKM.

METHODS

Research Desain

This study employed a descriptive method with a qualitative approach to explore students' needs regarding the development of Green Chemistry–based Student Worksheets (LKM) for the Physical Chemistry Practicum (Citradin, 2020). This approach was chosen because it allows for a deeper understanding of students' perceptions, experiences, and learning needs.

Research Target

The research target of this study was students' needs and perceptions regarding the development of Green Chemistry–based Student Worksheets (LKM) for the Physical Chemistry Practicum. This study did not involve any treatment or intervention; instead, it focused on identifying gaps between existing practicum materials and students' expectations related to environmentally responsible laboratory learning. The research subjects consisted of students from the Chemistry Education Study Program at Sriwijaya University who had

completed the Physical Chemistry Practicum course. The participants were selected using a purposive sampling technique, with criteria determined based on the needs of the study, including:

1. Students who had taken and completed the practicum;
2. Students who were willing to fill out the questionnaire;
3. Several lecturers and laboratory assistants involved in the practicum activities.

A total of 50 students participated in this study. This number was considered adequate to provide an initial overview of the students' needs for the development of Green Chemistry–based worksheets

Research Data

The data collection techniques consisted of questionnaires and interviews. The questionnaire was administered to students to obtain data on their abilities in green chemistry–based physical chemistry practicum. These interviews provided deeper insights into the specific needs and expectations related to the development of the worksheets.

Research Instruments

1. Questionnaire

   The questionnaire was distributed through Google Forms to ensure accessibility and convenience for respondents. It included questions related to:

   1. the availability and quality of existing practicum materials;
   2. students' understanding of practicum concepts;
   3. students' knowledge of Green Chemistry principles;
   4. challenges encountered during the practicum;
   5. the need for environmentally friendly and more supportive practicum materials.

2. Interview

   Semi-structured interviews were conducted with several students and laboratory assistants to strengthen and clarify the results obtained from the questionnaire.

Data Analysis

Data were analyzed using descriptive qualitative analysis. Questionnaire responses were summarized in the form of percentages to describe trends in students' perceptions and needs. Interview data were analyzed by identifying key themes that supported and clarified the questionnaire results. The analysis process included data reduction, data presentation, and conclusion drawing, ensuring that the findings accurately reflected students' needs for the development of Green Chemistry–based Student Worksheets.

RESULTS AND DISCUSSION

This research was conducted to be able to find out the needs of students in the development of Student Worksheets which are used to be able to support Physics Chemistry Practicum activities based on Green Chemistry. In this study, a questionnaire was distributed to 50 respondents who were students who had taken the Chemistry and Physics Practicum course. The distribution of questionnaires is carried out online so that the filling out of the questionnaire is carried out online by the respondents is then analyzed to be able to obtain an overview of the factual conditions regarding the needs for the development of teaching materials.

This study aimed to identify students' needs related to the development of Green Chemistry–based Student Worksheets (LKM) for the Physical Chemistry Practicum. The results obtained from the 50 participating students show a clear picture of their experiences and expectations toward practicum learning materials. Although all respondents (100%) reported

that teaching materials for the practicum were available, a substantial proportion (57.4%) indicated that these materials were not yet aligned with Green Chemistry principles. This finding suggests that existing worksheets or modules remain conventional and have not explicitly integrated sustainability-oriented practices, which is consistent with previous studies reporting that many chemistry laboratories in higher education still rely on traditional practicum guides that do not address environmental impacts or waste reduction (Anggraeni et al., 2024) and (Azzajjad et al., 2024) This condition highlights a gap between actual laboratory practices and the sustainable approaches promoted in Green Chemistry literature.

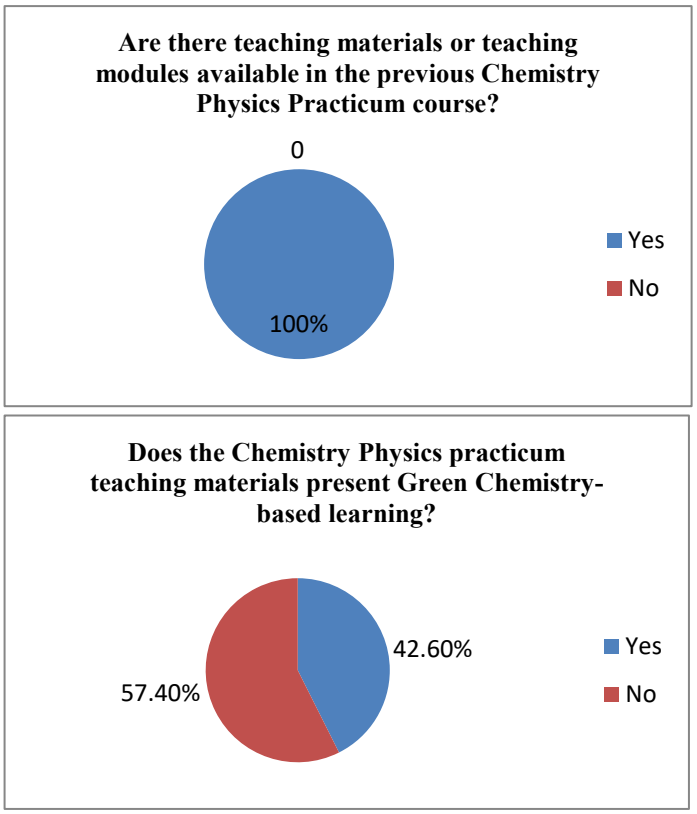
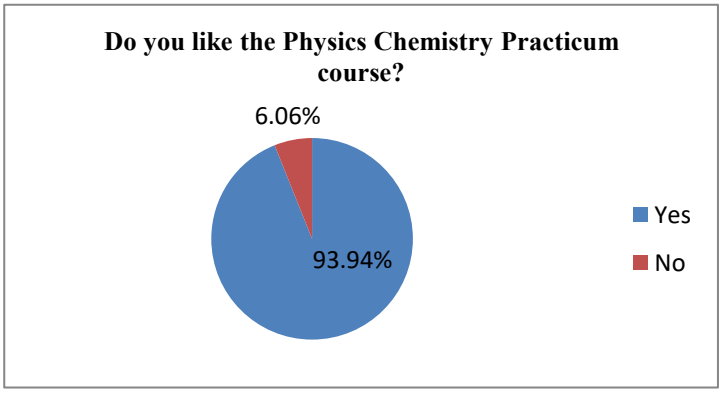


Figure 1. The results of Physical Chemistry practicum teaching materials that present Green Chemistry principles

Despite the limitations of existing materials, students showed strong enthusiasm toward practicum activities. The majority enjoyed the practicum (93.94%), felt motivated during sessions (99.04%), and reported understanding the concepts taught (98.58%). These responses indicate that laboratory activities are highly engaging for students and therefore hold strong potential as an effective channel for introducing sustainability concepts. This strengthens the argument who state that integrating Green Chemistry into laboratory instruction not only enhances conceptual understanding but also increases safety awareness and learning quality (Wahyuningsih et al., 2018).



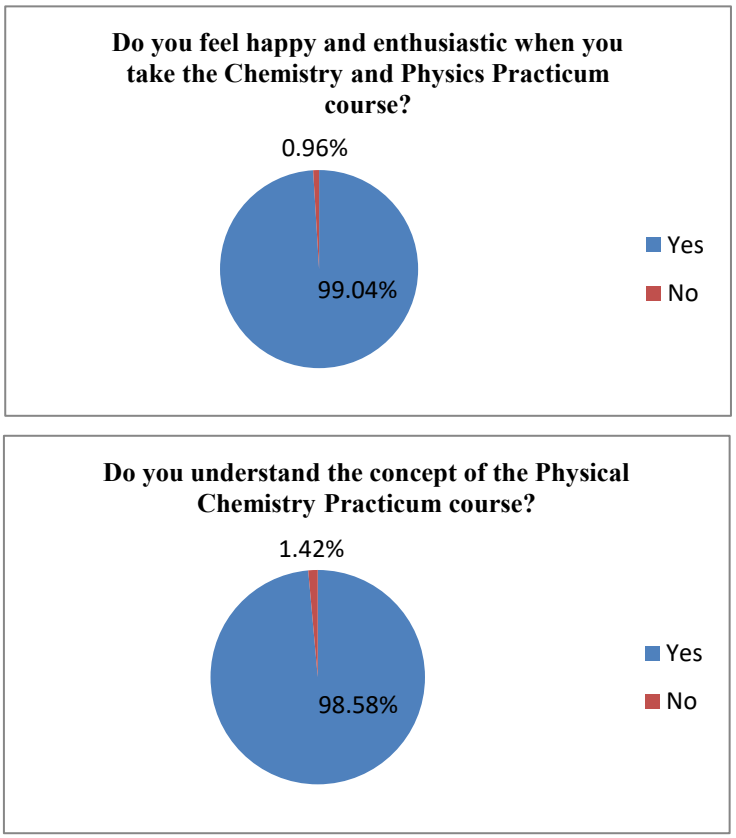


Figure 2. Survey Results on Students' Enthusiasm Toward Practicum Activities

However, students' knowledge of Green Chemistry is not yet fully developed. While 79.64% claimed to understand the principles, 20.36% admitted limited knowledge. This uneven understanding demonstrates the need for structured learning materials that embed Green Chemistry systematically into practicum instructions. Previous studies, such as those by Dewi & Listyarini, (2022) and Silva Júnior et al (2024) emphasize that learning resources incorporating Green Chemistry contribute significantly to improving students' environmental literacy, an important competency that connects scientific knowledge with responsible environmental behavior. Considering this, the development of Green Chemistry–based worksheets can serve as an important step toward strengthening environmental literacy among chemistry education students.

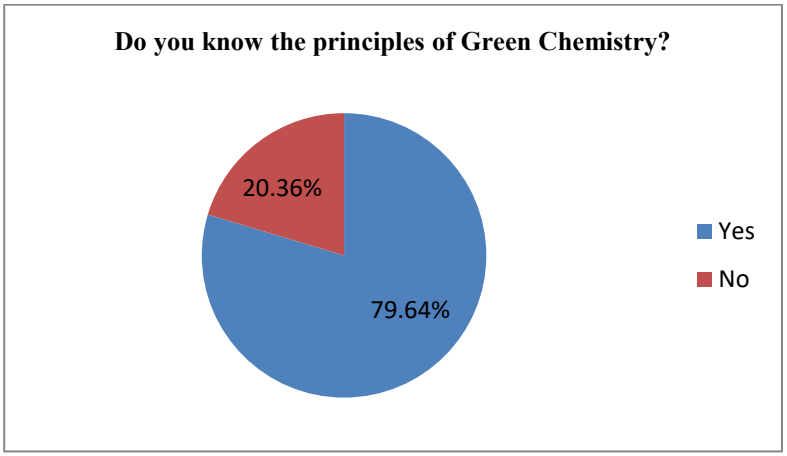


Figure 3. Students' Knowledge of Green Chemistry

The strongest finding in this research relates to the students' expressed need for environmentally friendly teaching materials and more guided learning resources. A remarkable 100% of respondents agreed that Green Chemistry principles should be applied in the Physical Chemistry Practicum, and 98.46% indicated the need for environmentally friendly materials to support their learning. Additionally, all respondents (100%) supported the development of Green Chemistry–based Student Worksheets. These responses collectively demonstrate that students desire worksheets that not only help them understand the material but also encourage safe, effective, and sustainable laboratory practices. This is in line with Ramagundam et al., (2020) who argue that integrating Green Chemistry principles into instructional materials promotes critical thinking, environmental awareness, and scientific problem-solving capabilities.

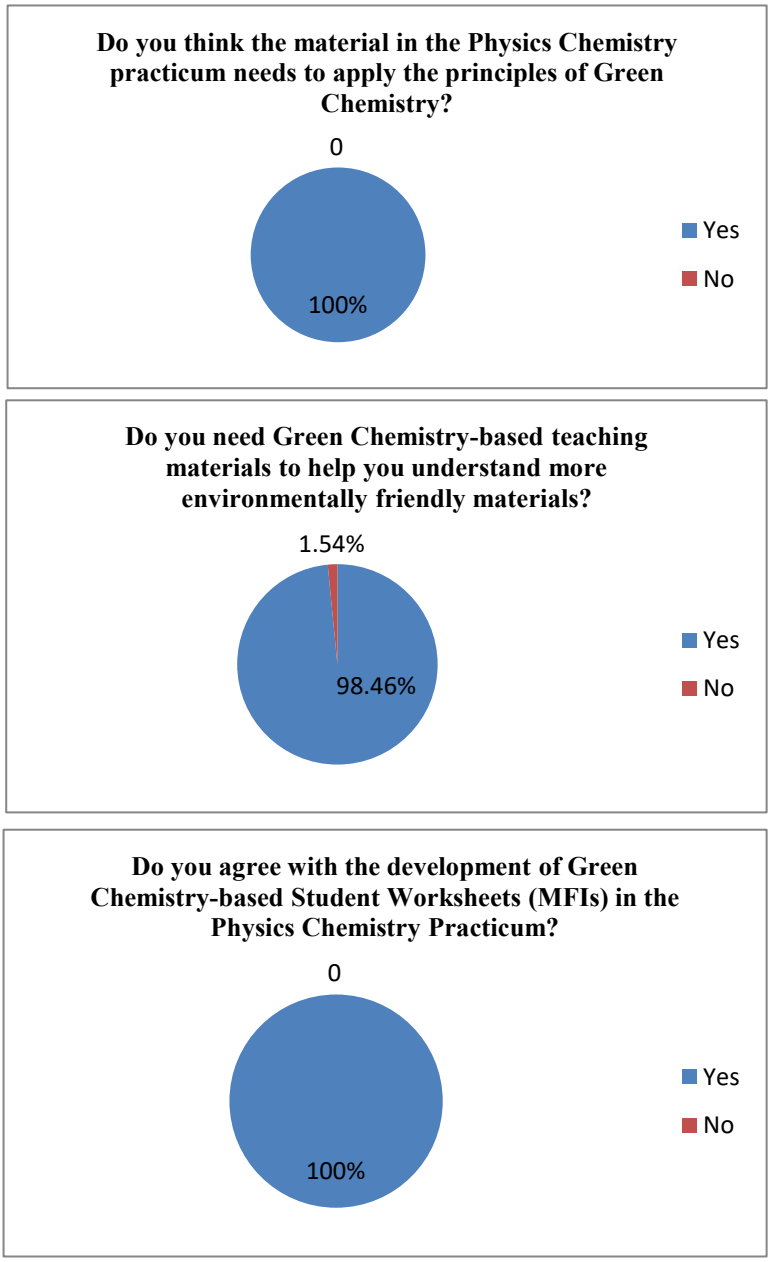
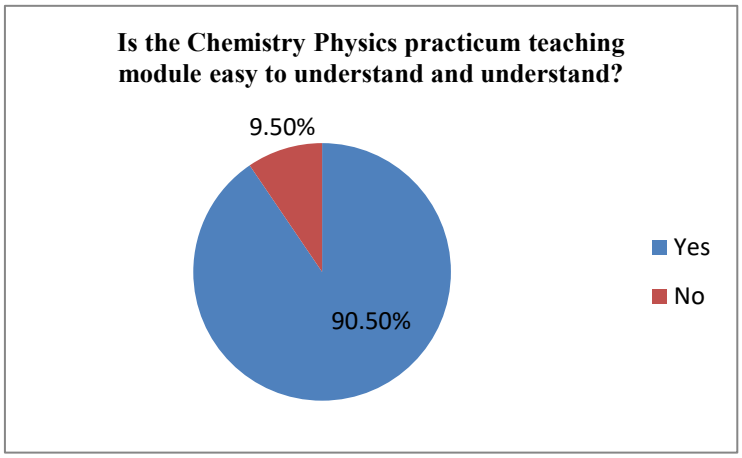
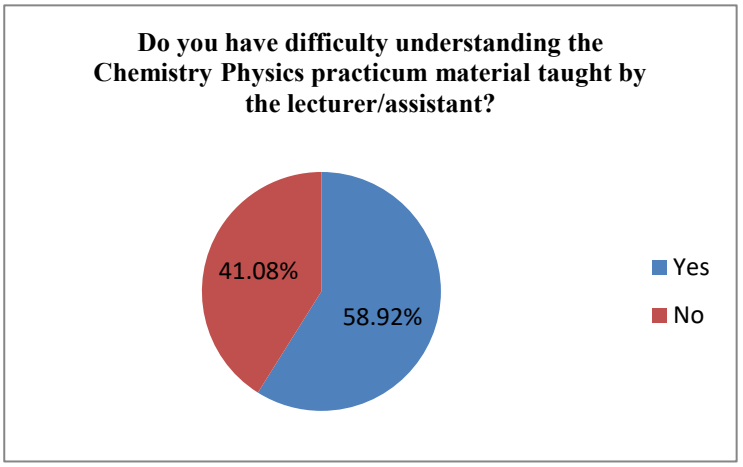


Figure 4. Students' Expressed Need for Environmentally Friendly Teaching Materials and More Guided Learning Resources

From the perspective of environmental literacy theory, the strong agreement among students illustrates a positive orientation toward sustainability and environmentally responsible behaviors. According to this theoretical framework, environmentally literate individuals should understand the relationship between human activities and ecological impacts and should demonstrate awareness and attitudes supporting sustainability (Ratri & Verina, 2024). This study's findings show that students already possess this foundational awareness, but they still lack structured learning tools that reinforce sustainable laboratory behavior. Therefore, incorporating Green Chemistry into practicum worksheets represents not only a pedagogical need but also a strategic effort to cultivate environmental literacy within chemistry education.

In terms of novelty, this study contributes a unique perspective by conducting a comprehensive needs analysis prior to the development of Green Chemistry–based worksheets. Previous studies have mostly focused on designing or implementing Green Chemistry–based modules at the secondary school level or within specific topics such as environmental chemistry (Azzajjad et al., 2024). In contrast, this research identifies specific needs in the context of a university-level Physical Chemistry Practicum, providing empirical data that reveal students' readiness, the shortcomings of existing materials, and their expectations for more sustainable practicum resources. This makes the study a foundational step for developing worksheets that are not only pedagogically meaningful but also environmentally responsible.





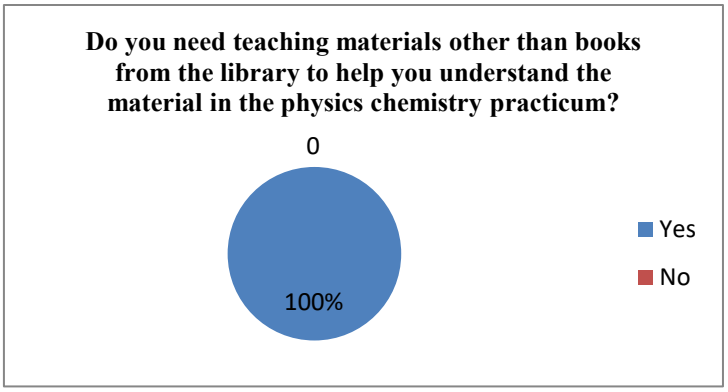


Figure 5. Students' Understanding of the Physical Chemistry Practicum

Overall, the results of this study emphasize the urgent need for learning materials that integrate Green Chemistry principles into the Physical Chemistry Practicum. Students' strong interest in practicum activities, their awareness of the importance of sustainability, and the inadequacy of current materials collectively indicate that a shift toward environmentally responsible worksheets is essential. These findings establish a strong basis for the subsequent development of comprehensive, effective, and sustainability-oriented Student Worksheets that can enhance the quality of laboratory learning while fostering environmentally conscious scientific practices.

CONCLUSION AND RECOMMENDATIONS

This study concludes that the development of Green Chemistry–based Student Worksheets (LKM) is urgently needed in the Physical Chemistry Practicum. Although practicum materials are currently available, most students perceive that these resources have not yet integrated sustainable laboratory practices. At the same time, students demonstrate high interest, motivation, and positive awareness regarding the application of Green Chemistry principles. This indicates that they are ready to adopt innovative and environmentally responsible learning materials that support independent learning and safe laboratory practices. Therefore, the development of Green Chemistry–based worksheets is not only pedagogically relevant but also holds strong potential to enhance students' environmental literacy and improve the overall quality of laboratory learning in chemistry education.

Theoretically, this study contributes to the growing body of literature on the integration of Green Chemistry within higher education, particularly in the context of Physical Chemistry practicums, which have been understudied. Practically, the findings provide empirical foundations for educators, material developers, and institutions to implement sustainable learning approaches through the provision of safe, efficient, and environmentally friendly practicum materials. Future research is recommended to develop and implement Green Chemistry–based Student Worksheets in other courses.

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