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Analysis of Waste Management Integration within the GPBLHS Framework in Grade XI Chemistry Curriculum

Indri Gus Permata Sari[1*], Nurhasan Syah[1], Aulia Azhar[1], Ratna Wilis[1]

[1] Environmental Science Study Program, Postgraduate School, Universitas Negeri Padang, Padang, Indonesia.

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Corresponding Author:
Indri Gus Permata Sari
nazafarinadreena19@gmail.com

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Abstract: Environmental Education (EE) is interdisciplinary and contextual because it connects natural sciences, social sciences, and humanities to build a holistic understanding of environmental issues. This approach enables students to connect academic concepts with real-world phenomena in the school and community, making learning more meaningful and applicable. This study aims to analyze the integration of waste management within the School Environmental Care and Culture Movement (GPBLHS) into Chemistry learning for Grade 11 students at SMA Pembangunan Laboratorium UNP, in terms of the implementation process, challenges, support from the school's physical condition, and its impact on students' environmental awareness and behavior. The study uses a multidisciplinary mixed-methods approach. The study uses quantitative data as the primary approach, supported by qualitative data. Data were collected through Likert-scale questionnaires, observations, interviews, and document analysis, then analyzed using descriptive statistics, linear regression, and thematic analysis. The results showed that waste management integration has been implemented through contextual learning but has not been systematically integrated into the curriculum. Key challenges include limited teacher understanding, minimal training, and suboptimal utilization of infrastructure. This integration has had a positive impact on increasing students' awareness and tendency to care for the environment.

Keywords: Chemistry learning; Environmental behavior; Environmental education; GPBLHS; Waste management

Introduction

The environment is a fundamental element for human survival, but it currently faces increasingly complex pressures due to anthropogenic activities, such as pollution, climate change, and ecosystem degradation (Ebner et al., 2022; Liu et al., 2023). This situation demands systematic and sustainable efforts, one of which is through education, which plays a strategic role in shaping environmental awareness, attitudes, and behaviors in the younger generation (Ratnasari et al., 2024). Environmental education (EEP) is understood as a learning process aimed at fostering individual awareness, understanding, values, and responsibility for the environment and ecosystem sustainability. UNESCO emphasizes that EEP is not only oriented toward increasing environmental knowledge but also toward developing attitudes, skills, and concrete actions that support sustainable development. In the context of modern education, EEP is positioned as transformative learning that integrates cognitive, affective, and psychomotor aspects through a reflective, collaborative, and experiential process (Kuo et al., 2024; Pears et al., 2025).

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Experiential learning, such as waste management practices and observations of the school environment, has been shown to increase students' emotional engagement and ecological awareness (Putri et al., 2025; Bustamante-Mora et al., 2025). In Indonesia's formal education system, environmental education (PLH) is implemented through the School Environmental Care and Culture Movement (GPBLHS), which is integrated with the Adiwiyata Program. GPBLHS emphasizes the internalization of environmental values into school policies, curriculum, learning activities, and infrastructure management to foster an environmentally conscious school culture (Petkou et al., 2025). However, the effectiveness of GPBLHS is largely determined by the extent to which these environmental values are systematically integrated into intracurricular learning, rather than simply being implemented as additional or ceremonial activities (Sakti et al., 2024).

At the senior high school (SMA) level, students are in a phase of cognitive development that allows for a critical and applicable understanding of environmental concepts. Therefore, the integration of environmental education (PLH) into science subjects, particularly chemistry, is highly relevant (Habibi, 2023; Sartika et al., 2019). Chemistry is directly related to environmental issues, such as pollution, waste, and waste management, making it a potential vehicle for developing environmental literacy through contextual and problem-based learning (Febriasari & Supriatna, 2017). Integrating waste management into chemistry learning can be done through various approaches, such as project-based and experiential learning, which enable students to connect chemical concepts with real-world practices in the school environment. Activities such as waste sorting, composting, or simple waste processing are effective ways to develop scientific skills while fostering environmentally conscious attitudes and behaviors (Etim, 2024; Henao-Rodríguez et al., 2024). This approach aligns with the Education for Sustainable Development (ESD) framework, which emphasizes action-based learning to achieve the Sustainable Development Goals.

From a behavioral change perspective, environmental education should not simply transfer knowledge but also encourage the internalization of sustainable values and habits. The Theory of Planned Behavior explains that pro-environmental behavior is influenced by attitudes, subjective norms, and perceived behavioral control formed through learning and school culture (Liao, 2024). In the school context, teacher role models, school policies, and supportive physical conditions such as waste management facilities play a crucial role in shaping students' environmental behavior (Miller et al., 2022). The selection of a curriculum integration model is a key factor in the successful implementation of PLH and GPBLHS. Integration models such as the connected model allow for linking concepts within a single subject without changing the curriculum structure, making it relevant for integrating waste management into Grade XI Chemistry learning (Sari & Atun, 2023). This model supports contextual learning and the use of the school environment as a living laboratory (living laboratory).

However, various studies show that the implementation of the integration of PLH and GPBLHS still faces challenges, including limited teacher understanding, minimal ongoing training, weak coordination between school units, and suboptimal utilization of supporting infrastructure (Bęś & Strzałkowski, 2024). These challenges were also found in schools that previously had (Agrawal et al., 2023) status but experienced a decline in implementation intensity after the COVID-19 pandemic. SMA Pembangunan Laboratorium UNP is one of the schools that has achieved the National Adiwiyata award. However, initial observations indicate a decline in the consistency of environmental stewardship, particularly in waste management and its integration into chemistry lessons. GPBLHS activities tend not to be optimally integrated into the curriculum and still rely on individual teacher initiative, resulting in a less than optimal impact on student behavior (Saifi et al., 2024).

Based on these conditions, this study aims to analyze the integration of waste management in GPBLHS into the Chemistry curriculum for grade XI by considering pedagogical aspects, school physical support, and its impact on students' environmental awareness and behavior. This study is expected to provide conceptual and practical contributions to developing a contextual, sustainable, and relevant environmental education integration model for secondary schools in Indonesia.

Method

This study employed a mixed methods approach with an explanatory sequential design, where quantitative data were used as the primary approach to identify patterns of relationships between variables, then were furthered with qualitative data to explain the context, process, and dynamics of the integration of the School Environmental Care and Culture Movement (GPBLHS) into the curriculum. This approach was chosen to gain a comprehensive understanding of the integration of waste management into Chemistry learning and its impact on students' environmental behavior. The research was conducted at SMA Pembangunan Laboratorium, Padang State University,

which was purposively selected based on the school's involvement in the GPBLHS program and its alignment with the school's environmental policy vision. The research subjects included the principal, curriculum team, GPBLHS team, an 11th-grade Chemistry teacher, and 11th-grade students.

Quantitative Data Collection

Quantitative data were obtained through a closed-ended Likert-scale questionnaire (1–5) that measured the perception and level of implementation of GPBLHS integration in Chemistry learning and school culture. The measurement scale was set as follows: 1 = very low to 5 = very high. The questionnaire was distributed to grade XI students who were selected purposively.

Quantitative Data Analysis

Quantitative data analysis was conducted using descriptive and inferential statistics with the aid of SPSS software. Descriptive statistics were used to describe general trends among respondents, while inferential statistics were used to test the effect of independent variables on dependent variables. Descriptive statistics were calculated using the mean and percentage values, using the following formula:

$$\overline{X} = \frac{\sum_{i=1}^{n} Xi}{n} \quad (1)$$

where is the $\bar{X}$ of the respondents' scores, xi is the score of the i-th respondent, and n is the number of respondents. The percentage of respondents in each Likert scale category was calculated using the formula:

$$P = \frac{f}{n} \times 100\% \quad (2)$$

where P is the percentage, f is the frequency of respondents in a particular category, and n is the number of respondents. To test the influence of independent variables on changes in students' environmental behavior, simple linear regression and multiple linear regression analyses were used. The simple linear regression model is formulated as follows:

$$Y=a+bX+e \quad (3)$$

where Y is the change in students' environmental behavior, X is the independent variable, a is a constant, b is the regression coefficient, and e is the error. Next, to test the influence of several independent variables simultaneously, multiple linear regression was used with the equation:

$$Y=a+b1X1+b2X2+b3X3+b4X4+b5X5+e \quad (4)$$

with X1 to X5 each representing school policy, environmentally based learning, school community participation, environmentally friendly school culture, and external support. The decision to test the hypothesis is based on the significance value (Sig. < 0.05) and the coefficient of determination (R^2) produced through SPSS analysis.

Qualitative Data Collection and Analysis

Qualitative data were collected through partial participant observation, semi-structured interviews, and document analysis. Observations focused on the implementation of GPBLHS values in chemistry learning, the school's physical condition, and student involvement in waste management activities. Interviews were conducted with the principal, teachers, students, the curriculum team, and the GPBLHS team. Qualitative data analysis was conducted using thematic analysis, including data familiarization, initial coding, theme development, theme review, and theme naming. Data validity was maintained through triangulation of sources and methods, as well as member checking to ensure the researcher's interpretations aligned with the informants' experiences.

Data Integration

The results of quantitative and qualitative analysis were integrated through triangulation of findings, so that this study not only shows the magnitude of the influence of GPBLHS integration on students' environmental behavior but also explains the processes and contextual factors that influence the effectiveness of this integration in Chemistry learning.

Result and Discussion

Results of Waste Management Integration in Chemistry Learning for Grade XI

The research results show that the integration of waste management in Chemistry learning for 11th graders at SMA Pembangunan Laboratorium UNP has been carried out by linking chemistry material with environmental issues, particularly waste management, across the planning, implementation, and evaluation stages of learning. This integration is evident in the use of contextual examples, project-based activities, and the utilization of the school environment as a learning resource.

Table 1. Descriptive statistics of waste management integration in chemistry learning

Integration Aspects	Mean	SD	Category
Environmentally based learning planning	3.82	0.56	Good
Implementation of contextual learning	3.75	0.60	Good
Student involvement in waste management practices	3.68	0.63	Good

Integration Aspects	Mean	SD	Category
Environmental context-based evaluation	3.54	0.58	Pretty good
Overall average	3.70	0.59	Good

These results indicate that teachers have consistently linked chemistry concepts to environmental issues. This integration supports meaningful learning, as emphasized in the Education for Sustainable Development (ESD) approach, which emphasizes the link between knowledge, attitudes, and concrete actions (Bramastia et al., 2025; MuhammedZein & Abdullateef, 2025; Holst et al., 2024).

Challenges and Obstacles in the Implementation of GPBLHS Integration

Although integration has been implemented, this study found a number of challenges that affect the optimization of the implementation of waste management in Chemistry learning and school culture (Lara et al., 2017; Quiroz-Martinez & Rushton, 2025).

Table 2. Challenges in implementing integrated waste management

Challenge Aspects	Mean	SD	Category
Teachers' understanding of PLH/GPBLHS	3.12	0.67	Enough
Availability of ongoing training	2.98	0.71	Enough
Coordination between school units	3.05	0.65	Enough
Integration into the formal curriculum	3.10	0.62	Enough
Overall average	3.06	0.66	Enough

The data indicates that the main challenges lie in structural aspects and human resource capacity. This condition aligns with the findings of Sukackė et al. (2022) and Tumanduk et al. (2018), which state that the success of GPBLHS is greatly influenced by teacher readiness and ongoing institutional support (Du et al., 2022).

The Role of Physical Conditions and School Facilities and Infrastructure

The physical condition of a school plays a crucial role in supporting environmentally-based learning. A clean school environment, the availability of waste management facilities, and green open spaces allow students to apply chemistry concepts directly through real-world experiences (Barnett-Itzhaki et al., 2025; Lathwesen & Eilks, 2024; Zidny et al., 2021).

Table 3. Support for physical conditions and school infrastructure

Indicator	Mean	SD	Category
Availability of waste sorting facilities	3.90	0.51	Good
Cleanliness of the school environment	3.85	0.54	Good
The existence of green open spaces	3.72	0.57	Good
Utilization of facilities as a learning resource	3.60	0.59	Good
Overall average	3.77	0.55	Good

These results strengthen the concept of the school as a living laboratory, where the physical environment of the school becomes an integral part of the learning process and the formation of students' environmental behavior (Rahmania, 2024; AlAli et al., 2025; Ardoin & Heimlich, 2021).

Impact of Integration on Students' Environmental Awareness and Behavior

The integration of waste management in Chemistry learning has a positive impact on increasing students' awareness, knowledge, and environmental behavior.

Table 4. Impact of integration on student awareness and behavior

Impact Aspects	Mean	SD	Category
Students' environmental awareness	3.88	0.52	Good
Waste management knowledge	3.92	0.49	Good
Environmental care attitude	3.80	0.55	Good
Waste management behavior	3.70	0.58	Good
Overall average	3.83	0.54	Good

This improvement shows that Chemistry learning integrated with waste management practices is able to encourage the internalization of environmental values, in line with the Theory of Planned Behavior which emphasizes the role of attitudes, norms, and behavioral control in the formation of pro-environmental behavior (Xu et al., 2022; Matos et al., 2025; Zhang et al., 2024). Overall, the research results indicate that integrating waste management into chemistry learning through GPBLHS has the potential to improve learning quality and foster a culture of environmental stewardship in schools. However, the sustainability and consistency of implementation depend heavily on strengthening teacher capacity, supporting school policies, and optimizing supporting infrastructure (Ibrahim et al., 2025; Baharuddin & Burhan, 2025; Hu et al., 2025).

Conclusion

This study shows that the integration of waste management concepts and practices into Chemistry learning for Grade XI at SMA Pembangunan Laboratorium UNP has been implemented as part of the implementation of the School Environmental Care and Culture Movement (GPBLHS) through a contextual and experience-based learning approach. Chemistry concepts are linked to real activities in the school environment, such as waste sorting, organic waste processing, and the application of environmentally

friendly principles in laboratory activities, so that Chemistry learning is not only oriented toward mastering concepts, but also toward the formation of environmental values and concerns. However, the integration process still faces various challenges and obstacles, including teachers' limited understanding and readiness to design environmentally based learning, minimal ongoing training related to environmental education, weak coordination between school units, and the suboptimal integration of GPBLHS into the curriculum in a systematic manner. These conditions have resulted in the implementation of waste management integration in Chemistry learning being inconsistent and still relying on individual teacher initiative. The research also shows that the physical condition and availability of school infrastructure play a crucial role in supporting the successful integration of waste management-based GPBLHS. The availability of waste management facilities, the cleanliness of the school environment, and the presence of green open spaces contribute to creating a learning environment that supports the implementation of contextual learning and the use of the school as a living laboratory. Furthermore, integrating waste management into chemistry lessons has had a positive impact on increasing students' environmental awareness, knowledge, and behavior.

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Author Contributions
I.G.P.S.: preparation of original draft, results, discussion, methodology, conclusions; N.S., A.A., and R.W.: analysis, review, proofreading and editing.

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Conflicts of Interest
No conflict interest.

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