Profile of High School Students' Sustainability Awareness in Chemistry Learning

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Abstract: This study aims to characterize students' sustainability awareness in the context of chemistry learning at SMA Negeri 1 Indralaya Utara and to provide a basis for developing worksheets aligned with the Sustainable Development Goals (SDGs). A quantitative descriptive design was employed with a sample of 34 grade XII students selected through simple random sampling. The research instrument was a 36-item sustainability awareness questionnaire adapted from Kelfina et al. (2025), encompassing three dimensions: behavioral and attitudinal awareness, emotional awareness, and awareness of sustainability practices. Data were analyzed using mean scores and percentage distributions. The results show that students' sustainability awareness was generally high, with an overall mean score of 82.33%. Each dimension also demonstrated high levels of awareness: 82.67% for behavioral and attitudinal awareness, 82.67% for emotional awareness, and 81.67% for awareness of sustainability practices. These findings suggest that chemistry learning particularly topics such as corrosion, green chemistry, and chemical bonding supports the development of students' conceptual understanding, emotional engagement, and sustainable practices in daily life. Overall, the study provides an empirical foundation for developing chemistry worksheets integrated with the SDGs to further strengthen students' sustainability awareness.

Keywords: Sustainability Awareness, Chemistry Learning, SDGs

1. Introduction

The concept of sustainable development, as articulated in the Sustainable Development Goals (SDGs), emphasizes meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. The United Nations underscores that a nation's progress is not solely determined by the development of physical infrastructure, but also by the advancement of human resources through the provision of quality education. According to Dayrit and Enriquez, in order to achieve sustainable development, the United Nations has established 17 SDGs that play a crucial role in shaping generations who not only understand the principles of sustainability but also possess awareness and responsibility toward environmental, social, and economic dimensions. Therefore, integrating sustainable development issues into educational practices has become an urgent necessity, particularly in chemistry education, which is directly related to environmental phenomena encountered in students' everyday lives.

Cai & Wolff (2023) emphasize that Education for Sustainable Development (ESD) plays a central role in achieving the Sustainable Development Goals (SDGs), as it equips individuals with the knowledge, skills, values, and attitudes necessary to actively contribute to sustainable development. Chemistry education holds a strategic position within the ESD framework, as many chemical concepts are closely associated with environmental and sustainability issues, such as corrosion, acid–base chemistry, green chemistry, and chemical bonding. The integration of the SDGs into chemistry instruction is not only intended to enhance students' conceptual understanding but also to foster sustainability awareness, encompassing cognitive, affective, and behavioral dimensions.

With the SDGs concept, students are not only expected to understand scientific concepts but also to develop environmental sustainability awareness. Sustainability awareness has become a global concern due to growing environmental, social, and economic challenges such as climate change, ecological degradation, and resource inequality. According to Mulyadiprana et al. (2023), sustainability awareness among students refers to their understanding of the impacts of human activities on environmental, social, and economic systems. This awareness encompasses not only conceptual understanding but also the development of caring attitudes and tendencies toward sustainable behavior resulting from ESD values (Suyitno et al., 2021). In chemistry learning, strengthening sustainability awareness is essential because it helps students connect chemical theories to real-life environmental issues. Febrizal et al. (2023) shows that chemistry instruction oriented toward sustainability principles enhances students' meaningful scientific understanding. Similarly, Hanifah et al. (2024) reported that integrating green chemistry principles into instruction significantly fosters students' sensitivity to sustainability issues. Furthermore, Sihombing et al. (2024) emphasized that the implementation of the Education for Sustainable Development (ESD) approach in science learning is able to foster a sustainability-oriented mindset, as reflected in students' readiness to engage in environmentally responsible actions. However, most existing studies have primarily focused on the implementation of learning strategies or the general development of

instructional materials and have not specifically examined students' sustainability awareness profiles as a foundational basis for developing project-based student worksheets (LKPD) utilizing local materials integrated with the Sustainable Development Goals (SDGs).

Students' sustainability awareness can be optimally developed through instructional materials that not only convey chemical concepts but also meaningfully connect them to environmental issues in their surrounding context. The development of contextual and relevant learning materials is therefore crucial for stimulating student engagement and fostering an understanding of the importance of sustainability. In the context of education that increasingly emphasizes sustainable development, the development of Project-Based Student Worksheets using Local Materials (PJBLLM) integrated with the Sustainable Development Goals (SDGs) is urgently needed to enhance students' sustainability awareness. Learning activities are strongly influenced by the instructional models implemented in the classroom. One instructional approach that can be effectively applied in schools is the project-based learning model. Project-based learning is a student-centered instructional model in which teachers act as facilitators and motivators. Through this model, students are given opportunities to work independently and collaboratively to construct their own understanding and knowledge. According to Doloksaribu et al. (2020), several studies have shown that the development of contextual chemistry learning materials, particularly those linking chemical concepts to environmental issues or local phenomena, has the potential to enhance students' sustainability awareness. For instance, an Environment Discovery Learning module in thermochemistry demonstrated that students were able to understand chemical concepts while simultaneously developing awareness of environmental impacts.

Furthermore, other research findings indicate that project-based learning can improve learning outcomes, scientific literacy skills, student activity levels, and creativity. Despite the growing number of studies on project-based worksheets in chemistry education, research that integrates project-based learning using local materials (Project-Based Learning with Local Materials/PJBLLM) with SDGs values remains very limited. This is notable, as the use of local materials in project-based learning has significant potential to enhance contextual relevance and strengthen students' sustainability awareness. In addition, most previous studies have primarily focused on the implementation of instructional models or the general development of learning materials, without being grounded in an in-depth analysis of students' sustainability awareness profiles. Early mapping of students' sustainability awareness is a crucial step to ensure that the development of student worksheets is well aligned with learners' needs, characteristics, and readiness to internalize sustainability values. The absence of such studies indicates a substantial research gap, particularly in senior high school chemistry education that integrates local materials as a context for sustainable learning, serving as a foundation for the development of PJBLLM-based worksheets integrated with the SDGs.

Based on this research gap, the objective of this study is to analyze the sustainability awareness profile of senior high school students in chemistry learning, encompassing behavior and attitude awareness, emotional awareness, and

sustainability practice awareness, as a foundation for the development of chemistry student worksheets based on project-based learning using local materials (PJBLLM) integrated with the Sustainable Development Goals (SDGs). The novelty of this study lies in the presentation of students' sustainability awareness profiles that are directly linked to the development of SDGs-oriented, project-based chemistry worksheets utilizing local materials, an area that has received limited attention in previous research.

2. Method

This This study employed a descriptive quantitative approach that aims to analyze high school students' sustainability awareness in chemistry learning as a basis for developing SDGs-integrated student worksheets (LKPD). According to Hardani et al. (2020), the quantitative approach examines relationships between variables using numerically measured data, emphasizing objective and measurable outcomes, allowing researchers to explain causal relationships clearly without the influence of personal perspectives.

The research sample consisted of 34 twelfth-grade students from SMA Negeri 1 Indralaya Utara who were enrolled in the chemistry specialization. The selection of Grade XII students was based on the consideration that students at this level have already been exposed to chemistry topics relevant to sustainability issues, such as corrosion, green chemistry, and chemical bonding. Therefore, they are expected to possess sufficient learning experiences to reflect on their sustainability awareness. The sample size was considered adequate for an initial descriptive study aimed at mapping students' awareness profiles prior to the development of instructional materials. Simple random sampling was employed to provide equal opportunities for all students in the population to be selected as research participants, thereby reducing potential selection bias. The research instrument was a questionnaire adapted from Kelfina et al. (2025), consisting of 36 items. The questionnaire was designed to measure three categories of sustainability awareness: behavior and attitude awareness, emotional awareness, and sustainability practice awareness. Each category encompassed environmental, social, and economic dimensions in accordance with the principles of the Sustainable Development Goals (SDGs). Data were collected using Google Forms, which was chosen for its efficiency, ease of access for students, and its ability to minimize data entry errors. A four-point Likert scale (1–4) was employed to avoid neutral responses and to encourage participants to express more definitive attitudes, with the following categories:

Table 1. Likert Scale

Response Category	Score
Strongly Agree	4
Agree	3
Disagree	2
Strongly Disagree	1

The obtained The collected data were analyzed using descriptive statistics, including mean scores and percentages. Percentage calculations were conducted using the following formula:

$$\text{Percentage} = \frac{\text{Mean} - 1}{3} \times 100\%$$

The use of descriptive statistics aimed to describe the overall trend of students' sustainability awareness levels as well as the trends within each category. The percentage scores were then interpreted based on the classification criteria proposed by Hasan et al. (2010), which are presented in the following table.

Table 2. Percentage of Sustainability Awareness Based on Classification Criteria (Hasan et al., 2010)

Percentage of Sustainability Awareness (%)	Interpretation
0,0 - 39,9	Behaviors that are rarely practiced or generally avoided
40,0 - 69,9	Behaviors that are moderately practiced or occur at a moderate level
70,0 - 100	Behaviors that are frequently or consistently practiced

3. Result and Discussion

Based on the results of the questionnaire analysis on sustainability awareness, various levels of sustainability awareness among students in their daily lives can be described. Data on sustainability awareness is classified into three categories, namely behavior and attitude awareness, emotional awareness, and sustainability practice awareness.

Table 3. Percentage of High School Students' Sustainability Awareness Responses in Chemistry Learning

Statement	Mean	Percentage (%)	Interpretation
Behavior and Attitude Awareness			
I am aware that rust (corrosion) can damage public facilities and pose risks to the environment.	3.29	76.33	Agree
I am concerned that rust (corrosion) may cause metal contamination in soil and water.	3.29	76.33	Agree
I agree that maintaining metal objects to prevent rust can reduce repair and replacement costs.	3.35	78.33	Agree
I believe it is important for communities to work together to prevent losses caused by rust (corrosion).	3.38	79.33	Agree

I consider awareness of rust (corrosion) as part of the younger generation's responsibility to protect the Earth.	3.52	84.00%	Agree
I agree that using environmentally friendly products is better than using products that harm nature.	3.64	88.00	Agree
I believe that energy-saving behavior and reducing waste support environmental sustainability.	3.58	86.00	Agree
I consider simple habits, such as disposing of waste properly, as forms of care for the surrounding community.	3.50	83.33	Agree
I am aware that choosing environmentally safe products can also reduce health risks for humans.	3.55	85.00	Agree
I am concerned that household waste such as soap or detergents may negatively affect public health when used excessively.	3.64	88.00	Agree
I agree that choosing refillable or low-packaging products helps reduce waste and saves costs.	3.52	84.00	Agree
I believe that using daily products efficiently supports sustainable living and reduces expenses.	3.52	84.00	Agree
Mean (Behavior and Attitude Awareness)	**3.48**	**82.67**	**Agree**
Emotional Awareness			
I feel concerned when public facilities become unusable due to rust (corrosion).	3.32	77.33	Agree
I feel uncomfortable when rusted metal contaminates surrounding soil or water.	3.58	86.00	Agree
I care even though rust (corrosion) increases maintenance and repair costs.	3.41	80.33	Agree
I feel proud when I contribute to preventing metal objects from rusting.	3.58	86.00	Agree
I consider it important to clean metal objects at home to prevent rust.	3.41	80.33	Agree
I feel concerned when community drinking water becomes cloudy or contaminated by fine particles (such as dust or soap residue).	3.41	80.33	Agree
I care when household waste such as soap or detergents causes river water to become cloudy.	3.50	83.33	Agree

I feel encouraged when low-cost methods are available to purify cloudy water for reuse.	3.47	82.33	Agree
I feel proud when society uses environmentally friendly products, such as cloth bags or reusable water bottles.	3.52	84.00	Agree
I care about replacing single-use plastics with safer alternatives for the environment.	3.52	84.00	Agree
I feel pleased when environmentally friendly products help reduce daily expenses.	3.58	86.00	Agree
I feel motivated when eco-friendly products (such as refillable soap or energy-saving appliances) help protect the Earth and save money.	3.41	80.33	Agree
Mean (Emotional Awareness)	**3.48**	**82.67**	**Agree**
Sustainability Practice Awareness			
I usually take care of metal objects to prevent rust and extend their lifespan.	3.38	79.33	Agree
I believe it is necessary to protect personal belongings from rust (corrosion) to avoid damage and unnecessary costs.	3.55	85.00	Agree
I frequently apply simple practices such as painting or storing metals in dry areas to prevent rust.	3.55	85.00	Agree
I consider it important to help maintain school facilities, such as fences or laboratory tools, to prevent rust.	3.35	78.33	Agree
I am interested in discussing corrosion prevention as part of sustainability solutions.	3.44	81.33	Agree
I usually keep water clean to avoid contamination by small particles such as soap or detergent residues.	3.50	83.33	Agree
I consider it important to reduce excessive use of soap or detergent even though it may cause cloudy water.	3.41	80.33	Agree
I have tried or supported simple methods to purify cloudy water for reuse.	3.38	79.33	Agree
I regularly choose environmentally friendly products, such as bringing my own water bottle.	3.52	84.00	Agree

I care about reducing the use of single-use plastics.	3.47	82.33	Agree
I have practiced energy-saving habits at home or school, such as turning off lights when not in use.	3.35	78.33	Agree
I am interested in participating in school activities promoting eco-friendly products or recycling.	3.44	81.33	Agree
Mean (Sustainability Practice Awareness)	**3.45**	**81.67**	**Agree**
Overall Mean	**3.47**	**82.33**	**Agree**

Table 4. Average Percentage of High School Students' Sustainability Awareness Responses in Chemistry Learning

Statement	Mean	Percentage (%)	Interpretation
Behavior and Attitude Awareness	3,48	82,67	Agree
Emotional Awareness	3,48	82,67	Agree
Sustainability Practice Awareness	3,45	81,67	Agree
Mean	**3,47**	**82,33**	**Agree**

Based on Table 4, it can be observed that the sustainability awareness of students at SMA Negeri 1 Indralaya Utara is categorized as high. This is evidenced by the calculated mean percentage of 82.33%, with students indicating agreement across all statements provided. The high average level of students' sustainability awareness (82.33%) not only reflects normative agreement with sustainability issues but also indicates an internalization of sustainability values in students' ways of thinking about chemical phenomena. This finding extends previous research by demonstrating that chemistry learning does not merely enhance conceptual knowledge but also plays a significant role in shaping students' systemic thinking regarding the interconnections among science, the environment, and socio-economic life, in alignment with the 2030 Sustainable Development Goals (SDGs).

The questionnaire given to students in this study was compiled by taking into account the understanding and application of simple SDG principles in chemistry learning that incorporates economic, social, and environmental aspects. The economic aspect is presented, for example, from students' understanding of the cost efficiency of metal maintenance and a resource-efficient lifestyle, and the use of environmentally friendly chemicals. The social aspect is presented through a sense of responsibility and concern for shared public facilities. How students wisely use and maintain public facilities. The environmental aspect is reflected in students' awareness of the significant and negative impact of corrosion on soil and water pollution, with students preferring to use environmentally friendly everyday products. Awareness of the impact of corrosion and the excessive use of products such as detergents or soaps will be directed towards environmentally friendly

prevention or solutions in accordance with SDG principles. Based on this, the questionnaire instrument developed not only evaluates students' conceptual understanding but also captured their ethical perspectives and personal awareness regarding the interconnectedness of chemistry learning with human well-being, environmental sustainability, and economic considerations.

In the category of behavior and attitude awareness, the average score was 82.67%, indicating that students' attitudes toward sustainability issues were quite strong. This score also shows that the behaviors listed in the questionnaire were already being practiced by most of the student sample. Students' self-awareness in implementing integrated sustainability values was evident in their views and daily behaviors, as demonstrated by their responses to the impact of corrosion. Students realize that rust not only causes physical damage to materials in public facilities, but also has a greater impact on the social and economic welfare of the community, as well as polluting the environment through the release of metal ions. This understanding is in line with the concept of green chemistry, particularly the principles of waste prevention and the selection of safer materials. In addition, students show concern for the efficient use of energy and resources and prefer environmentally friendly products as a form of responsibility. Such attitudes show that chemistry learning can provide a sufficient scientific basis for students to assess the impact of chemical use in everyday life. The dominance of scores in the behavior and attitude awareness category indicates that students are able to position themselves as part of the solution to sustainability challenges, rather than merely as observers of chemical phenomena. Students' awareness of the impacts of corrosion on public infrastructure, environmental pollution, and economic inefficiency suggests that they understand the broader implications of chemistry at a systemic level. These findings are consistent with the study by Hanifah et al. (2024), which reported that the integration of green chemistry concepts into chemistry instruction can foster students' pro-environmental attitudes. Students' awareness of the environmental, social, and economic impacts of corrosion further reflects an understanding that chemical phenomena do not exist in isolation but have tangible consequences in societal contexts.

In terms of emotional awareness, the average score was the same as that for behavior and attitude awareness, reaching 82.67%. This percentage shows that students not only understand sustainability issues but are also emotionally involved and empathetic in environmental efforts. Emotional awareness is closely related to sense of empathy, which is well demonstrated among students at SMA Negeri 1 Indralaya Utara through their concern and worry about public facilities damaged by corrosion. These feelings indicate that they see chemical phenomena as real issues in life, not just academic material. In addition, the high level of concern about water pollution caused by soap, detergent, and other household waste shows that chemistry lessons have succeeded in raising awareness of the impact of everyday chemical use. Emotional habits like this are very important because they provide the initial motivation to form sustainable habits. The sense of pride when involved in preserving a good environment shows that students understand the meaningful contribution to sustainability. This aspect plays an important role in fostering the

drive for self-awareness to act consistently. These findings reinforce the results of Rini and Nuroso (2022), who reported that emotional awareness plays a crucial role as a driving force behind the emergence of sustainable behavior. The feelings of concern, empathy, and pride demonstrated by students toward environmental preservation efforts indicate that chemistry learning has successfully engaged students' affective dimension.

The third category, sustainability practice awareness, obtained an average percentage of 81.67%. This percentage is still considered good, although it is the lowest among the three categories. Although the sustainability practice awareness category exhibited the lowest percentage compared to the other two categories, this finding provides important insights into the challenges of translating sustainability values into concrete actions. It indicates the presence of a gap between awareness and practice, a phenomenon commonly observed in sustainability education. This gap highlights the need for instructional materials that extend beyond conceptual learning and provide authentic learning experiences through project-based activities and the utilization of local materials. The results further suggest that, while students' understanding and attitudes toward sustainability are relatively strong, their implementation in the form of concrete actions still requires reinforcement. At the same time, the percentage obtained indicates that students have begun to apply sustainable behaviors in their daily lives. Sustainability practice awareness refers to students' conscious efforts to adopt sustainable habits, which are frequently reflected in simple practices such as painting or storing metals in dry conditions to prevent rust (corrosion), choosing more environmentally friendly daily products (e.g., bringing reusable drinking bottles), and other similar actions. These seemingly simple yet meaningful behaviors demonstrate that students' understanding and positive attitudes have begun to translate into tangible practices that reflect sustainability values across social, economic, and environmental dimensions. These findings are consistent with Anggraeni et al. (2024), who reported that sustainable practices often develop more slowly than cognitive and affective aspects. Therefore, this study contributes to the existing literature by demonstrating that chemistry education requires more applicative pedagogical approaches to effectively support the transformation of students' attitudes into sustainable actions.

The integration of corrosion, green chemistry, and chemical bonding materials has helped students better assess their impact on the environment and apply it in their daily lives. These findings are in line with the research by Anggraeni et al. (2024), which shows that green chemistry-based chemistry learning can increase students' environmental awareness and sustainable practices. In addition, Gomes & Ziedler (2024) emphasize that sustainable chemistry learning is effective in enabling students to connect chemistry concepts with sustainability issues.

From a theoretical perspective, this study contributes to the advancement of Education for Sustainable Development (ESD) research in chemistry education by providing empirical evidence that students' sustainability awareness can be measured multidimensionally and used as a foundation for the development of instructional tools. The findings extend the conceptual framework of sustainable chemistry education by highlighting the urgency of incorporating local contexts to

strengthen students' understanding of sustainability-related issues. From an applied perspective, these findings offer practical guidance for educators and instructional material designers in developing chemistry student worksheets based on project-based learning using local materials (PJBLLM) that are aligned with students' sustainability awareness characteristics. By identifying patterns in students' attitudes, emotions, and actions, such worksheets are expected to be more relevant, practical, and impactful in fostering concrete sustainable habits both within school settings and in the wider community.

Overall, the results of this study show that all three aspects of sustainability awareness behavior and attitude awareness, emotional awareness, and sustainability practice awareness developed in a balanced manner, as indicated by average percentages exceeding 80%. These findings are consistent with the criteria established by Hasan et al. (2010), which state that percentages above 70% reflect behaviors that are frequently and consistently practiced. Therefore, it can be concluded that students at SMA Negeri 1 Indralaya Utara possess a strong level of sustainability awareness within the context of chemistry learning. Their sustainability awareness profile reflects the effectiveness of chemistry education in fostering environmentally responsible behavior. This result is further supported by findings from Febrizal et al. (2024), who highlight that chemistry learning plays a significant role in building students' sustainable awareness and actions that support the achievement of the SDGs.

The limitations of this study include the relatively small sample size and the restricted research scope, which was confined to a single school, thereby limiting the generalizability of the findings. In addition, the use of a questionnaire-based instrument may be subject to respondent bias and subjectivity. These limitations may affect the accuracy of representing students' sustainable behaviors in real-life practices; therefore, future research involving larger and more diverse samples, as well as data triangulation methods, is strongly recommended.

4. Conclusion

This study demonstrates that students at SMA Negeri 1 Indralaya Utara exhibit a high level of sustainability awareness in chemistry learning, with a mean percentage of 82.33% across the three main dimensions. The primary contribution of this study lies in presenting students' sustainability awareness profiles as an empirical foundation for the development of chemistry student worksheets based on project-based learning using local materials (PJBLLM) integrated with the Sustainable Development Goals (SDGs). The findings confirm that chemistry education holds strategic potential in fostering students' sustainability awareness and sustainable behaviors. Accordingly, this study advances existing knowledge by showing that an initial analysis of sustainability awareness constitutes a strategic stage in designing effective, contextual, and sustainability-oriented chemistry learning. The results are expected to serve as a reference for future research and to support more meaningful chemistry education practices that contribute to the achievement of the SDGs.

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