



A Needs Analysis for the Development of E-assesment in Sustainable Chemistry Project Based Learning

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Abstract

The purpose of this study was to analyze the needs of high school chemistry teachers in Bantul, Yogyakarta, regarding the development of an LMS-based e-assessment design for evaluating chemistry learning projects oriented toward the values of the Sustainable Development Goals (SDGs). The research subjects consisted of five chemistry teachers selected using purposive sampling. Data were collected through open-ended questionnaires and semi-structured interviews, then categorized into four main themes: the implementation of Project-Based Learning (PjBL), the integration of SDG-related values and skills, project assessment systems, and the use of Learning Management Systems (LMS). The results indicate that all teachers had implemented PjBL and integrated SDG values into chemistry learning; however, the implementation was not yet fully systematic. Project assessments were still conducted manually, resulting in challenges related to time efficiency and the provision of individualized feedback. Approximately 60% of the teachers had used LMS platforms, but their utilization remained limited to administrative tasks and grade input. These findings highlight the need to develop an LMS-based e-assessment design that is simple, efficient, and capable of assessing both cognitive and non-cognitive aspects of students' SDG-oriented chemistry projects.

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INTRODUCTION

The shifting demands of twenty-first-century education have encouraged a transition from teacher-centered instruction to learning approaches that provide greater space for student activity and autonomy. This shift aligns with the achievement of the 17 Sustainable Development Goals established by the United Nations in 2015 (Othman et al., 2024; Willis, 2016). Current educational practices are directed toward cultivating a set of twenty-first-century competencies that enable students to face increasingly complex future challenges. One of the goals most relevant to education is SDG 4, which emphasizes quality education. Integrating various global and environmental issues into learning contexts helps strengthen students' sense of relevance and meaningful engagement in the learning process (Abu et al., 2023; Zinchenko et al., 2021). Such learning patterns foster mindsets that support the development of essential skills and character, a sense of intellectual curiosity, and meaningful scientific understanding.

SDG-oriented learning tends to promote investigative activities that require active student participation. This exploratory approach reflects the principles of student-centered learning, wherein students are involved throughout the learning process. SDG-oriented instruction provides open and contextually relevant learning experiences through discussions, projects, and other interactive activities. This approach encourages students to develop independence within a facilitated and supportive environment (Kurniawati et al., 2022; Suryaningsih et al., 2021). The SDGs introduced by the United Nations serve as a framework for addressing a wide range of social, economic, environmental, and other global issues. Using relevant contexts and discussing issues familiar to students can enhance engagement and increase the attractiveness of the learning experience.

In an ideal learning context, students' abilities and skills develop progressively through the learning process. Each individual must undergo a series of steps to achieve specific learning goals. The learning process includes several aspects, such as strengthening comprehension, enhancing memory, and continuously processing information (Prasetyo et al., 2015). Integrating SDG-oriented approaches into chemistry instruction is considered capable of supporting the learning process of high school students. Through interactive and exploratory learning methods and models, students are able to learn within a more dynamic environment. Research conducted by Fajariah and Mirza (2024) shows that learning processes that actively involve students lead to improvements in the standard competencies expected of senior high school learners.

Project-Based Learning (PjBL) emphasizes active learning (Handayani Trisni, 2024). Learning becomes active when interactive engagement occurs between teachers and students. To sustain student attention throughout the learning process, teachers may incorporate a variety of discussions and real-world explorations. The use of real-world contexts in learning aligns with global issues highlighted by the United Nations within the SDGs framework (Pambuko et al., 2025). This indicates that PjBL not only focuses on academic achievement but also emphasizes twenty-first-century skills—such as the 4Cs—that are relevant to SDG competencies (Handoko et al., 2024).

Thus, the characteristics and processes inherent in PjBL support and align closely with SDG-oriented learning, particularly in developing the SDG-related skills students need. Findings from Chanpet et al. (2020) indicate that SDG-oriented competencies can be fostered when students engage in explorations connected to real-world contexts. According to Abidin and Kuningan, (2025) SDG-oriented PjBL has been shown to improve students' learning motivation. In addition, empirical studies conducted by Putra et al. (n.d.) found that implementing SDG-based PjBL in science subjects enhances students' environmental literacy and sustainability awareness. These findings suggest that integrating SDGs into chemistry learning is not only relevant to the curriculum but also has a tangible impact on students' attitudes and behaviors.

However, the implementation of SDG-oriented learning still faces various significant challenges and obstacles. These include the complexity of systematically integrating SDGs into chemistry learning projects and the limitations in developing and comprehensively assessing students' SDG-related skills. Current learning conditions indicate that most schools have not yet implemented e-assessment optimally due to gaps in facilities, teachers' digital competencies, and misalignment between instructional methods and the assessment systems commonly used in classrooms (Fadzil et al., 2022; Hartono & Murniati, 2024).

Senior high school chemistry learning, which involves complex concepts and strong connections to environmental and sustainability issues, requires an assessment approach capable of accommodating both cognitive and non-cognitive aspects (Ramdani et al., 2021). However, conventional assessment practices still face limitations in terms of time efficiency, consistency, and transparency. In this context, a Learning Management System (LMS) serves as a promising solution. LMS platforms can provide flexible and well-documented assessment systems that allow continuous monitoring of students' learning processes. Integrating e-assessment into such platforms can reduce teachers' administrative burdens in managing SDG-oriented PjBL projects, from planning and monitoring progress to evaluating student outcomes (Yana, D. 2019).

Given the conditions described above, the guiding question for this study is: *“Is an LMS-based e-assessment design aligned with SDG-oriented chemistry learning needed for senior high school instruction?”* Accordingly, this research aims to develop an LMS-based e-assessment design capable of integrating SDG principles into project-based chemistry learning at the senior high school level.

METHOD

Research Design

This study employed a qualitative descriptive design. This approach was selected because the purpose of the research was to explore in depth the needs and urgency of developing an LMS-based e-assessment design for SDG-oriented senior high school chemistry learning.

- a. Research Context
This study did not place participants under experimental conditions. Data were collected from authentic learning setting through interviews and discussions with chemistry teachers.
- b. Intervention/Behavior
The study did not divide respondents into experimental or control groups. All informants were treated as sources of information who provided insights into their perceptions, experiences, and needs related to SDG-oriented project assessment.
- c. Data Collection, Timeframe and Types of Data
Data were collected within a specific timeframe according to the research schedule. The types of data obtained included:
 - Teachers' perceptions of the challenges in assessing SDG-oriented chemistry projects
 - Teachers' experiences with project assessment and their responses regarding the potential use of an LMS

- Documentation related to current project assessment practices. The data were then analyzed qualitatively to identify the needs and urgency of developing an LMS-based e-assessment design

Participants and Research Context

This study involved five senior high school chemistry teachers from schools located in Bantul, Yogyakarta. The teachers were selected using a purposive sampling technique, based on the consideration that they had experience implementing project-based chemistry learning and were familiar with the challenges of conducting project assessment. The limited number of participants aligns with the characteristics of qualitative descriptive research, which prioritizes depth of information over the size of the respondent group.

The participating teachers were not assigned to experimental or control groups, as the study did not aim to compare treatments. Instead, the research sought to explore teachers' needs, experiences, and perceptions regarding the urgency of developing an LMS-based e-assessment design to support SDG-oriented chemistry learning. The research context focused on the teachers' current project assessment practices in the classroom, as well as the suitability of an LMS as an alternative assessment tool that can facilitate the evaluation process in senior high school chemistry instruction.

Data Collection Techniques and Instruments

The data for this study were obtained through an interview protocol developed by the researchers to explore chemistry teachers' needs regarding an LMS-based e-assessment design for SDG-oriented senior high school chemistry learning. The interview protocol consisted of several open-ended questions covering aspects such as teachers' assessment needs, their perceptions of the technical ease of using an LMS, its suitability for chemistry project assessment, and its relevance to SDG indicators.

The instrument was validated by two experts in chemistry education to ensure content relevance, linguistic clarity, and logical organization of the questions. The validation process examined the dimensions, sub-dimensions, and grammatical accuracy of the interview items. After undergoing revisions based on expert feedback, the interview protocol was used as the primary data collection instrument.

Data Analysis

The data obtained from the interview guidelines were analyzed using a content analysis technique. The analysis process was carried out through three stages: data reduction, data display, and conclusion drawing. To ensure that the analysis proceeded systematically, this study employed an instrument blueprint as the basis for categorizing the themes. The blueprint includes aspects related to teachers' needs in project assessment, perceptions of LMS usability, and the alignment of assessment practices with SDGs indicators.

Table 1. The Question Lists to gain the respondents' responses

No	Questions
1	Have you ever implemented project-based learning?
2	What do you know about the PjBL learning model?
3	How do you apply the PjBL model in chemistry learning at school?
4	What chemistry topics have you implemented using PjBL?
5	Have you ever integrated SDGs-related skills or values into chemistry instruction?
6	Which chemistry topics have you linked to SDG-related issues or skills?
7	How is the chemistry assessment system implemented at your school?
8	Does the current assessment system support project-based learning?
9	What challenges do you face in conducting project-based assessment?
10	Has your school ever used a Learning Management System (LMS)? If yes, please specify the platform used
11	Has your school ever implemented an online assessment or grade input system?
12	Perceived Advantages and Disadvantages of Written vs. LMS-Based Assessment Systems
13	Did you encounter any obstacles when using an online (network-based) assessment system?

During the data reduction stage, teachers' responses were categorized based on the main themes referenced in the blueprint. The reduced data were then presented in a narrative description that illustrates the general tendencies of the participants' responses.

To maintain consistency in interpretation, the processing of responses was conducted systematically by grouping similar information according to emerging themes. Patterns were identified by repeatedly reviewing each response to determine similarities and differences across participants. Data verification was conducted through

repeated reading and consultation with chemistry education experts to ensure that the emerging themes aligned with the focus of the study. Thus, the data analysis provides an in-depth understanding of teachers' needs regarding LMS-based e-assessment design in SDGs-oriented chemistry learning.

RESULT AND DISCUSSION

Result

The results obtained from this research and development process consist of a needs analysis conducted with chemistry teachers. The purpose of this needs analysis was to serve as a foundation and reference in developing an LMS-based e-assessment design for project-based chemistry learning oriented toward the Sustainable Development Goals (SDGs). In addition, the analysis aimed to determine whether the product being developed is genuinely needed by teachers and students in schools. In this study, the data were collected through interview guidelines administered to five high school chemistry teachers in Bantul, Yogyakarta.

The interview guideline consisted of four main themes:

1. Implementation of Project-Based Learning (PjBL) in Chemistry Instruction,
2. Integration of SDGs-related Values and Skills in Chemistry Learning,
3. Assessment Systems in Chemistry Learning and the Need for Project Assessment, and
4. Use of LMS and the Need for Digitalization of Assessment.

The results of the interviews are presented in Table 2.

Table 2. Implementation of Project-Based Learning (PjBL) in Chemistry Instruction

No.	Questions	Response	%
1	Have you ever implemented project-based learning?	Already integrated	100%
		Not yet	0%
2	What do you know about the PjBL learning model?	A learning model that integrates theory with project-based activities	100%
3	How do you apply the PjBL model in chemistry learning at school?	Laboratory/practicum activities or small-group projects	40%
		Implementing the complete PjBL syntax	40%
		Connecting projects with daily-life contexts or environmental issues	20%
4	What chemistry topics have you implemented using PjBL?	Colligative properties	20%
		Acids and bases	30%
		Green chemistry/SDGs	20%
		Atomic structure	15%
		Basic chemical laws	15%

Based on Table 2, all teachers (100%) have implemented PjBL, although the depth of implementation varies. A PjBL using the complete instructional syntax, and 20% connect the project to environmental contexts. This indicates that while the teachers' conceptual understanding of PjBL is relatively consistent, uniformity in classroom practice has not yet been achieved.

The types of materials taught through PjBL also vary, with acid-base topics (30%) and green chemistry/SDGs-related content (20%) being the most dominant. This variation suggests that teachers tend to choose materials that are applicable and easily contextualized to real-world situations. However, since only a portion of the teachers implement the full PjBL syntax, this finding indicates a need for more systematic technical guidance to support optimal implementation of PjBL in chemistry learning.

Table 3. Integration of SDGs Values and Skills in Chemistry Learning

No.	Questions	Response	%
1	Have you ever integrated SDGs-related skills or values into chemistry instruction?	Already integrated	100%
		Not yet	0%
2	Which chemistry topics have you linked to SDG-related issues or skills?	Green Chemistry	30%
		Electrochemistry	20%
		Acids and bases	20%
		Periodic table of elements	10%
		Hydrocarbons	10%

Based on Table 3, 100% of the teachers reported that they had integrated SDGs values into chemistry instruction. Most integrations occurred in green chemistry topics (30%), electrochemistry (20%), and acids–bases (20%), as these topics are the easiest to connect with sustainability issues. However, the integration remains largely contextual and does not yet refer to structured SDGs skill indicators. Some teachers incorporated environmental issues, while others emphasized collaboration or responsibility. This inconsistency indicates that teachers require standardized instruments, rubrics, or indicators to ensure that SDGs integration becomes more systematic and can be objectively measured within chemistry project assignments.

Table 4. Chemistry Assessment System and Project Assessment Needs

No.	Questions	Response	%
1	How is the chemistry assessment system implemented at your school?	Formative and Summative	60%
		Formative and Summative (aligned with PjBL syntax)	40%
2	Does the current assessment system support project-based learning?	Yes	100%
		No	0%
3	What challenges do you face in conducting project-based assessment?	Conversion of product scores	10%
		Lack of detailed feedback documentation	30%
		Long assessment time	30%
		Subjectivity	10%
		Difficulty developing rubrics	20%

Based on Table 4, most teachers (60%) employed general formative–summative assessment, while 40% adapted their assessment to the PjBL syntax. Although all teachers (100%) stated that their current assessment system “supports PjBL,” they still encountered several challenges, including:

- Difficulty providing individual feedback (30%)
- Lengthy assessment time (30%)
- Difficulty constructing rubrics (20%)
- Subjectivity in scoring (10%)
- Converting product scores into final grades (10%)

These challenges indicate that manual assessment mechanisms are not effective for evaluating complex project-based tasks. Teachers require a more structured and automated assessment system that can document students’ progress more consistently. This condition provides strong justification for the need for an LMS-based e-assessment system.

Table 5. The Use of Learning Management System (LMS) and The Need for Assessment Digitalization

No.	Questions	Response	%
1	Has your school ever used a Learning Management System (LMS)? If yes, please specify the platform used	Yes	60%
		No	20%
		Not familiar with LMS	20%
2	Has your school ever implemented an online assessment or grade input system?	Yes	100%
		No	0%
3	Perceived Advantages and Disadvantages of Written vs. LMS-Based Assessment Systems	Written system allows for more in-depth evaluation	20%
		Written system makes it easier to monitor student progress	10%
		Written records are susceptible to loss/damage	20%

4	Did you encounter any obstacles when using an online (network-based) assessment system?	Written system is less flexible	25%
		LMS offers greater flexibility and administrative security	25%
		Inability to display individual feedback and grades	20%
		None	40%
		Reliable internet access	25%
		Susceptible to misuse by learners	15%

Table 5 shows that 60% of teachers have used an LMS (such as *E-Sekolah*), while 20% have never used one, and another 20% are not familiar with the concept of an LMS. Although all teachers (100%) have entered grades online, the usefulness of LMS platforms is still limited to administrative functions. Teachers acknowledged that LMSs are more flexible and secure for documentation purposes, yet they still face several challenges, including:

- Internet connectivity issues (25%)
- Lack of features for providing individual feedback (20%)
- Potential misuse by students (15%)

These findings indicate that teachers are generally ready for digitalization but require an LMS that is simpler, more user-friendly, and equipped with features specifically designed to support project-based assessment in chemistry learning.

Discussion

The findings indicate that all high school chemistry teachers in Bantul have implemented project-based learning and integrated Sustainable Development Goals (SDGs) values into their instructional practices. This condition suggests that teachers demonstrate a high level of awareness toward student-centered learning and sustainability-oriented issues. However, although such awareness is evident, the implementation in classrooms remains varied, particularly regarding the consistent application of complete PjBL syntax and the structured use of SDGs indicators. These results align with Handoko et al. (2024), who emphasize that the success of PjBL is determined not only by selecting appropriate projects but also by the accuracy with which its procedural steps are implemented.

The selection of acid–base, colligative properties, and green chemistry topics as project contexts shows that teachers tend to choose content that can be easily linked to real-world phenomena. When projects are connected to everyday issues, learning becomes more meaningful and can stimulate student creativity and problem-solving skills, as indicated in previous studies on the effectiveness of contextual project-based learning (Pambuko et al., 2025). Nevertheless, some teachers have not implemented the full PjBL sequence due to limited time and the complexity of classroom activities, rendering the implementation suboptimal and still in need of further support.

The integration of SDGs values carried out by teachers also tends to be situational. Some teachers emphasize environmental issues, while others focus more on collaboration or responsibility. Since no shared, standardized indicators are used, the assessment of SDGs-related skills remains unsystematic. In fact, SDGs-oriented learning should ideally enable students to develop sustainable decision-making abilities and increase environmental literacy, as highlighted by Abu et al (2023). Therefore, a comprehensive assessment instrument capable of capturing these competencies is urgently needed.

In terms of assessment practices, teachers have implemented formative and summative assessments, yet these are still conducted manually, leading to several challenges. Project assessment requires considerable time, individual feedback is difficult to provide, and rubrics are not always constructed objectively. These obstacles are consistent with the findings of Hartono & Murniati (2024), who argue that conventional assessment is often inefficient and prone to subjectivity when used to evaluate complex learning activities such as projects. This condition reinforces the need for a more systematic digital assessment approach.

Most teachers have used a Learning Management System (LMS), but its utilization remains limited to grade input and general administrative functions. Existing platforms lack features that support comprehensive project assessment, such as digital rubrics, progress tracking, or individualized feedback. This indicates that current LMSs are not fully designed to accommodate the needs of chemistry project assessment. Meanwhile, Yana, D (2019) emphasizes that a properly designed LMS can enhance administrative organization, simplify evaluation processes, and maintain transparency of learning outcomes. Thus, LMS platforms possess strong potential as a solution, provided that their design is aligned with the characteristics of project-based assessment.

Overall, the findings of this study underscore the need to develop an LMS-based e-assessment system that is simpler, more structured, and supportive of the characteristics of SDGs-oriented chemistry project assessment. Such a system would not only reduce teachers' administrative burdens but also enable more objective evaluation of both cognitive and non-cognitive aspects. The development of a digital assessment system of this kind is well aligned with the demands of 21st-century education, which emphasizes technological literacy, sustainability, and higher-order thinking skills (Othman et al., 2024). Therefore, LMS-based e-assessment can serve as a strategic step in improving the quality of chemistry education while strengthening the school's orientation toward sustainable development.

CONCLUSION

Based on the results of the interview analysis, which show that all teachers have implemented PjBL and integrated SDGs values into chemistry instruction, it can be concluded that teachers possess a strong awareness of the importance of project-based learning and sustainability-oriented education. However, the implementation still faces challenges in terms of the systematization of PjBL syntax, the development of assessment rubrics, and the provision of individualized feedback.

The teachers' need for an assessment system that is efficient, objective, and well-documented highlights the urgency of developing an LMS-based e-assessment design that aligns with the characteristics of project-based chemistry learning. A well-designed LMS is expected to assist teachers in managing project assessments, providing individualized feedback, and evaluating both cognitive and non-cognitive aspects more transparently.

The implications of this study emphasize the need for developing specialized LMS features for chemistry teachers, particularly assessment tools capable of evaluating students' critical thinking, collaboration skills, and sustainability awareness. The development of this e-assessment design serves as a strategic step in supporting the implementation of SDGs-oriented chemistry learning in secondary schools.

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