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The Impact of Outcome-Based Digital Assessment on Self-Regulated Learning in General Chemistry Education

HRA Mulyani[1*], Ratini Ratini[2]

[1] Department of Biology Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Metro, Lampung, Indonesia
[2] Department of Teacher Professional Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Metro, Lampung, Indonesia

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Corresponding Author:
HRA Mulyani
hra.mulyani@gmail.com

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Abstract: This study aims to investigate the impact of integrating Outcome-Based Education (OBE)-oriented digital assessments on students' self-regulated learning (SRL) in General Chemistry courses. A quasi-experimental design was employed involving 50 undergraduate students who participated in four sessions of formative assessments delivered through digital platforms such as Quizizz and Google Forms. Each assessment item was carefully aligned with specific learning outcomes and designed to support five SRL dimensions: goal setting, time management, self-monitoring, help-seeking, and self-evaluation. Data were collected using pre- and post-intervention questionnaires and tests, and subsequently analyzed through paired sample t-tests. The results revealed a statistically significant improvement in overall SRL scores (from 64.52 to 77.84, $p < 0.001$), with the most notable increases observed in self-monitoring and help-seeking. These findings indicate that embedding digital formative assessments within an OBE framework can foster learners' autonomy, metacognitive engagement, and reflective learning strategies. The study underscores the pedagogical value of aligning assessment with learning outcomes while leveraging feedback-driven digital tools to create meaningful and sustainable learning experiences in higher education, particularly in science-related disciplines.

Keywords: Chemistry education; Digital assessment; Higher education; Outcome Based Education; Self-regulated learning

Introduction

In the evolving landscape of higher education, there is a growing imperative to design instructional models that not only impart disciplinary knowledge but also cultivate learner autonomy, critical thinking, and lifelong learning competencies (Arsyad et al., 2023). Among various curriculum reform paradigms, Outcome-Based Education (OBE) has garnered increasing attention for its emphasis on the attainment of clearly defined learning outcomes that align with both academic standards and professional expectations (Lashari et al., 2024). Within this framework, learning is reframed from passive content reception to active competency development.

General Chemistry commonly regarded as a gateway course for science and health-related disciplines represents a particularly complex learning environment. Its conceptual difficulty arises from abstract theories, symbolic representations, and the need to interrelate macroscopic, microscopic, and particulate levels of understanding (El-Mansy et al., 2022). For students in programs such as biology education, pharmacy, and biomedical sciences, these challenges are further compounded by traditional lecture-based instruction and summative assessment models that often fail to support adaptive, student-centered learning (Hayashi et al., 2023). These difficulties are often compounded by the use of traditional instructional and assessment approaches that fail to provide adaptive and personalized learning experiences.

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A key determinant of students' success in such cognitively demanding contexts is their capacity for Self-Regulated Learning (SRL). SRL encompasses the cognitive, metacognitive, motivational, and behavioral processes that learners employ to plan, monitor, and evaluate their learning (Kirschner et al., 2018). Students with strong SRL skills are better equipped to set meaningful goals, manage their study time, select appropriate learning strategies, seek help when necessary, and reflect critically on their performance (Yot-Domínguez & Marcelo, 2017). These competencies are not only essential for academic achievement but also for fostering sustainable, lifelong learning.

However, despite its recognized value, SRL remains underdeveloped in many students, especially within General Chemistry courses (El-Mansy et al., 2022). A contributing factor to this issue is the misalignment between traditional assessment methods and students' learning processes. Summative, high-stakes assessments often lack formative components such as timely feedback and opportunities for revision, thus failing to support the iterative, reflective nature of SRL (Lukman et al., 2023). Moreover, such practices conflict with the OBE philosophy, which advocates for continuous, formative assessment that guides students toward mastery of specific outcomes (Brata et al., 2022; Kuklick et al., 2023).

The integration of digital applications into assessment design offers a promising avenue to bridge this gap. To address these challenges, the integration of digital assessment tools presents a promising solution. Platforms like Quizizz, Google Forms, Kahoot, and Edmodo enable educators to conduct frequent, low-stakes formative assessments that provide instant feedback and performance analytics (Lashari et al., 2024). These features are conducive to the development of SRL, as students can identify their learning gaps, monitor their progress, and refine their strategies accordingly (Hagos & Andargie, 2024; Hokanson & Kenny, 2020). Furthermore, the gamification elements and interactive interfaces of these tools enhance learner motivation and engagement two critical drivers of self-regulated behaviors.

In an OBE framework, digital assessments can be purposefully designed to evaluate both cognitive learning outcomes and metacognitive skills, thereby aligning assessment more closely with instructional goals (Eleje et al., 2022; Viberg et al., 2024). The flexibility and diversity of assessment formats (e.g., multiple-choice, matching, open-ended responses), along with features like asynchronous access and individualized feedback, promote a more inclusive and student-centered learning environment (Lukman et al., 2023).

Nevertheless, empirical evidence on the synergistic integration of OBE and digital assessments to enhance SRL remains limited, particularly in the Indonesian higher education context (El-Mansy et al., 2022). Existing studies tend to examine either the implementation of OBE or the effectiveness of digital tools in isolation, with little focus on their combined impact on learners' self-regulation capabilities (Kirschner et al., 2018). Despite these pedagogical potentials, there remains a paucity of empirical research that explicitly examines the synergistic integration of OBE-aligned digital assessments and SRL development, especially within the context of Indonesian higher education. Existing studies tend to address either the implementation of OBE or the effectiveness of digital tools in isolation, offering limited insight into how their integration can support metacognitive growth and learner autonomy in science education.

Digital assessment tools provide a promising solution by embedding formative, feedback-driven practices into the learning process. According to constructivist learning theory, meaningful learning occurs when students actively construct knowledge through interaction, reflection, and feedback (Kirschner et al., 2018). Platforms such as Quizizz and Google Forms operationalize these principles by offering frequent low-stakes assessments, instant feedback, and gamified features that enhance motivation and engagement (Hagos & Andargie, 2024; Hokanson & Kenny, 2020). When embedded in an OBE framework, digital assessments can be systematically aligned with intended learning outcomes, thereby bridging the gap between assessment and instruction while simultaneously fostering SRL competencies (Brata et al., 2022; Viberg et al., 2024).

Therefore, the rationale for this research lies in addressing a critical gap in the literature: while prior studies have examined the implementation of OBE or the use of digital assessments in isolation, limited empirical evidence exists on their synergistic integration and its effect on SRL, particularly in the Indonesian higher education context (Kirschner et al., 2018; El-Mansy et al., 2022). By investigating how digital assessments designed under OBE principles influence SRL dimensions in General Chemistry courses, this study seeks to contribute theoretically by extending SRL and OBE frameworks into a digital learning environment, and practically by offering evidence-based insights to educators and policymakers for enhancing science education.

This study addresses this critical gap by investigating the influence of digital formative assessments designed within an OBE framework on students' SRL in a General Chemistry course. Conducted among first-year undergraduate students at Universitas Muhammadiyah Metro Lampung, the research explores how explicitly articulated learning outcomes, coupled

with digital assessment strategies, can foster SRL dimensions such as goal setting, time management, self-monitoring, and help-seeking. The novelty of this research lies in its dual focus: (1) integrating OBE principles directly into digital assessment design, and (2) empirically examining how this integration supports SRL as a metacognitive competency. The findings are expected to inform educators, curriculum developers, and policymakers about effective strategies for embedding assessment as an instructional tool that promotes meaningful and autonomous learning in foundational science education.

Method

Research Design

This study employed a quantitative approach with a pra-experimental one-group pretest-posttest design design to examine the impact of integrating Outcome-Based Education (OBE) oriented digital assessments on the enhancement of students' self-regulated learning (SRL) in General Chemistry instruction. This design was selected to observe changes in SRL before and after the intervention, without the use of a strict control group.

Participants and Setting

The participants were 50 first-semester undergraduate students enrolled in a General Chemistry course during the odd semester of the 2024/2025 academic year. The sample included students from Biology, Physics, and Mechanical Engineering programs, selected through purposive sampling based on inclusion criteria to ensure diverse academic representation and reduce potential sampling bias.

Over the course of four instructional weeks, students engaged in OBE-based formative assessments administered through digital platforms, including Quizizz and Google Forms. Each assessment item was aligned with specific learning outcomes (LOs) derived from the course syllabus and aimed to provide immediate, actionable feedback.

The digital formative assessments were purposefully designed to activate key dimensions of Self-Regulated Learning (SRL). Goal setting was promoted through prompts requiring students to articulate their learning objectives. Self-monitoring was supported by reflective items evaluating their understanding and strategy use. Help-seeking was facilitated through embedded links to learning resources triggered by incorrect responses. Time management was encouraged via timed assessments, guiding students to plan and regulate their pacing. Finally, self-evaluation was fostered through open-ended questions prompting students to reflect on their performance and feedback. These features were aligned with OBE principles to enhance metacognitive engagement and autonomous learning.

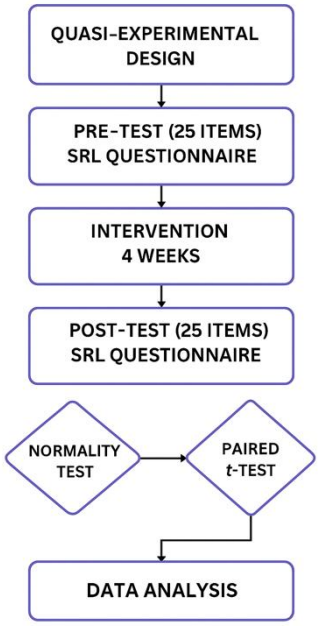

Figure 1. Research Flow Diagram

Instruments

The primary instrument was a Self-Regulated Learning (SRL) questionnaire, adapted from Zimmerman's (2002), encompassing five dimensions: (1) Goal setting, (2) Time management, (3) Self monitoring, (4) Help seeking, and (5) Self evaluation. The instrument was previously validated by subject-matter experts and pilot-tested, a specific Cronbach's Alpha coefficient (e.g., 0.85 or 0.91) would be much more robust and credible.

Additionally, digital pre-test and post-test assessments in multiple choice format were administered to measure students' learning progress and to triangulate the SRL data

Data Collection Procedures

Data collection was conducted in two stages:

- Pre-test and pre-questionnaire administered prior to the digital assessment intervention.
- Post-test and post-questionnaire administered following four rounds of digital OBE-based assessments.

All instruments were distributed and completed through the institution's Learning Management System (LMS), with student responses stored in secure digital files.

Data Analysis

Quantitative data from the questionnaires and tests were analyzed using descriptive statistics (mean, standard deviation) and paired sample t-tests to

determine statistically significant differences between pre- and post-intervention scores. Normality tests were conducted using the Kolmogorov–Smirnov method. All statistical analyses were performed using SPSS version 2.

Result and Discussion

This section presents the results of the study based on the analysis of students' pre-test and post-test scores on self-regulated learning (SRL) following the implementation of OBE-based digital assessments in General Chemistry learning. Data were analyzed across five key dimensions of SRL: goal setting, time management, self-monitoring, help-seeking, and self-evaluation.

Table 1. Mean Pre-Test and Post-Test Scores per SRL Dimension

SRL Dimension	Pre-Test Mean	Post-Test Mean	Mean Gain (+)
Goal Setting	61.80	75.40	+13.60
Time Management	63.50	74.10	+10.60
Self-Monitoring	65.20	79.00	+13.80
Help-Seeking	66.10	80.50	+14.40
Self-Evaluation	68.00	80.20	+12.20
Overall Average	64.52	77.84	+13.32

Table 1 presents the average scores of students on each SRL dimension before and after the implementation of OBE-based digital assessment. All five dimensions show significant improvement. The largest gains are found in Help-Seeking (+14.40) and Self-Monitoring (+13.80), indicating that students became more proactive in using support resources and in tracking their own understanding. The total average score improved by +13.32 points, reflecting the intervention's overall effectiveness

Table 2. Descriptive Statistics of Overall SRL Scores

Statistic	Pre-Test	Post-Test
Overall Mean	64.52	77.84
Standard Deviation (SD)	6.93	6.57
Minimum Score	52.00	66.00
Maximum Score	76.00	89.00
Score Range	24.00	23.00

Table 2 shows the distribution of scores before and after the intervention. Post-test scores have a slightly lower standard deviation, indicating a more consistent performance among students. The minimum and maximum scores also increased, suggesting improvement occurred not only among average performers but also among the lowest- and highest-scoring students.

Table 3. Paired Sample t-Test Results for Each SRL Dimension

SRL Dimension	t-Value	Sig. (2-tailed)	Interpretation
Goal Setting	-8.72	0.000	Significant improvement
Time Management	-7.45	0.000	Significant improvement
Self-Monitoring	-9.11	0.000	Significant improvement
Help-Seeking	-10.04	0.000	Significant improvement
Self-Evaluation	-8.60	0.000	Significant improvement
Total SRL Score	-11.87	0.000	Highly significant

Table 3 presents the results of the paired sample t-test, comparing pre-test and post-test scores for each SRL dimension. All *p*-values are below 0.001, indicating statistically significant improvements across all areas. The highest *t*-value was recorded for Help-Seeking and Total SRL Score, emphasizing the overall effectiveness of the digital assessment approach in promoting independent learning behaviors.

Discussion

The findings of this study indicate that the integration of OBE-based digital assessments in General Chemistry instruction contributed to a positive shift in students' self-regulated learning (SRL). The increase in the overall SRL score from 64.52 (pre-test) to 77.84 (post-test) reflects an improvement in students' learning behavior, particularly in aspects of self-monitoring and help-seeking. Although standard deviations and score distributions were not reported in the results section, the observed increase in mean scores suggests a general trend toward enhanced metacognitive engagement. This trend, while promising, should be interpreted as an initial indication of the potential role of digital assessment tools in supporting SRL development rather than a definitive measure of reduced performance variation.

Enhancing SRL through Digital Assessment

The most notable improvements were observed in the dimensions of help-seeking (+14.40) and self-monitoring (+13.80), suggesting that students became more engaged in identifying learning gaps and actively sought resources to address them. This aligns with the findings of (Raimondi et al., 2025), who argue that formative digital tools enhance metacognitive awareness by enabling students to receive immediate feedback and reflect on their performance iteratively. Moreover, the digital format allowed students to manage their pace and revisit content, supporting the

principles of self-paced and adaptive learning (Viberg et al., 2024).

Consistent with Zimmerman's (2002) model of SRL, improvements across dimensions indicate that students moved toward more autonomous learning behaviors, particularly in their ability to plan, monitor, and evaluate their learning strategies. The increase in goal setting and self-evaluation scores is indicative of a more deliberate and reflective approach to learning a core goal of learner-centered pedagogies

Relevance to OBE Framework

From an OBE perspective, the implementation of assessments aligned with specific learning outcomes facilitated deeper student engagement and accountability. Rather than treating assessments as isolated endpoints, the digital tools integrated into the course enabled continuous formative evaluation, which is critical in OBE driven instruction (Susetyarini et al., 2022; Suwono et al., 2023). As Brown et al. (2017) noted, formative assessments embedded within OBE frameworks help students internalize learning goals, engage with content meaningfully, and develop lifelong learning competencies.

The study the tools can improve learning-to-learn capacity, specifically SRL, and potentially impact academic performance. The personalized feedback and gamified features (especially in tools like Quizizz) also increase student motivation—an essential antecedent of self-regulation (Lashari et al., 2024).

Implications for Instructional Practice

These results have several implications for instructional design in science education. First, digital formative assessments should be systematically integrated into the course structure not merely used as supplemental tools. Secondly, instructors must ensure that assessments are clearly mapped to intended learning outcomes (ILOs) and offer feedback loops that enable learners to adjust strategies. As suggested by (Pappu et al., 2023), well-designed feedback mechanisms are central to building learners' confidence and promoting self-directed learning behaviors.

Furthermore, the relatively higher post-test scores accompanied by a lower standard deviation suggest a potential trend toward more consistent learning outcomes among students. While this pattern may reflect a reduced disparity in performance, such an interpretation remains indicative rather than conclusive and should be viewed as a preliminary insight into the possible equalizing effect of digital assessment.This supports the view of (Wood et al., 2020), who emphasize that digital interventions can promote learning equity by providing multiple opportunities for feedback and revision especially beneficial in foundational courses like General Chemistry where prior knowledge often varies.

Limitations and Future Research

While the improvements were statistically significant, this study is limited by its one-group pretest-posttest pre-experimental design and the absence of a control group, which restricts the ability to attribute changes solely to the intervention. Furthermore, the long-term retention of self-regulated learning (SRL) skills was not assessed. Future research should consider employing longitudinal and comparative designs to evaluate the sustainability of SRL improvements and to examine how digital assessment tools interact with other pedagogical approaches, such as problem-based learning (PBL) or flipped classroom models.

Conclusion

This study indicates that the integration of Outcome-Based Education (OBE)-oriented digital assessments into General Chemistry instruction is associated with a positive shift in students' self-regulated learning (SRL), as reflected in the significant improvement of mean scores across all SRL dimensions—particularly in self-monitoring and help-seeking. Although the one-group pretest-posttest design limits causal inference, the observed changes suggest that digital formative assessments, when aligned with clearly defined learning outcomes, may support the development of learner autonomy and reflective academic behaviors. In line with the aim of this research, these findings offer preliminary evidence of the pedagogical value of digital assessments not only as evaluation tools but also as instructional strategies that can enhance learning processes. This approach holds potential for broader application in foundational science courses to encourage deeper engagement and foster competency development in higher education.

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Author Contributions

Conceptualization, HRA Mulyani and Ratini; methodology, H.R.A. Mulyani; software, H.R.A. Mulyani; validation, H.R.A. Mulyani and Ratini; formal analysis, H.R.A. Mulyani; investigation, H.R.A. Mulyani; resources, H.R.A. Mulyani; data curation, H.R.A. Mulyani; writing—original draft preparation, H.R.A. Mulyani; writing—review and editing, H.R.A. Mulyani and Ratini; visualization, H.R.A. Mulyani; supervision, H.R.A. Mulyani; project administration, H.R.A.

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The authors declare no conflict of interest.

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