

Analysis of Competency-Based Biology Learning Evaluation Systems Through A Systematic Literature Review

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Abstract

Competency-based learning evaluation is an important aspect of Biology instruction in secondary education, as it assesses not only students' mastery of knowledge but also their skills and attitudes. However, various studies indicate that evaluation practices in Biology learning remain dominated by cognitive assessment, thereby limiting the optimal measurement of competencies in a comprehensive manner. This study aims to analyze competency-based Biology learning evaluation systems in secondary education using a Systematic Literature Review (SLR) approach. The research method followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Articles were retrieved from Google Scholar, SINTA, DOAJ, and Scopus databases, with publications limited to the period from 2021 to 2026. The selection process consisted of article identification, screening, eligibility assessment, and inclusion. Of the 120 articles identified, 15 met the inclusion criteria and were analyzed using content analysis techniques. The findings indicate that competency-based evaluation in Biology learning has developed through the implementation of authentic assessment, performance assessment, portfolios, higher-order thinking skills (HOTS) assessment, and the use of digital technology. The application of these evaluation approaches contributes to improving students' critical thinking skills, scientific literacy, and problem-solving abilities. Nevertheless, several challenges remain, including the dominance of written tests, limited affective and psychomotor assessment instruments, and teachers' limited competence in developing competency-based assessments. Therefore, strengthening teachers' capacity and developing more comprehensive evaluation instruments are necessary to support competency-oriented Biology learning.

Keywords: Learning Evaluation, Biology, Competency-Based Assessment, Secondary Education, Systematic Literature Review

INTRODUCTION

Twenty-first-century education requires students not only to master knowledge but also to possess critical thinking skills, creativity, communication, collaboration, and problem-solving abilities (Indarini, 2024). In the context of Biology learning, the attainment of these competencies is highly important because Biology is a subject that examines life phenomena through scientific processes, observation, experimentation, and reasoning (Solihin S et al., 2025). Therefore, the Biology learning evaluation system functions not only to measure

cognitive learning outcomes but also to assess science process skills, scientific attitudes, and various competencies that students need in real-life contexts (Nuralisa et al., 2021).

The shift in the educational paradigm toward competency-oriented learning has encouraged the implementation of various educational policies, including the Merdeka Curriculum in Indonesia (Andreani & Gunansyah, 2023). This curriculum emphasizes the importance of student-centered assessment, holistic competency development, and the use of various forms of authentic evaluation (Khafidin et al., 2022). In Biology learning, competency-based evaluation is expected to provide a more comprehensive representation of students' abilities than assessment practices that focus solely on written test results (Puspita A. F et al., 2024). Thus, evaluation becomes an integral component of the learning process in supporting the improvement of educational quality (Magfiroh & Indrati, 2026).

Various studies indicate that Biology learning evaluation has developed quite significantly in recent years. Teachers have begun to implement authentic assessment, project assessment, performance assessment, portfolios, HOTS-based assessment (Higher Order Thinking Skills), and digital technology in the assessment process (Ekasari & Hidayati, 2021). The use of these various evaluation models aims to measure students' competency achievement more comprehensively across the domains of knowledge, skills, and attitudes (Rahmawati & Trimulyono, 2022). In addition, the use of technology in evaluation has continued to expand in line with digital transformation in education.

Nevertheless, research findings indicate that Biology learning evaluation practices at the secondary education level still face various challenges. Most teachers still tend to use written tests as the primary instrument in the assessment process (Andri et al., 2024). The assessment of affective and psychomotor aspects is often not conducted optimally because of limitations in instruments, time, and teachers' understanding of competency-based assessment. As a result, the information obtained from the evaluation process does not yet fully reflect students' competencies in a comprehensive manner (Dianti et al., 2025).

Furthermore, the implementation of competency-based evaluation also faces challenges in developing instruments that are valid, reliable, and aligned with the characteristics of Biology learning (Liana, 2020). Many assessment instruments remain oriented toward measuring students' ability to recall and understand concepts, whereas higher-order thinking skills, science process skills, scientific literacy, and problem-solving abilities have not received sufficient attention (Kurniawan et al., 2026). In fact, these competencies constitute the primary objectives of Biology learning in the twenty-first century.

Previous studies have generally focused on the effectiveness of specific learning models, such as Problem-Based Learning, Project-Based Learning, Inquiry Learning, and the use of instructional media in improving Biology learning outcomes. Several studies have also examined the development of HOTS assessment instruments, authentic assessment, and digital assessment. However, these studies remain partial and tend to highlight specific aspects of learning evaluation without providing a comprehensive overview of the competency-based Biology learning evaluation system (Solihin et al., 2025).

Based on the results of the literature search, studies that specifically discuss competency-based Biology learning evaluation systems through a Systematic Literature Review (SLR) approach remain highly limited (Mustika & Hamidah, 2025). Most studies have employed experimental methods, surveys, research and development designs, or case studies.

Consequently, information regarding research trends, evaluation characteristics, the types of instruments used, and the effectiveness of competency-based evaluation implementation in Biology learning remains scattered across various publications and has not yet been systematically synthesized (Anditiasari et al., 2021).

The first research gap lies in the continued dominance of studies focusing on cognitive learning outcomes rather than holistic competency evaluation that includes affective and psychomotor aspects. The second gap is that most studies evaluate specific learning models rather than comprehensively analyzing the Biology learning evaluation system. The third gap is the very limited number of literature reviews that integrate various research findings on competency-based Biology learning evaluation in secondary education during the 2021–2026 period. The fourth gap is that few studies have systematically identified the relationship among the implementation of the Merdeka Curriculum, authentic assessment, and the use of digital technology in Biology learning evaluation.

These conditions indicate the need for research that can present a comprehensive synthesis of the development of competency-based Biology learning evaluation systems in secondary education. Through a Systematic Literature Review approach guided by PRISMA, this study is expected to provide an overview of research trends, the types of evaluation instruments used, the competencies measured, the supporting and inhibiting factors in implementation, and the effectiveness of the evaluation systems applied in Biology learning. Therefore, the study entitled “Analysis of Competency-Based Biology Learning Evaluation Systems in Secondary Education: A Systematic Literature Review for the 2021–2026 Period” is important to conduct in order to address the existing research gaps. The findings of this study are expected to serve as a reference for teachers, researchers, and policymakers in developing Biology learning evaluation systems that are more comprehensive, authentic, and aligned with the demands of twenty-first-century competencies and the implementation of the Merdeka Curriculum.

RESEARCH METHODS

This study employed the Systematic Literature Review (SLR) method to identify, evaluate, and synthesize research findings related to competency-based Biology learning evaluation systems in secondary education (Al-Kamzari & Alias, 2025). The SLR method was selected because it is capable of providing a comprehensive overview of research developments, evaluation trends, the instruments used, and the effectiveness of implementing competency-based evaluation in Biology learning (Khotimah et al., 2023). The research process referred to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which include the stages of identification, screening, eligibility, and inclusion of studies.

RESULTS AND DISCUSSION

Based on the selection stages referring to the PRISMA framework, as described in the methodology section, several articles that met the inclusion criteria within the 2021–2026 period were obtained. The resulting data are presented as follows :

Table 1. PRISMA Stages of the Study

PRISMA Stage	Numbe of Articles	Description
Identification	120	Articles were identified from Google Scholar, DOAJ, Garuda, SINTA, and Scopus.
Duplicate Removed	20	Duplicate articles were removed.
Screening	100	Screening was conducted based on titles and abstracts.
Excluded	60	Articles that did not discuss Biology learning evaluation or were not related to secondary education were excluded.
Eligibility	40	Articles were read in full text.
Excluded Full Text	25	Articles that did not meet the inclusion criteria were excluded.
Included	15	Articles were used in the SLR analysis.

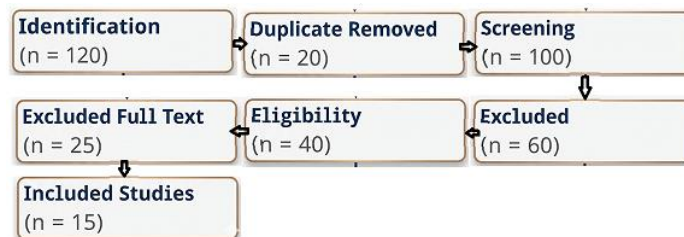


Figure 1. PRISMA Flow Diagram of the Study

Table 2. Data Extraction Results from Selected Articles

No	Penulis & Tahun	Judul	Metode	Fokus Evaluasi	Temuan Utama
1	A1	Analysis of the Implementation of the Merdeka Curriculum in Biology Learning	Qualitative	Competency assessment	Assessment remains dominated by the cognitive domain.
2	A2	Assessment Literacy of Biology Education Students in Designing HOTS Test Blueprints	Descriptive	HOTS assessment	Assessment literacy remains in the moderate category.
3	A3	Development of an E-Module for Biology Learning Evaluation	R&D	Digital evaluation	The e-module improves evaluation skills.
4	A4	Lesson Study Based on the Deep Learning Approach	Mixed Method	Learning evaluation	Teacher competence increased significantly.

5	A5	Analysis of the Effectiveness of Merdeka Curriculum-Based Biology Learning	Case Study	Implementation evaluation	Learning is effective; however, assessment has not yet been optimized.
6	A6	Implementation of Lesson Study among Vocational High School Teachers	Qualitative	Process assessment	Collaboration improves the quality of evaluation.
7	A7	Collaboration between Lesson Study and Deep Learning	Experimental	Scientific literacy	Students' evaluation results improved.
8	A8	Deep Learning in Biology Inquiry Learning	Experimental	Evaluation of thinking skills	HOTS improved.
9	A9	The Quality of Biology Learning from a Twenty-First-Century Perspective	Survey	Competency assessment	Teachers have begun to implement authentic assessment.
10	A10	Enhancing Problem Solving Skills with Lesson Study	Experimental	Problem solving assessment	Problem-solving abilities improved.
11	A11	Digital Technologies, Online Learning and Lesson Study	Review	Digital evaluation	Technology supports continuous assessment.
12	A12	Lesson Study Model in Teacher Development	SLR	Teacher competence	Reflection-based evaluation is effective.
13	A13	Creation and Evaluation of AI Curriculum	Mixed Method	Competency Assessment	Students' competencies improved after the implementation of the AI curriculum.
14	A14	Evaluasi Penerapan Model Inkuiri Terbimbing	SLR	Evaluation of learning models	Inquiry improves learning outcomes and competencies.
15	A15	Technology Integration in PjBL	Bibliometrik-SLR	Evaluation of twenty-first-century competencies	Technology strengthens the assessment of students' skills.

The review of the 15 articles that met the inclusion criteria indicates that the Biology learning evaluation system in secondary education experienced relatively significant development during the 2021–2026 period. This development was marked by a shift in the evaluation paradigm from one initially oriented toward measuring cognitive learning outcomes to a more comprehensive competency-based evaluation (Pratiwi & Muazansyah, 2022). This change aligns with the demands of the Merdeka Curriculum, which emphasizes the holistic development of students' competencies through the mastery of knowledge, skills, and attitudes (Andreani & Gunansyah, 2023).

Based on the synthesis of the articles, Biology learning evaluation remains dominated by the use of written tests in the form of multiple-choice and essay questions. These instruments are generally used to measure conceptual understanding, analytical ability, and students' learning achievement. Nevertheless, several studies indicate that the use of written tests alone is not sufficient to represent students' competencies comprehensively, particularly in relation to science process skills and scientific attitudes, which are the core characteristics of Biology learning (Sinurat, 2025).

The review also shows that the implementation of competency-based assessment has begun to develop through the use of authentic assessment. The forms of authentic assessment identified include project assessment, portfolios, presentations, laboratory practice, and performance assessment. Authentic assessment enables teachers to evaluate students' ability to apply Biology concepts in real-life situations; therefore, the evaluation results become more meaningful than those obtained through conventional tests (Fahlevi, 2022).

In addition to authentic assessment, several studies reported an increase in the use of HOTS-based instruments (*Higher Order Thinking Skills*) in Biology learning evaluation. HOTS instruments are designed to measure students' ability to analyze, evaluate, and create solutions to problems related to biological phenomena (Utami et al., 2023). This finding indicates the efforts of teachers and researchers to align the evaluation system with the demands of twenty-first-century skills, which require higher-order thinking abilities (Ekasari & Hidayati, 2021).

Regarding the competencies measured, most studies still focus on the cognitive domain. Meanwhile, evaluation of the affective and psychomotor domains remains relatively limited. In fact, Biology learning has characteristics that require laboratory skills, observation, scientific investigation, and the development of environmental awareness and scientific ethics. This imbalance indicates that the implementation of competency-based evaluation has not yet fully operated in accordance with the expected concept (Santosa et al., 2025).

The review findings also indicate that the use of digital technology in Biology learning evaluation has increased. Various digital platforms, such as Google Forms, Quizizz, Kahoot, learning management systems (LMS), and e-portfolios, have begun to be used to support the assessment process. The use of technology facilitates the management of learning outcome data, improves the efficiency of the evaluation process, and enables more flexible assessment implementation. However, its implementation still faces challenges related to limited infrastructure and teachers' digital competence.

In the context of the Merdeka Curriculum, Biology learning evaluation is directed toward measuring competency achievement continuously through diagnostic, formative, and summative assessments. Research findings show that some teachers have implemented these various forms of assessment, but their implementation has not yet been optimal. Many teachers still experience difficulties in developing assessment instruments that are aligned with learning outcomes and the Pancasila Student Profile, which constitutes the primary objective of the Merdeka Curriculum.

Another factor that influences the success of competency-based evaluation is teachers' competence in designing and implementing assessments. Several studies indicate that some teachers still have limited understanding of the concept of authentic assessment, the development of assessment rubrics, and the design of HOTS-based instruments. This condition affects the quality of the evaluation conducted and has the potential to reduce the accuracy of students' competency measurement.

Based on the analysis of the reviewed articles, the effectiveness of competency-based evaluation is reflected in the improvement of students' critical thinking skills, scientific literacy, problem-solving skills, and collaborative abilities. These results indicate that evaluation designed in accordance with the characteristics of Biology learning can make a positive contribution to the development of students' competencies. Therefore, the use of various forms of authentic assessment should continue to be encouraged in learning practices.

Overall, the results of this Systematic Literature Review indicate that competency-based Biology learning evaluation systems in secondary education have developed toward evaluations that are more comprehensive and oriented toward the development of twenty-first-century competencies. However, various challenges remain, including the dominance of cognitive assessment, limited affective and psychomotor instruments, low teacher competence in assessment, and the suboptimal use of technology. Therefore, strengthening teachers' capacity, developing valid and authentic evaluation instruments, and providing educational

policy support are necessary to promote the more effective implementation of competency-based evaluation in schools.

CONCLUSION

Based on the results of the Systematic Literature Review of 15 articles published during the 2021–2026 period, competency-based Biology learning evaluation systems in secondary education show development toward a more comprehensive approach oriented to students' competency achievement. The evaluation forms widely used include authentic assessment, performance assessment, portfolios, HOTS assessment, and digital technology-based evaluation. The implementation of these evaluations has been shown to improve students' critical thinking skills, scientific literacy, and problem-solving skills. However, their implementation still faces several challenges, including the dominance of cognitive assessment, limited affective and psychomotor assessment instruments, and teachers' low competence in developing competency-based assessments. Therefore, strengthening teachers' capacity and developing a more holistic evaluation system are necessary to support Biology learning in accordance with the demands of the Merdeka Curriculum and twenty-first-century learning.

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