Journal of Learning on History and Social Sciences
Homepage : https://journal.antispublisher.id/index.php/EJLHSS
Email : admin@antispublisher.com

e-ISSN : 3031-7347
JLHSS, Vol. 2, No. 7, July 2025
Page 424-431

Comparative Analysis of Genetic Material in the Merdeka Curriculum and Cambridge A Level Biology: Content, Competencies, and Cognitive Levels Approach

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DOI : https://doi.org/10.61796/ejlhss.v2i7.1352

Sections Info

Article history:
Submitted: May 24, 2025
Final Revised: May 31, 2025
Accepted: June 15, 2025
Published: July 5, 2025

Keywords:
Curriculum analysis
Cambridge a level
Genetics
Merdeka curriculum
Cognitive level
Bloom's taxonomy

ABSTRACT

Objective: *This study aims to comparatively analyze genetic material in the Merdeka Curriculum and Cambridge A Level Biology, focusing on the approach to content, built competencies, and cognitive levels based on Bloom's taxonomy.* ***Method:*** *The study was carried out through the analysis of official curriculum documents and reference textbooks for each curriculum.* ***Results:*** *The results showed that both curricula covered similar key themes of genetics, such as DNA structure and trait inheritance. However, the Merdeka Curriculum emphasizes more conceptual understanding and local contextualization with the dominance of the cognitive level of understanding (C2) and applying (C3). Meanwhile, Cambridge A Level presents material in a systematic and in-depth manner, demanding analytical and evaluative competencies (C4–C5), and integrating quantitative and statistical approaches. These differences reflect different philosophical orientations. The Merdeka curriculum focuses on meaningful learning and character building, while Cambridge A Level emphasizes scientific precision and advanced academic readiness.* ***Novelty:*** *The implications of this study lead to the importance of integrating approaches so that genetic learning becomes more balanced between academic depth and contextual relevance.*

INTRODUCTION

The science of genetics has been a major foundation in the development of modern biology, especially since the discovery of the structure of DNA by Watson and Crick in 1953. In the world of education, genetic material plays an important role in helping students understand the mechanisms of inheritance of traits and genetic variation [1], [2], [3], [4], [5], [6]. In addition, this topic has high relevance to applications in the fields of biotechnology and health. Learning genetics is also considered crucial in shaping science literacy, as well as encouraging critical thinking and scientific problem-solving skills [7], [8], [9], [10].

The Merdeka Curriculum, which was introduced in Indonesia in 2022, is the latest education policy that emphasizes strengthening competence, flexibility, and real-world context-based learning [11]. In Biology subjects, especially genetic material, this curriculum directs students to understand basic concepts such as DNA structure, protein synthesis, and Mendel's heredity. The material is also associated with local and global issues to be more relevant to real life. This curriculum seeks to balance conceptual understanding and character development through strengthening the Pancasila Student Profile.

Cambridge A Level Biology is an international curriculum that is widely adopted by global standard schools. The curriculum emphasizes a depth of scientific understanding, data analysis skills, and an experimental approach to discussing the topic

of genetics. These topics include DNA structure, protein synthesis, inheritance of Mendel's traits, genetic mutations, and gene expression [12]. Genetic material is delivered systematically and in depth, and is complemented by relevant statistical analysis and problem-solving exercises.

In global schools that adopt the Merdeka Curriculum and Cambridge A Level at the same time, comparative studies are required to understand the suitability and differences in the genetic material taught. This comparison covers not only the content, but also the learning approach, cognitive level, and targeted competencies. This analysis is important to identify a balance between conceptual understanding and scientific skills. However, there has not been much research that specifically addresses the differences in the structure of genetic material from the two curricula, especially in terms of depth of concept and demands for high-level thinking.

Therefore, this study aims to conduct a comparative analysis of genetic material in the Merdeka Curriculum and Cambridge A Level Biology. The focus of the analysis includes the content of the material, the competencies developed, and the cognitive level based on Bloom's taxonomy. This study was conducted to assess the suitability and differences between the two curricula in their approach to genetic learning. It is hoped that the results of the research can contribute to the development of a more harmonious curriculum in schools that apply both approaches.

RESEARCH METHOD

In This study applies a descriptive qualitative approach using the document analysis method. This approach was chosen because it is appropriate to explore and compare the content of the textual curriculum in depth. The focus of the analysis includes the identification of the material structure, learning objectives, and the level of cognitive depth expected of learners. This method allows researchers to systematically review curriculum policies without having to be directly involved in the learning process.

The main source of data in this study comes from the official curriculum documents of the two education systems analyzed. The document includes the Biology Learning Outcomes of Phase F of High School in the Merdeka Curriculum [11] and *Cambridge International AS and A Level Biology* (9700) *Syllabus* for 2022–2024 [12]. Both documents are used as a basis for comparing the structure and content of genetic material. In addition, the researcher also refers to the recommended textbooks of each curriculum to deepen the exploration of material coverage.

Data collection is carried out through the identification of the content of curriculum documents that are directly related to the topic of genetics. The data is then grouped based on the category of material content, intended competencies, and operational verbs used in formulating learning outcomes. Data analysis is carried out through several stages. First, mapping the content of genetic material, all topics included in the scope of genetics in both curricula are mapped and compared in terms of scope and order of delivery. Second, the competency analysis contained in the curriculum document, both knowledge, skills, and scientific attitudes, is analyzed to find out the direction of learning

emphasized by each curriculum. Third, the classification of the cognitive level of operational verbs on learning objectives is classified based on the revision of Bloom's Taxonomy [13] into six cognitive categories: *remembering*, *understanding*, *applying*, *analyzing*, *evaluating*, and *creating*). This aims to assess the extent to which the curriculum encourages high-level thinking skills.

RESULTS AND DISCUSSION

A. Content Approach

The coverage of genetics material in the two curricula shows similarities in the main themes, but there are significant differences in the depth of content, presentation structure, and pedagogical orientation.

The Merdeka Curriculum organizes genetic material in an integrated thematic framework, focusing on core concepts such as:

1) Structure and function of DNA and RNA.
2) Mechanism of inheritance of traits based on Mendel's law.
3) Protein synthesis (transcription and translation).
4) Genetic mutations and their impact.

The material is structured to build a basic conceptual understanding, and is accompanied by reinforcement of real-life contexts, such as disease inheritance. The focus of learning is conceptual and contextual, so that students can relate science to global issues [11].

In contrast, Cambridge A Level Biology compiles genetic material with a deductive and systematic approach, starting from molecular biochemistry to the application of genetic engineering techniques. The scope is wider and deeper, including:

1) Nucleotide structure and chromosomal organization.
2) Regulation of gene expression (including operons and regulatory proteins).
3) Genetic inheritance with a quantitative approach.
4) Linkage and crossing-over phenomenon.
5) Examples of genetic mutations.
6) Genealogy analysis and allele frequency calculation in the population.
7) The application of statistics in genetics, such as the use of the chi-square test to test phenotype ratios.

The Cambridge curriculum emphasizes not only comprehension, but also mastery of technical terminology and quantitative thinking skills, which are the foundation for advanced science education [14].

B. Competency Analysis

The Merdeka Curriculum develops learning outcome-based competencies that emphasize the integration of knowledge, scientific skills, and scientific attitudes. In the context of genetics, students are expected to:

1) Identify DNA structure and protein formation processes.
2) Presenting observation results or data in verbal and visual form.

3) Relate the concept of genetics to everyday issues such as genetic diseases and biotechnology.

This competency is aimed at forming active, critical, and contextual learners, in accordance with the profile of Pancasila Students. The approach used is holistic and cross-disciplinary, with an emphasis on collaboration, communication, and empathy.

Meanwhile, Cambridge A Level sets out more academic and detailed competencies, including:

1) Interpret pedigree diagrams and identify patterns of genetic inheritance.
2) Calculating the probability of genetic crosses mathematically.
3) Using experimental data to test hypotheses using basic statistics.
4) Calculate the expected ratio of the results of genetic crosses (e.g. 9:3:3:1).
5) Using the chi-square test to test the compatibility between the observation data and the expected data.
6) Determine the significance value and degrees of freedom.
7) Conclude whether the data support a genetic hypothesis or not.

The competencies in this curriculum require a high level of learning independence, the ability to read scientific data, and analytical thinking based on scientific methods. This is in line with Cambridge's orientation as a formal science-based curriculum that prepares students for university level.

C. Cognitive Levels Based on Bloom's Taxonomy

In examining the learning outcomes of genetics in the Merdeka Curriculum and Cambridge A Level Biology, it can be seen that there is a difference in emphasis on the cognitive level that underlies the formulation of learning objectives. The Merdeka Curriculum tends to emphasize mastery of concepts through activities that involve understanding (C2) and application (C3). This is reflected in the use of operational verbs such as explaining, interpreting, and applying in the context of daily life. For example, students are directed to describe the process of transcription and translation, as well as apply the concept of inheritance of traits in case studies of genetic diseases. This shows that the Merdeka Curriculum focuses on the formation of conceptual understandings that are applicable in contextual and social contexts.

On the other hand, Cambridge A Level Biology shows a stronger tendency towards the use of lower cognitive levels such as remembering (C1), but also integrating high levels such as evaluating (C5) and analyzing (C4). Many statements in the syllabus ask students to define terms, explain molecular structures, and evaluate the ethical impact of genetic engineering. In addition, there is a demand for the use of analytical skills in solving quantitative genetic problems, including pedigree analysis and statistical tests such as chi-square, which clearly require logical and systematic thinking skills.

The Cambridge curriculum explicitly encourages students to develop high-level scientific skills, such as data-driven reasoning, interpretation of graphs and tables, and assessments of the validity of genetic experiments. This approach requires not only mastery of concepts, but also skills in evaluating and making scientific decisions. Thus,

although the curriculum includes more activities at the level of remembering and understanding at the beginning, it develops towards high-level thinking that is deductive and evaluative.

In contrast, the Merdeka Curriculum, while encouraging creativity and originality, does not explore evaluative or synthesis abilities in formal academic contexts. Activities such as designing experiments or evaluating genetic research results are still limited to introduction, not deepening. As a result, in terms of cognitive level, the Merdeka Curriculum is more inclined towards meaningful learning based on understanding, while Cambridge A Level emphasizes more on mastery of content and advanced scientific thinking skills.

The use of this approach reflects Cambridge's orientation on the development of quantitative understanding in biology, which is in line with the demands of modern scientific research. On the other hand, the Merdeka Curriculum has not touched on this aspect, which shows that there is a gap in the integration of numeracy in biology learning.

The difference between the two curricula does not only lie in the content of the material, but also reflects the educational philosophy that underlies it. The Merdeka Curriculum emphasizes relevance, learning independence, and local contextualization, while Cambridge A Level emphasizes academicism, scientific precision, and quantitative literacy.

The implication of these findings is that the Merdeka Curriculum has the power in meaningful learning and character development, but it needs to strengthen the quantitative aspect. Cambridge A Levels are suitable for application in the context of higher education and research preparation, but lack the emphasis on local and cultural contexts. These results are consistent with previous studies [15] which stated that the integration of statistical methods in the science curriculum can significantly improve students' analytical skills.

Table 1. Comparison Table of Merdeka Curriculum and Cambridge A Level Curriculum.

Comparative Aspects	Merdeka Curriculum	Cambridge A Level Biology
Curriculum background	Indonesia's national curriculum launched in 2022.	The international curriculum of Cambridge Assessment International Education.
Educational approach	Contextual, competency-based, oriented to Pancasila Student Profile.	Academic, scientific, focuses on the exploration of concepts in depth and experimentally.
Focus of genetics learning	DNA structure, protein synthesis, Mendel's heredity, linkages to local/global issues.	DNA structure, protein synthesis, Mendel inheritance, mutations, gene expression, and statistical analysis.

Cognitive level	Dominant in understanding and application, analysis and evaluation began to be introduced.	Encourage high-level thinking such as analysis, evaluation, and synthesis.
Competency objectives	Building science literacy, reflective, collaborative, and contextual character.	Develop scientific skills, critical thinking, and problem-solving skills.
Delivery of material	It is associated with real issues, based on local and national issues.	It is delivered systematically and in detail, based on experiments and theories.
Curriculum structure	Adaptive and flexible to the context of the school and students.	Internationally standardized and follows a strict structure.
Supporting teaching materials	National textbooks, project modules, and local teaching resources.	Cambridge textbooks and international supporting scientific journals.
Assessment and evaluation	Formative and summative, project-based, portfolio-based, and competency observation.	Summative through the international final exam (Paper 1–5), based on theory and experimentation.
Cross-field competence	Integrated with digital literacy, character, and numeracy.	Focused on scientific and numerical skills in the context of biology.
Global orientation	Contextual with national values and local issues.	Globally oriented with international scientific references and global applications.
The role of teachers	Facilitator of learning based on students' interests and needs.	Instructor and evaluator with high scientific accuracy demands.
Role of students	Active, reflective, collaborative, and problem-solving.	Critical, independent, and skilled in scientific investigation.

CONCLUSION

Fundamental Finding : The results of a comparative analysis of genetic material in the Merdeka Curriculum and Cambridge A Level Biology show that both curricula have similarities in the main themes of genetics, such as DNA structure, trait inheritance, and genetic mutations. However, there are fundamental differences in terms of depth of material, teaching approach, and cognitive competency demands. The Merdeka Curriculum emphasizes more on contextual conceptual understanding with a thematic approach and strengthening local values through the Pancasila Student Profile. The

competencies built are more holistic, oriented to application in daily life, and emphasize the understanding and application of concepts (C2 and C3 in Bloom's Taxonomy). Meanwhile, Cambridge A Level organizes the material systematically and in-depth, emphasizing scientific precision, quantitative literacy, and analytical and evaluative thinking skills (C4–C5), with strong integration of scientific methods and statistical analysis. Implication: Both curricula reflect different educational orientations: The Merdeka Curriculum leans towards meaningful learning that shapes local character and contextualization, while Cambridge A Level focuses on academic mastery and scientific research readiness. These findings provide important implications for schools that adopt both curricula in parallel, namely the need to develop teaching strategies that are able to bridge academic depth with contextual relevance so that students can get the most out of both approaches. **Limitation :** However, there are fundamental differences in terms of depth of material, teaching approach, and cognitive competency demands. The Merdeka Curriculum emphasizes more on contextual conceptual understanding with a thematic approach and strengthening local values through the Pancasila Student Profile. Meanwhile, Cambridge A Level organizes the material systematically and in-depth, emphasizing scientific precision, quantitative literacy, and analytical and evaluative thinking skills (C4–C5), with strong integration of scientific methods and statistical analysis. These contrasts may pose implementation challenges when aligning curriculum content and pedagogy in schools that integrate both systems. **Future Research :** These findings provide important implications for schools that adopt both curricula in parallel, namely the need to develop teaching strategies that are able to bridge academic depth with contextual relevance so that students can get the most out of both approaches. Future research can further explore how such integrated strategies affect student learning outcomes, particularly in terms of critical thinking development, scientific literacy, and local identity reinforcement across different educational contexts.

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