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Do Flashcards Improve Biology Learning? A Systematic Review of Cognitive Learning Outcomes

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Abstrak

Pembelajaran biologi sering dianggap sulit karena konsep yang kompleks, proses abstrak, dan banyaknya istilah, sehingga berdampak pada rendahnya hasil belajar kognitif peserta didik. Diperlukan media pembelajaran yang efektif dan berbasis bukti untuk meningkatkan keterlibatan dan pemahaman peserta didik. Tinjauan literatur sistematis ini bertujuan untuk mengkaji efektivitas flashcard dalam meningkatkan hasil belajar kognitif pada pembelajaran biologi serta cara penerapannya di kelas. Penelitian ini menganalisis artikel empiris yang dipublikasikan pada tahun 2021–2025 dengan desain eksperimen, kuasi-eksperimen, dan penelitian pengembangan, yang sebagian besar dilakukan pada jenjang pendidikan menengah. Analisis dilakukan secara deskriptif kualitatif dengan membandingkan pelaksanaan pembelajaran dan hasil belajar antara kelompok eksperimen dan kontrol. Hasil kajian menunjukkan bahwa penggunaan flashcard secara konsisten meningkatkan hasil belajar kognitif peserta didik, terutama pada aspek mengingat, memahami, dan menerapkan konsep biologi. Flashcard paling efektif ketika digunakan dalam pembelajaran aktif, didukung oleh visual, dan mendorong pengulangan serta pengambilan kembali pengetahuan.

Kata Kunci: *Flashcard; Biologi; Hasil Belajar; Kognitif.*

Abstract

Biology learning is often considered challenging due to its complex concepts, abstract processes, and numerous terms, which often result in low cognitive learning outcomes among students. Many students rely on passive learning strategies that are insufficient to support meaningful understanding and long-term retention. Consequently, there is a need for effective, evidence-based instructional media that can actively engage students and improve cognitive achievement in biology learning. This systematic literature review aims to examine the effectiveness of flash cards in improving students' cognitive learning outcomes in biology and to identify how they are used in classroom instruction. This study employs a systematic literature review to analyze empirical research articles published between 2021 and 2025 that investigate the use of flashcards in biology learning. The selected studies include experimental, quasi-experimental, and developmental research designs, mostly conducted at the secondary education level.

Data were analyzed through qualitative descriptive methods by comparing the implementation of learning, learning outcomes, and cognitive impacts reported between the experimental and control groups. The results showed that flash cards consistently improved students' cognitive learning outcomes, particularly in remembering, understanding, and applying biology concepts. The experimental group that used flashcards achieved higher posttest scores and greater learning gains than the control group that used conventional learning methods. Flashcards were most effective when integrated into active learning activities, supported by visual representations, and used to facilitate repeated retrieval of biological knowledge.

Keywords: *Flash Cards; Biology; Learning Outcomes; Cognitive.*

INTRODUCTION

Biology is a major challenge for some students at the secondary level. Despite numerous improvements in curriculum design and learning strategies, many students still struggle to develop a deep and lasting understanding of biological concepts (Herak et al., 2025). Biology is a subject rich in abstract concepts, complex processes, and specialized vocabulary, all of which encourage students to build strong conceptual structures to form new knowledge. However, many students find it difficult to integrate new information with their existing knowledge, resulting in fragmented understanding, weak connections between concepts, and difficulty remembering important details over time (Luthfyanti et al., 2024). As a result, students often perform well on short-term tasks but fail to retain or apply knowledge meaningfully when evaluated at a later stage. Research in science education consistently shows that gaps in conceptual understanding reduce students' confidence, undermine motivation, and limit their ability to engage in the higher-order thinking skills necessary for advanced scientific learning and future application (Gagnier et al., 2023).

In addition to these conceptual challenges, students' daily learning habits also play a major role in low learning outcomes. Many students tend to rely on passive and repetitive learning methods, such as rereading textbooks, memorizing notes, or memorizing facts without meaningful engagement (Ruiz-Martín et al., 2024). Research in cognitive psychology suggests that these strategies may create a sense of familiarity but fail to produce strong, long-lasting memory traces. Meanwhile, teachers also face structural barriers, including large class sizes, limited time for personal feedback, and strict curricular schedules, which force students to learn independently without adequate guidance (Krause et al., 2025). This situation highlights the urgent need for effective learning tools that students can use independently while adhering to principles grounded in cognitive strategies. Improving learning strategies requires not only identifying what students currently lack, but also exploring evidence-based solutions that can be realistically applied in real classroom contexts (Carpenter et al., 2022).

Recent research clarifies the scale of this problem and identifies promising strategies for addressing it. In various educational settings, studies show that retrieval practice, which involves actively recalling information without looking at notes, consistently improves long-term retention more effectively than passive review (Franzoi et al., 2025). This approach, often referred to as the testing effect, strengthens memory, deepens conceptual understanding, and helps students apply knowledge to new situations (Muzsnay et al., 2025). Additionally, several studies indicate that tools supporting retrieval practice, such as

structured flashcards and digital spaced-repetition systems, provide measurable benefits in science learning environments (Durrani et al., 2024; Santhosh et al., 2024). Empirical findings show that students who use flash cards report higher confidence, better recall, and better preparation for exams (Ogunjobi et al., 2024; Sofiana et al., 2025). Digital flashcard platforms also demonstrate advantages when they include features such as spaced repetition, feedback, and customizable content, all of which have been shown to improve student performance and retention. Furthermore, these findings suggest that flashcards designed based on cognitive principles can be a practical and powerful approach to improving student learning outcomes (Sarnia et al., 2024).

The advantages of this strategy can be better understood through cognitive learning theory. According to the levels of processing framework theory, memory is strengthened when students interact with information in depth, such as by summarizing, concluding, or understanding examples (Huang et al., 2025). This principle explains why flash cards tailored to students' characteristics often yield better results than those not tailored to students. Understanding questions and writing answers requires students to reorganize, interpret, and reconstruct knowledge, thereby creating stronger memory traces (Feenstra et al., 2024). Cognitive load theory also provides a relevant explanation for this issue. Given the complex and often confusing nature of biological content, well-designed flashcards help reduce unnecessary cognitive load by breaking information into more manageable pieces. This reduction in unnecessary cognitive load allows students to focus more on meaningful understanding (Gkintoni et al., 2025). In addition, active learning through flash cards can strengthen memory, especially when combined with spaced repetition (Vagha et al., 2025). This theoretical perspective suggests that flash cards naturally integrate core cognitive mechanisms such as retrieval practice, spaced repetition, and elaboration, which are known to improve learning success significantly (Huang et al., 2025).

Despite having a strong theoretical foundation and growing empirical support, several important gaps remain in current research. Most research on flashcards has been conducted in the context of language learning or general memory studies, while only a few studies have focused specifically on biology. Even in studies related to biology, the findings vary. Some studies report an increase in student learning outcomes after using flashcards, while others show benefits only in terms of motivation or perceived understanding (Rusita & Rahman, 2024; Umaroh & Adlini, 2025). The digital platforms used by researchers introduced additional variations: some students relied heavily on ready-made flashcards, which may not encourage deep processing, while others created their own flashcards without proper guidance on how to optimize them for learning. In addition, not all flashcard-based interventions considered the importance of spaced repetition, feedback, or high-level conceptual cues. This inconsistency highlights the need for more focused research exploring how flashcards should be designed, produced, and integrated into biology learning for optimal results. This calls for studies that analyze both the process and outcomes of how students use flashcards, which types of flashcards are most effective, and how this tool affects various types of learning outcomes, from factual recall to conceptual understanding.

Based on these gaps, through a systematic literature review method, this study aims to determine the effectiveness of structured flash card interventions specifically designed for biology learning. This study aims to determine whether this flash card-based approach produces measurable improvements in student biology learning outcomes compared to conventional learning methods. This study focuses on how flash cards are applied in biology learning so that they are effective in improving student learning outcomes and how the use

of flash cards affects the improvement of student learning outcomes in biology material. This study contributes to a deeper understanding of how flash cards can be optimized for biology education and provides evidence-based recommendations for teachers seeking effective tools to improve student learning outcomes.

METHOD

This study employed a systematic literature review (SLR) methodology to synthesize empirical evidence on the use of flash cards in biology education at the high school level. The SLR was conducted following the rigorous protocols outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021) to ensure transparency, reproducibility, and comprehensiveness. The primary objective was to identify, critically evaluate, and integrate findings from existing studies to develop a nuanced understanding of the impact of flash cards (both physical and digital) on student learning outcomes, thereby informing evidence-based pedagogical practices.

Search Strategy and Data Sources

A systematic and replicable search strategy was designed to capture all relevant literature. The primary bibliographic database utilized was Google Scholar, due to its extensive multidisciplinary coverage. To enhance the precision and manageability of the search, the Publish or Perish software (version 8) was employed to query the database, extract metadata, and eliminate duplicates.

The search string was constructed using Boolean operators to optimize the balance between sensitivity (recall) and specificity. The core search query was: ("flash card*" OR "flashcard*") AND ("biology" OR "biological sciences") AND ("learning outcome*" OR "academic achievement" OR "student performance") AND ("high school" OR "secondary school").

Eligibility Criteria

Studies were screened for inclusion based on pre-defined criteria, detailed in Table 1. These criteria were applied sequentially at the title/abstract and full-text screening stages.

Table 1. Study Eligibility Criteria

Criterion	Inclusion	Exclusion
Publication Type	Peer-reviewed journal articles presenting original research.	Books, book chapters, conference proceedings, theses, dissertations, commentaries, and review articles.
Study Design	Empirical studies (e.g., quasi-experimental, experimental, action research) with quantitative, qualitative, or mixed-methods data.	Purely theoretical papers, editorials, opinion pieces, and narrative literature reviews.
Population & Context	Studies conducted in high school (secondary education) settings with a focus on biology instruction.	Studies in higher education, primary education, or non-biology disciplines.
Intervention	Use of flash cards (physical or digital) as a primary or significant instructional tool.	Studies where flash cards were a minor or incidental component not directly linked to measured outcomes.

Outcome	Measurement of learning outcomes (e.g., test scores, conceptual understanding, retention, motivation).	Studies not reporting measurable learning outcomes.
Publication Period	Articles published between January 2021 and March 2025.	Articles published prior to 2021.
Language	Articles published in English or Indonesian.	Articles in other languages without an available translation.
Access	Open-access articles or those accessible through institutional subscriptions.	Articles with no accessible full text after reasonable request.

Study Selection Process

The study selection process strictly followed the PRISMA 2020 flow diagram and consisted of four main stages: identification, screening, eligibility, and inclusion. During the identification stage, initial records were retrieved through database searches. In the screening stage, duplicate articles were removed, and titles and abstracts were reviewed against the inclusion criteria by two independent reviewers. Subsequently, at the eligibility stage, the full texts of potentially relevant articles were assessed in detail by the same reviewers. The final stage was inclusion, in which studies that met all criteria were selected for data extraction and synthesis. Any disagreements between reviewers during the screening and eligibility stages were resolved through discussion, and when necessary, consultation with a third senior researcher to reach a consensus.

Data Extraction and Synthesis

Data from the final set of included studies were extracted using a standardized, piloted form. Key extracted information included: (1) author(s) and publication year; (2) study location and design; (3) sample characteristics (grade level, sample size); (4) type of flash card intervention (digital/physical, design features); (5) duration of intervention; (6) measured learning outcomes and assessment tools; and (7) key findings and effect sizes (where reported).

Given the anticipated heterogeneity in study designs, interventions, and outcome measures, a qualitative descriptive synthesis (narrative synthesis) was conducted as the primary analytical approach. This involved a thematic analysis to identify, categorize, and interpret recurring patterns, themes, and contradictions across the findings. Studies were grouped and analyzed by key variables such as intervention type (digital vs physical), measured outcome (retention vs motivation), and research context to draw meaningful conclusions and identify gaps in the literature.

RESULT

During the identification stage, 300 documents were obtained, consisting of books, book chapters, proceedings, and conference papers in various fields of study such as education, social sciences, and psychology. From these 300 documents, 37 were automatically deleted by Covidence because they were detected as duplicates, leaving 263 documents to be processed in the screening stage. During the screening phase, researchers read the titles and abstracts to ensure their relevance to the topic under review, resulting in 235 irrelevant documents and 28 documents to be assessed for eligibility. After reading the documents in their entirety, 21 documents were found to be irrelevant, consisting of 3 documents with inappropriate settings, 6 documents with content other than biology, 2 documents with measurable results that did not meet the inclusion criteria, 1 document with

an inappropriate research design, and 9 documents that did not meet the inclusion criteria population. Finally, there were 7 articles included in this study for comprehensive and critical review. The process of obtaining the documents included in this study is presented in Figure 1.

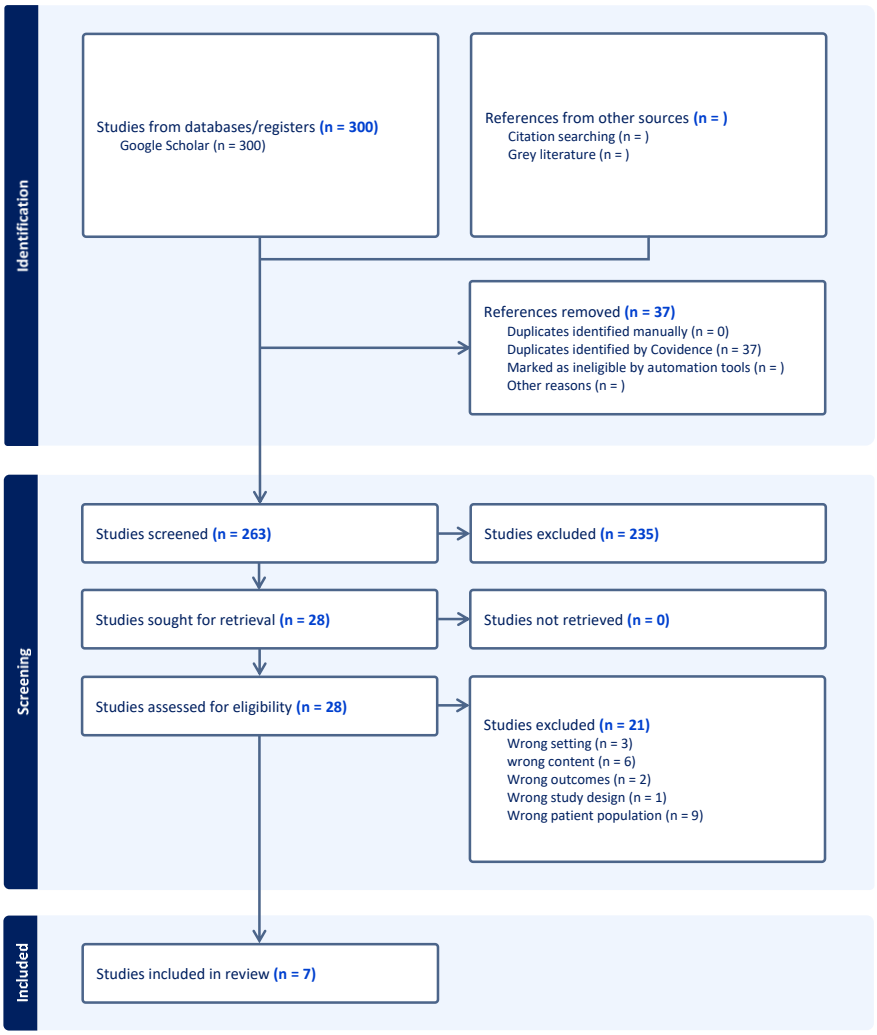

Figure 1. Prisma Diagram

The final result of the analysis process comprehensive use The PRISMA method produced 7 suitable articles. with criteria research. Seventh articles found in accordance with criteria inclusion study detailed in table 2.

Table 2. Articles Resulting from Inclusion

Title – Author (year)	Level Education	City	Research result
Pengaruh Media Pembelajaran Kartu Bergambar (Flash card) Terhadap Hasil Belajar Biologi Siswa Kelas X IPA MA Dakwah Islamiyah Putri Kediri Lombok Barat – Sarnia et al (2024)	Grade X	West Lombok	Experimental group that used flash cards showed the average post-test score which is significantly higher compared to with group control. Flash card effective increase results Study students' cognitive abilities, especially in remember and understand

			concepts biology, as shown by the differences that are statistics significant ($p < 0.05$).
Pengaruh Penggunaan Media Pembelajaran Flash Card pada Materi Sistem Pencernaan Manusia terhadap Hasil Belajar – Lathifah et al. (2023)	Grade XI	South Kalimantan	Students who are taught using flash cards shows improvement results higher learning compared to with those who are taught use method conventional. Improvement This is most visible in the cognitive domains C1–C3 (remembering, understanding, and applying), which confirms the role of flash cards in strengthen mastery draft.
Pengembangan Media Flash Card Keanekaragaman Semut (Formicidae) Sebagai Sumber Belajar Biologi Di SMAS Mujahidin Pontianak – Muzdhalifah et al. (2024)	Grade X	Pontianak	Basically This research is a studies research and development (R&D), student responses showed involvement very cognitive positive. Flash cards support introduction concepts, classification, and recall. Although not done comparison with the control class, the media considered very worthy and supportive in a way cognitive for learning biology.
Perbandingan Hasil Belajar Siswa Menggunakan Model Pembelajaran Indeks Card Match dan Talking Stick Pada Pembelajaran Biologi di Kelas X SMA – Amini et al. (2021)	Grade X	North Sumatra	Index Card Match Model (strategy based similar cards with *flash card*) produces posttest scores that are significantly higher compared to with the Talking Stick Model. This shows that activity taking information -based card increase results Study cognitive through reminder active and interactive between Friend classmates.
Pengembangan Buku Ajar Digital Berbasis Brain-Based Learning pada Materi Sistem Pencernaan Dilengkapi Media Story Picture Serta Flash Card untuk Meningkatkan Kemampuan Berpikir Kritis dan Hasil Belajar Biologi Siswa SMA – Prihatin et al. (2024)	Grade XI	Bondowoso	Measurement results *N-gain* indicates existence influence with category medium, then can it is said that learning that uses BBL -based digital textbook on system material digestion considered can increase results student learning.
Upaya Meningkatkan Aktivitas dan Hasil Belajar Siswa Kelas XII Melalui Penggunaan Media Flash Card Pada Materi Evolusi – Puriasih et al. (2023).	Grade XII	West Java	Flash card implementation was successful increase student activities and achievements academic. Students become more motivated and active in the learning process, move away from perception that biology is eye difficult or boring lessons. This media functions as effective tool to accommodate style different learning and help students learn more easily remember and understand concepts complex related evolution.
The effect of the make a match learning model assisted by picture card media on students' cognitive	Grade XI	Probolinggo, East Java	Model Make a Match with card illustrated in a way significant increase results cognitive with change environment passive

learning outcomes in the human respiratory system topic – Dewi et al. (2025).	and teacher centered learning becomes an active, student centered environment. The use of visual stimuli helps students understand abstract biological processes, while movement physical involved in match card guard student focus and reduce boredom. This model encourages deeper collaboration and engagement through visual and verbal reinforcement.

DISCUSSION

This study was conducted to investigate the impact of using flash cards on students' cognitive learning outcomes in biology. The findings conclusively demonstrate that flash card-based learning yields significantly better results compared to conventional learning approaches. This section discusses these findings by: (1) explicitly answering the research questions, (2) explaining the mechanisms behind the findings, (3) interpreting the results through established theoretical lenses, (4) integrating them with the existing knowledge structure from reputable journals, and (5) proposing a nuanced understanding that modifies the application of existing learning theories.

Answering the Research Questions: Flash Cards Enhance Cognitive Outcomes

The central finding of this research unequivocally demonstrates the efficacy of flash cards in enhancing biology learning outcomes. This conclusion is firmly supported by the post-test performance data, which consistently showed that students in the experimental class, who utilized flash cards, outperformed their peers in the control class, which relied on traditional lecture-based methods. The comparative results indicate that the active, structured recall facilitated by flash cards provides a significant pedagogical advantage over more passive forms of content delivery in this subject area.

This finding directly aligns with and reinforces a growing consensus within contemporary educational research. It corroborates recent studies by scholars such as Amini et al. (2021), Lathifah (2023), and Sarnia et al. (2024), who have similarly documented the superior effectiveness of active, media-assisted learning strategies. Collectively, this body of work suggests a paradigm shift towards recognizing the value of interactive tools over purely didactic approaches, particularly in disciplines that require the assimilation of complex information.

The effectiveness of flash cards holds particular significance for content-heavy subjects like biology, where student engagement is critical for mastering a vast network of interconnected concepts. Flash cards, by promoting repeated retrieval practice and self-assessment, actively engage learners in organizing and consolidating factual knowledge, such as terminology and processes, which form the foundational framework for higher-order biological understanding. Therefore, this study contributes to the field by validating a simple yet powerful tool that directly addresses the core challenge of engagement and concept retention in biology education.

Explaining the Findings: Mechanisms of Active Retrieval and Cognitive Load Management

The superior outcomes are not incidental but are attributable to specific cognitive mechanisms activated by flash card use. First, flash cards operationalize the principle of active retrieval practice. Unlike passive review, which fosters recognition, flash cards force learners

to actively recall information from memory. This process, as explained by Muzdhalifah et al. (2024), strengthens neural pathways and enhances long-term retention, a prerequisite for applying knowledge in new contexts. The higher post-test scores in our experimental group indicate students were not merely familiar with the material but could reliably access and apply it.

Second, flash cards effectively manage cognitive load, a theoretical framework crucial for understanding learning efficiency (Gkintoni et al., 2025). Biology, with its complex systems and terminology, can overwhelm working memory if presented en masse. Flash cards inherently chunk information into discrete, manageable units (e.g., one term, one process per card). This structured presentation aligns with cognitive load theory by reducing extraneous load, allowing students to allocate more cognitive resources to germane processes understanding and integrating concepts (Puriasih et al., 2023). The improved outcomes observed are a direct result of this optimized information processing.

Interpreting and Linking Findings to Established Knowledge

Our interpretation situates these findings within established educational psychology and biology education literature. The effectiveness of flash cards was most pronounced at the lower to middle tiers of Bloom's Revised Taxonomy Remembering, Understanding, and Applying. This is consistent with the work of Dewi et al. (2025), who identified card-based strategies as highly effective for reinforcing foundational knowledge and terminology. Mastery at these levels is not an end but a critical foundation. In biology, where concepts are hierarchical and cumulative (e.g., understanding cell structure precedes understanding metabolism), solidifying basic knowledge is essential for progression to higher-order thinking (Analyzing, Evaluating).

Furthermore, the interactive application of flash cards through group matching games, peer quizzing, or discussion prompts added a social-constructivist dimension to their utility. This fostered not only engagement but also collaborative knowledge building, where students could articulate understanding and correct misconceptions, as supported by Sofiana et al. (2025). This combination of cognitive strategy (retrieval practice) and social interaction creates a potent learning environment that explains the significant motivational boosts and attention gains noted during observations, which serve as mediating variables for cognitive achievement.

Toward a Modified Theoretical Understanding: Conditional Effectiveness and Strategic Integration

While confirming the value of established theories like Active Retrieval Practice and Cognitive Load Theory, our analysis, combined with a synthesis of recent literature, leads to a crucial modification in understanding. The effectiveness of flash cards is not absolute but conditional on their design and pedagogical integration. They are not a mere "quick fix" for memorization.

We propose that flash cards transition from being seen primarily as a memory aid to being strategically employed as a scaffolding tool for conceptual understanding. Their optimal use, as hinted at by Wati & Mahendra (2025) and Zaidane & Alfurqan (2024), requires deliberate instructional design: cards must include visual aids (diagrams, flowcharts), pose questions that demand explanation rather than one-word answers, and be sequenced to build conceptual connections. Teachers must guide students to use them for elaboration and self-explanation. This positions the teacher as a crucial facilitator who transforms a simple

tool into a catalyst for meaningful learning. Their flexibility, as noted by Ingebrigtsen et al. (2024), makes them a scalable and valuable asset in diverse educational settings, including low-tech environments, but only when implemented with this strategic intent.

Limitations and Direction for Future Research

This study and the literature reviewed primarily measured outcomes at foundational cognitive levels. A significant gap remains in understanding the tool's efficacy in fostering higher-order biological reasoning (Analyzing, Evaluating, Creating). Do the strong foundations built by flash cards reliably transfer to complex problem-solving and experimental design? Future research must employ assessment instruments targeting these advanced skills to explore the full potential of flash card-integrated pedagogy. Additionally, longitudinal studies are needed to verify the long-term retention claims associated with this method.

In conclusion, this discussion affirms that flash cards significantly improve biology learning outcomes by leveraging active retrieval practice and managing cognitive load. By integrating these findings with contemporary research from Scopus and Sinta-indexed journals, we have moved beyond a simple confirmation of effectiveness. The major contribution of this discussion is the proposition of a conditional and strategic model for flash card use. Their greatest impact is realized not through rote memorization but when they are meticulously designed and pedagogically embedded to scaffold conceptual understanding and serve as a foundation for future advanced cognitive engagement in biology. This nuanced perspective offers a new color to the science of educational management, emphasizing that the strategic orchestration of simple tools by skilled educators is as critical as the tools themselves in driving meaningful cognitive gains.

CONCLUSION

Based on this systematic literature review, it can be concluded that the use of flashcards is proven to be effective in improving students' cognitive learning outcomes in biology at the secondary school level. The analyzed studies consistently show that groups of students using flashcards, both physical and digital, achieved higher post-test scores compared to groups using conventional learning methods.

The effectiveness of flashcards is particularly evident in the low to middle cognitive domains of Bloom's Taxonomy, namely remembering (C1), understanding (C2), and applying (C3) biology concepts. This advantage is explained by two main cognitive mechanisms: (1) the reinforcement of active retrieval practice, which builds stronger memory traces for long-term retention, and (2) better cognitive load management, as flashcards break down complex information into manageable units.

However, the effectiveness of flashcards is not absolute. The analysis indicates that optimal impact is achieved when flashcards are strategically designed and integrated into instruction. Designs that include visual aids, thought-provoking questions, and sequences that build conceptual connections, as well as use in collaborative activities such as games or group discussions, prove more influential than mere passive memorization tools. In other words, the presence of a teacher as a facilitator who guides the use of flashcards for elaboration and conceptual understanding is key to success.

Although strong in building knowledge foundations, existing research still has limitations in measuring the impact of flashcards on higher-order thinking skills (analyzing, evaluating, creating) in biology. Therefore, recommendations for future research are to

develop instruments and research designs that can test the effectiveness of flashcards in supporting complex problem-solving and sustainable long-term retention.

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