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The application of multiple intelligences in the development of biology learning materials: A literature review

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Abstract. The need for Biology learning materials that can accommodate the diverse intelligences of learners has driven the growing use of the Multiple Intelligences approach in instructional material development. However, no systematic review has yet mapped how Multiple Intelligences are actually implemented in the development of Biology learning materials, nor the extent to which the different intelligences are integrated. This study employs a Systematic Literature Review (SLR) using the PRISMA model to analyze the application of Multiple Intelligences in Biology learning materials based on ten selected articles from 696 identified publications. The review findings show that various Multiple Intelligences–based products, such as e-books, flipbooks, modules, and e-worksheets, demonstrate strong validity, practicality, and effectiveness in improving conceptual understanding, learning motivation, critical thinking skills, and student engagement. Nevertheless, the implementation of Multiple Intelligences in most studies remains partial, as only a few intelligences are typically adopted, and only one article fully applies all nine intelligences comprehensively and contextually. The main contribution of this review lies in identifying this gap and mapping the patterns of Multiple Intelligences implementation in the development of Biology learning materials, a focus which has not been addressed in previous studies. Furthermore, this study highlights the lack of long-term evaluation and the limited exploration of affective aspects, thus offering important directions for future research.

Abstrak. Kebutuhan akan bahan ajar Biologi yang mampu mengakomodasi keragaman kecerdasan peserta didik mendorong berkembangnya penggunaan pendekatan Multiple Intelligences (MI) dalam pengembangan bahan ajar. Namun, sejauh ini belum ada kajian sistematis yang memetakan bagaimana MI benar-benar diterapkan dalam pengembangan bahan ajar Biologi, termasuk sejauh mana kecerdasan-kecerdasan MI diintegrasikan. Penelitian ini menggunakan metode Systematic Literature Review (SLR) dengan model PRISMA untuk menganalisis penerapan MI pada bahan ajar Biologi berdasarkan 10 artikel terpilih dari 696 publikasi yang diidentifikasi. Hasil telaah menunjukkan bahwa berbagai produk seperti e-book, flipbook, modul, dan E-LKPD berbasis MI menunjukkan hasil yang valid, praktis, dan efektif dalam meningkatkan pemahaman konsep, motivasi belajar, kemampuan berpikir kritis, dan keterlibatan peserta didik. Meskipun, implementasi MI pada sebagian besar penelitian masih bersifat parsial karena hanya mengadopsi beberapa kecerdasan, dengan hanya satu artikel yang menerapkan sembilan kecerdasan secara komprehensif dan kontekstual. Kontribusi utama kajian ini terletak pada identifikasi kesenjangan tersebut serta pemetaan pola implementasi MI dalam pengembangan bahan ajar Biologi, yang belum dijelaskan dalam kajian sebelumnya. Selain itu, penelitian ini menyoroti kurangnya evaluasi jangka panjang dan minimnya eksplorasi aspek afektif, sehingga menjadi arah penting bagi pengembangan penelitian selanjutnya.

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Introduction

The need for Biology instructional materials that are able to accommodate the diversity of students' intelligences has encouraged the adoption of the Multiple Intelligences (MI) approach in instructional material development. However, to date, there has been no systematic study that maps how MI is actually implemented in the development of Biology instructional materials, including the extent to which the various MI intelligences are integrated. This study employed a Systematic Literature Review (SLR) method using the PRISMA model to analyze the implementation of MI in Biology instructional materials based on 10 selected articles out of 696 identified publications.

The review results indicate that various instructional products, such as e-books, flipbooks, modules, and MI-based E-LKPD, are categorized as valid, practical, and effective in improving conceptual understanding, learning motivation, critical thinking skills, and student engagement. Nevertheless, the implementation of MI in most studies remains partial, as it only adopts several types of intelligence. Only one article applied all nine intelligences in a comprehensive and contextual manner. The main contribution of this review lies in identifying this gap and mapping patterns of MI implementation in Biology instructional material development, which have not been clearly explained in previous reviews. In addition, this study highlights the lack of long-term evaluation and the limited exploration of affective aspects, which represent important directions for future research.

Understanding student characteristics, including interests, talents, and intelligences, is a fundamental foundation in the learning process (Janawi, 2019). Individual intelligence is not singular but diverse and can develop through appropriate learning experiences (Fitri, 2019). This concept is explained in Howard Gardner's theory of Multiple Intelligences (MI), which classifies human intelligence into nine main types (Wicaksono et al., 2014). In line with this, Afnan et al. (2025) emphasize that MI plays an important role in the cognitive transformation of Biology learning and supports deeper conceptual understanding. Although the MI concept has long been recognized and developed, educational practice still predominantly assesses student achievement based solely on cognitive abilities. Affective and psychomotor domains are often neglected, resulting in students' diverse potentials—such as linguistic, motor, social, and naturalistic abilities—not being optimally facilitated (Apriana et al., 2025). This paradigm causes learning to be less capable of accommodating differences in learning styles and students' innate intelligences.

In Biology learning, variations in multiple intelligences have been shown to influence learning outcomes. As demonstrated by Fuad et al. (2023), multiple intelligences, together with learning motivation and anxiety levels, have a positive effect on Biology learning outcomes, where students with higher multiple intelligence scores tend to achieve better academic results. In addition, Purnamasari and Admoko (2015) reported that the application of MI-based learning improved learning outcomes, achieving 86% mastery and a significant difference between pretest and posttest scores ($t_{calculated} = 14.30 > t_{table} = 1.69$). Other studies indicate that linguistic, logical-mathematical, interpersonal, musical, naturalistic, and existential intelligences have significant relationships with Biology learning achievement. In contrast, visual-spatial, kinesthetic, and intrapersonal intelligences are less developed due to limitations in strategies, media, and exploration opportunities provided by teachers (Dewi, 2013; Mulyani et al., 2021; Fuad et al., 2023). Ikbari et al. (2021) further add that MI plays a strong role in enhancing students' 21st-century science process skills, although its implementation is still uneven.

The diversity of learning styles and student potential in understanding biological concepts indicates the need for MI-based Biology instructional materials that are adaptive, varied, and contextual. Various studies show that the MI approach can improve cognitive, affective, and psychomotor learning outcomes through activities tailored to the strengths of each intelligence, such as field observations for naturalistic intelligence, data analysis for logical-mathematical intelligence, discussions for interpersonal intelligence, visualization for spatial intelligence, laboratory practices for kinesthetic intelligence, and self-reflection for intrapersonal intelligence (Rahmah & Sriyati, 2015). Thus, MI-oriented Biology learning enables more meaningful learning experiences. For students with spatial intelligence, visual models can clarify biological concepts (Ikbari, 2021), while interpersonal intelligence develops through discussions or group work that enhance communication and collaboration skills (Wulandari et al., 2016). Kinesthetic intelligence is sharpened through laboratory practice, while intrapersonal intelligence is fostered through self-reflection that supports meaningful learning. Therefore, Biology learning does not only emphasize cognitive aspects but also integrates students' intelligence potentials in a holistic, interactive, and contextual manner.

Numerous studies have developed MI-based Biology instructional materials, such as worksheets (LKS), LKPD, textbooks, and flipbooks, and the majority have reported effective results (Lestari & Nisa, 2018; Zuhriyah & Trimulyon, 2019). However, these findings remain partial, focus on diverse subject matter, and have not been systematically synthesized, thus failing to provide a comprehensive overview of the implementation of the Multiple Intelligences approach in Biology learning (Sofa & Indana, 2022; Mulyani et al., 2021). This condition results in teachers lacking a complete reference to understand how variations in students' intelligences, interests, talents, and cognitive, affective, and psychomotor potentials can be optimally accommodated. Learning that is still dominated by cognitive assessment and less varied media causes certain intelligences to be underdeveloped. Therefore, more adaptive, varied, and

contextual MI-based Biology instructional materials are needed, along with a literature review that integrates previous research findings so that their implementation can be comprehensively understood.

Therefore, this review aims to systematically examine the importance of developing MI-based Biology instructional materials as an effort to comprehensively address the diversity of students' intelligences. This analysis not only provides an overview of the need for adaptive, varied, and contextual instructional materials, but also synthesizes previous studies that remain scattered and insufficiently comprehensive. Thus, the findings of this review are expected to serve as a foundation for teachers and researchers in designing more effective and meaningful Biology instructional materials that can enhance students' skills and learning outcomes.

1. What are the research trends related to the development of Multiple Intelligences-based Biology instructional materials over the last ten years?
2. What are the objectives of using Multiple Intelligences-based Biology instructional materials, and how are they implemented in classroom learning?
3. How does the implementation of Multiple Intelligences-based instructional materials affect the improvement of students' critical thinking skills and engagement?

Research Methods

1) Type

This study employed a Systematic Literature Review (SLR) method, which is a systematic approach used to collect, critically evaluate, integrate, and synthesize findings from multiple research studies related to specific research questions or topics of interest. The research process began with the identification of articles relevant to the research topic, which were subsequently examined in a structured and systematic manner. The SLR approach was selected to provide a comprehensive overview of recent studies on the development of Biology instructional materials using the Multiple Intelligences approach.

The article selection process was conducted systematically through several stages based on clearly defined inclusion and exclusion criteria (as presented in Table 1). These criteria were adapted from the framework proposed by Fajeriadi et al. (2024) to ensure that the analyzed articles met high standards of quality, relevance, and validity. Of the 696 articles identified during the initial search, titles and abstracts were screened, followed by full-text analysis. Ultimately, 10 articles were selected as the most relevant studies for in-depth analysis.

Table 1 Inclusion and exclusion criteria

Exclusion Criteria	Exclusion Criteria
Studies relevant to the topic	Non-empirical studies
Published within the last ten years	Publications in languages other than English or Indonesian
Studies using empirical methods	Conference papers, dissertations, or research reports
Full access to the article	Studies with small sample sizes
Published in national journals	Articles that do not include the required data

2) Data Sources and time

The data sources for this literature review consisted of scientific articles obtained from the Google Scholar digital database. Selective databases such as Web of Science (WoS) or Scopus have limitations in coverage for highly cited documents in certain fields, particularly in the Social Sciences and Humanities (Martín *et al.*, 2018). The selection of Google Scholar was based on its broad coverage of scholarly literature at both national and international levels. The use of Google Scholar is particularly relevant when researchers require extensive literature coverage, as the platform integrates various types of publications, ranging from multidisciplinary journal articles to local works and conference proceedings that are often not indexed in more selective databases (Gusenbauer, 2022).

Nevertheless, a strict screening process was applied to ensure that the selected articles originated from accredited, peer-reviewed journals. The data search was conducted on September 29, 2025, using the keywords "Multiple Intelligence-Based," "Development," and "Instructional Materials." The search results were focused on articles relevant to the development and visualization of instructional materials aimed at creating contextual and meaningful learning experiences.

3) Data collection techniques

The data collection process in this study was carried out through a literature search using Google Scholar, focusing on scientific articles published between 2014 and 2024. The time frame ends in 2024 because the year 2025 is still ongoing, and publication data for that year are not yet complete; therefore, they cannot be used as a reliable basis for analysis. The selection of a ten-year publication period was intended to ensure that the literature reviewed remains

current and relevant, while avoiding publications that are too recent and have not yet been sufficiently validated. In addition, inclusion and exclusion criteria were established to ensure that the selected sources were highly relevant and aligned with the research objectives. Accordingly, the data used in this review are expected to provide a comprehensive, valid, and scientifically robust overview of the research topic. The literature selection process was conducted systematically and in multiple stages, following the procedural flow illustrated in Figure 1.

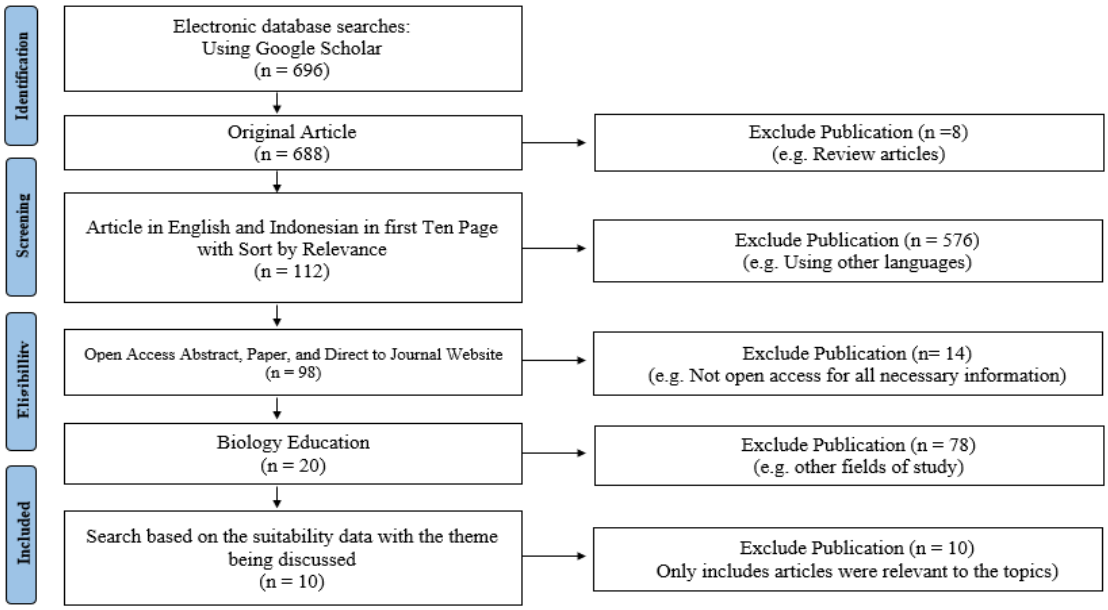

Figure 1 Article selection process in SLR studies using the PRISMA model

4) Data Analysis Techniques

The data in this study were analyzed using content analysis techniques. Content analysis is a research method used to describe research objectives, perspectives, and the content under investigation through systematic and, when appropriate, quantitative data processing (Sofwatillah et al., 2024). According to Krippendorff (2019), content analysis enables researchers to generate reliable and replicable inferences from textual data within their context of use. The stages of the analysis included:

(1) Reading and Reviewing the Articles

Reviewing the content of each article related to the development of Biology instructional materials based on the Multiple Intelligences approach.

(2) Identifying the Main Themes

Identifying the key themes that emerged, including instructional material development methods, the application of Multiple Intelligences theory in Biology learning, and the outcomes of its implementation for students.

(3) Grouping and Categorizing the Data

Organizing the analysis results into several categories, such as the types of intelligences emphasized, the instructional models employed, and the effectiveness of the developed instructional materials.

(4) Formulating Findings and Summarizing the Results

Synthesizing the analysis results based on the identified themes to address the research objectives and to provide a comprehensive understanding of the implementation of the Multiple Intelligences approach in the development of Biology instructional materials.

Results and Discussion

An increasing trend in the number of relevant documents is observed over time, as illustrated in the following graph, which presents the total number of documents published between 2018 and 2024.

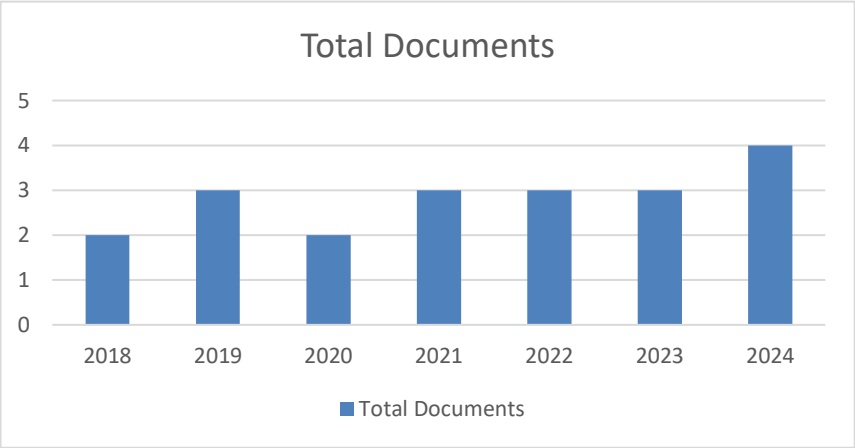

Figure 2 Graph showing the distribution of the number of documents from 2018 to 2024

Based on publication data from 2018 to 2024, the number of articles related to Biology learning using the Multiple Intelligences approach shows an overall increasing trend, although some fluctuations are evident. The graph indicates that publications remain limited, ranging from two to three articles per year, with a decline observed in 2020. From 2021 to 2023, the number of publications was relatively stable, indicating a consistent interest in this approach. In 2024, the number increased to four articles, suggesting that the Multiple Intelligences approach has begun to receive greater attention in Biology education research. Overall, these data indicate that research on Multiple Intelligences remains limited, highlighting substantial opportunities for further development in this area.

The Multiple Intelligences approach has increasingly been explored as an innovative strategy in the development of Biology learning materials, particularly because it can accommodate the diversity of learning styles and students' varying potentials. This is consistent with findings showing that the application of the Multiple Intelligences approach in Biology learning demonstrates the significant roles of various intelligences, including linguistic, logical mathematical, visual spatial, kinesthetic, musical, interpersonal, intrapersonal, and naturalistic intelligences, in students' cognitive transformation (Afnan et al., 2025). Learning materials developed using the Multiple Intelligences approach have been shown to improve conceptual understanding, motivation, and active participation among learners, as they provide opportunities for each individual to learn in accordance with their dominant intelligences.

Through the article selection process using the PRISMA model within a Systematic Literature Review framework, out of a total of 696 articles collected from the Google Scholar database, 10 articles met the inclusion criteria and were published in national journals. The review of these articles indicates that the development of Biology learning materials based on the Multiple Intelligences approach has been widely applied across various types of instructional products, ranging from modules to digital learning materials, as described in more detail in Table 2.

Table 2 Findings of the 10 most relevant articles

Code	Researcher (Year)	Product	Materi	Method	Findings
A1	Septiana dkk. (2023)	E-book	Excretory system	Research and Development (R&D) with the 4D model	The e-book was feasible for use, with a validation score of 92.6%, and was shown to improve students' critical thinking skills and cognitive learning outcomes.
A2	Khastini dkk. (2023)	Flipbook	Circulatory system	Research and Development (R&D) with the 4D model	The module achieved a feasibility score of 96.4%, with a student response rate of 90.14%, indicating a very high level of feasibility.
A3	Herni dkk. (2022)	LKPD	Biology learning	Research and Development (R&D) with the 4D model	The worksheet was highly valid and effective in enhancing students' learning experiences.
A4	Sofa (2022)	E-book	Cell division	Research and Development (R&D) with the ADDIE model	The product demonstrated high validity (95%) and practicality (96.53%), and was considered highly effective.

Code	Researcher (Year)	Product	Materi	Method	Findings
A5	Nisa & Iza (2024)	Modul	Human digestive system	Research and Development (R&D)	The module was effective in increasir student engagement and understandin
A6	Sifasari & Trimulyono (2023)	Electronic Student Worksheet	Human heredity	Research and Development (R&D) with the 4D model	The product was highly valid, with a practicality score of 97.3%, and demonstrated high effectiveness.
A7	Zuhriyah & Trimulyono (2019)	Student Worksheet	Viruses	Research and Development (R&D) with the 4D model	The worksheet was highly valid and showed high effectiveness.
A8	Wijayanti & Trimulyono (2019)	Flipbook	Genetic material	Research and Development (R&D) with the ADDIE model	The product achieved a validity score of 93.53%, was practical, and effectively improved students' critical thinking skills.
A9	Lestari & Nisa (2018)	Student Worksheet	Enzymes	Research and Development (R&D) with the 4D model	Media expert validation reached 96.43%, content expert validation 84.21%, with a readability score of 65.33%
A10	Nurjannah (2022)	Electronic Student Worksheet	Human heredity	Research and Development (R&D) with the 4D model	The product was highly valid (97.8%), very practical (93.09%), achieved 100% learning mastery, and improved critical thinking skills to 85.6%.

Based on Table 2, all studies included in this review employed a Research and Development (R&D) approach, although different instructional design models were applied, namely the 4D and ADDIE models. Studies utilizing the 4D model (A1, A2, A3, A6, A7, A9, and A10) consistently reported product feasibility indicators in the form of validity, practicality, and effectiveness. The findings from these seven studies indicate that each product underwent expert validation, followed by limited-scale practicality and effectiveness testing. The two studies adopting the ADDIE model (A4 and A8) also reported high levels of validity and practicality; however, they did not proceed to advanced stages such as dissemination or large-scale implementation. This suggests that the application of the ADDIE model in these studies primarily emphasized the quality of instructional design, without detailed reporting of phased testing procedures commonly associated with the 4D model.

The developed instructional products varied in form, including e-books (A1, A4), flipbooks (A2, A8), student worksheets (LKPD) and electronic student worksheets (e-LKPD) (A3, A6, A7, A10), as well as printed modules (A5, A9). The diversity of media formats demonstrates the flexibility of the Multiple Intelligences (MI) approach in accommodating different instructional modalities, both print-based and digital. Furthermore, the increasing emphasis on digital products such as e-books and e-LKPD reflects a paradigm shift toward 21st-century learning, which prioritizes technological literacy and learner autonomy. This digital transformation has led to the emergence of electronic worksheets (e-LKPD), which enable students to interact with learning materials more dynamically through digital platforms (Umriani & Suparman, 2019).

In terms of content, the biology topics developed across the reviewed studies also exhibited substantial variation, encompassing complex concepts such as the excretory system (A1), circulatory system (A2), human digestive system (A5), human heredity (A6, A10), cell division (A4), as well as genetic material and enzymes (A8, A9). This pattern indicates that MI-based instructional development is frequently directed toward subject matter requiring deep conceptual understanding and active student engagement. According to previous studies, the MI approach is considered particularly relevant because it allows teachers to adapt instructional strategies to the diverse learning preferences present within a single classroom (Tabiin, 2017). For instance, visual–spatial intelligence can be supported through illustration-rich e-books and flipbooks, while kinesthetic and interpersonal intelligences can be facilitated through worksheet-based activities that promote collaboration and hands-on exploration.

Another noteworthy finding is the consistently high levels of validity, practicality, and effectiveness reported across the reviewed studies. As shown in Table X, several studies explicitly reported product validity scores exceeding 90%, including A1 (92.6%), A2 (96.4%), A4 (95%), A6 (97.3%), A8 (93.53%), and A10 (97.8%). These values indicate that the developed instructional materials fall within the highly valid category, based on expert evaluations of content accuracy, visual design, and language clarity. Such findings suggest that the instructional products were well aligned with student needs and curriculum standards. The high validity outcomes can be attributed to development processes grounded in instructional design principles and the involvement of subject-matter experts and teachers during the

expert review stage. Nevertheless, further analysis remains necessary to examine potential biases, variations in assessment criteria, and limitations related to the number of validators involved. The practicality aspect showed similarly strong results, with several studies reporting scores above 95% (A4, A6, A10), indicating that the instructional materials were easy to use for both teachers and students. Meanwhile, product effectiveness was evidenced by significant improvements in cognitive learning outcomes, critical thinking skills, and student learning motivation (A1, A3, A6, A10). Consistent with these findings, existing literature suggests that the MI approach not only enhances cognitive achievement but also strengthens students' affective and socio-emotional domains (Apriana et al., 2025).

Based on the review of the 10 selected articles, only study A5 explicitly demonstrated the implementation of the Multiple Intelligences (MI) approach through genuinely contextual learning activities, by providing instructional tasks that separately represent all nine intelligences. This is evident in the module design, which incorporates linguistic, logical–mathematical, visual–spatial, bodily–kinesthetic, musical, interpersonal, intrapersonal, naturalistic, and existential intelligences in activities directly aligned with the topic of the human digestive system. Examples presented in the study include drawing the digestive process to support visual–spatial intelligence, writing explanations of digestive mechanisms to engage linguistic intelligence, and relating types of natural foods to the functions of digestive organs to address naturalistic intelligence. The module presented in this study indicates that the MI approach was applied in a comprehensive and contextual manner, as each intelligence was integrated into learning tasks that were relevant to students' real-life experiences and aligned with the conceptual characteristics of biology content. This finding reinforces the notion that MI-based instructional materials in this study were not merely developed at a structural level, but also functioned to enhance meaningful learning through differentiated activities that accommodate students' diverse intelligence potentials.

The review also reveals several challenges and limitations that warrant further attention. Most of the studies primarily focused on the validation and limited trial phases, resulting in a lack of evidence regarding long-term effects on learning outcomes and concept retention. In addition, the application of the MI approach in many studies tended to be general in nature and did not comprehensively map students' dominant intelligences that most strongly influence learning achievement. Affective aspects, such as students' interest and self-confidence in learning biology, were also rarely examined in depth. These conditions highlight opportunities for more focused future research, particularly studies exploring how MI-based instructional material development influences student motivation, self-confidence, and learning attitudes through more comprehensive research designs, such as experimental or mixed-methods approaches. Moreover, although the use of digital media is increasing, the integration of interactive elements—such as animations, simulations, or AI-based adaptive features—remains very limited. Variation in instructional strategies and assessment methods is therefore crucial to achieving effective learning and maximizing each student's potential. Consequently, the implementation of the MI approach not only helps teachers avoid instructional monotony, but also supports students in developing their intelligence potential more optimally (Latifah & Widjajanti, 2017).

Overall, the synthesis of findings indicates that the development of biology instructional materials based on the Multiple Intelligences approach holds substantial potential for enhancing the quality of learning, particularly in the context of abstract biological concepts. The research trends identified across the reviewed studies reflect a commitment to contextual and humanistic pedagogical innovation, positioning students' diverse intelligence profiles as a fundamental basis for instructional design. Therefore, future research should focus on the development of MI-based instructional materials that are more interactive and adaptive, as well as on integrating the MI approach with other learning models such as Problem-Based Learning (PBL) and Project-Based Learning (PjBL), in order to promote more meaningful biology learning experiences. Overall, the development of MI-based biology instructional materials is synthesized in a schematic representation illustrating the interrelationships among key aspects derived from the reviewed findings, as presented in Figure 3.

This review highlights the potential of applying Multiple Intelligences (MI) theory in the development of biology instructional materials as a strategy to promote learning that is more contextual, meaningful, and student-centered. Figure 3 illustrates the interrelationships among the positive aspects of MI implementation, including the integration of cognitive, affective, and scientific skills domains within the biology learning process.

Based on the analysis of the studies presented in Table 2, a strong trend can be identified in the development of MI-based instructional materials that are aligned with students' learning styles and the characteristics of biology content. Examples include the development of MI-based e-books for the excretory system (A1; Septiana et al., 2023), flipbooks for the circulatory system (A2; Khastini et al., 2023), and student worksheets (LKPD) emphasizing active learning experiences in biology instruction (A3; Herni et al., 2022). This approach is consistent with the principles of Contextual Teaching and Learning (CTL), which emphasize the connection between learning content, real-life experiences, and the diverse intelligence potentials of learners. Therefore, the main contribution of this review lies not only in demonstrating product validity, but also in highlighting efforts to develop instructional materials that are adaptive to the diversity of students' abilities.

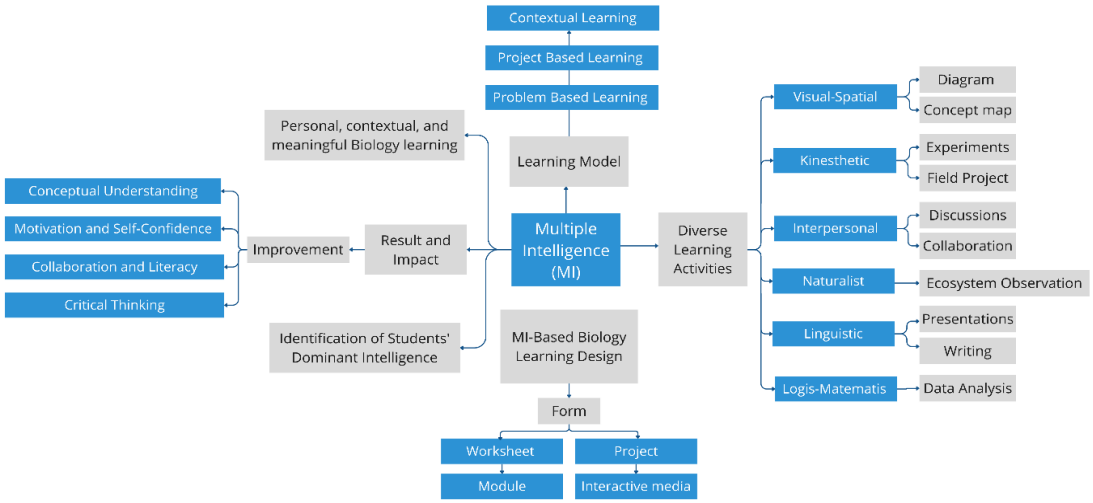

Figure 3 Schematic diagram of the application of multiple intelligences in the development of biology teaching materials

Furthermore, several studies indicate the effectiveness of MI implementation in improving student learning outcomes and motivation. For instance, the development of an MI-based e-book on cell division (A4; Sofa, 2022) was shown to be highly effective, achieving a validity level of 95% and a practicality score of 96.53%. Similarly, an MI-based module on the human digestive system (A5; Nisa & Iza, 2024) significantly increased student engagement and understanding. Comparable findings were reported by Sifasari (2023) through the development of an MI-based electronic student worksheet (e-LKPD) on human heredity (A6), which achieved a practicality score of 97.3% and demonstrated high effectiveness. These findings confirm that incorporating MI principles into the design of biology instructional materials can produce tangible improvements in learning outcomes through activities that optimize various intelligences, including linguistic, logical–mathematical, visual–spatial, bodily–kinesthetic, and naturalistic intelligences.

Moreover, several studies emphasize the contribution of the MI approach to strengthening critical thinking skills and active learning. Research conducted by Zuhriyah (2019) on virus-related LKPD materials (A7) and by Wijayanti (2019) on a genetic material flipbook (A8) demonstrates that MI-based instructional products are not only valid and practical, but also effective in enhancing students' critical thinking abilities. Meanwhile, the study by Lestari and Nisa (2018) on enzyme-related LKPD materials (A9) indicates that instructional materials developed by considering students' diverse intelligences can improve readability and learning mastery. Collectively, these findings reinforce the view that Multiple Intelligences theory can serve as a comprehensive framework for designing biology learning activities that balance the development of cognitive, affective, and psychomotor domains.

In a broader context, the study conducted by Nurjannah (2022) (A10) further strengthens previous findings by demonstrating that an MI-based e-LKPD on human heredity achieved a validity score of 97.8%, a practicality score of 93.09%, and very high effectiveness, with learning mastery reaching 100%. These results indicate that MI-based instructional materials are not only feasible for implementation, but also play a crucial role in fostering critical thinking skills and increasing students' active participation in learning. Consequently, the development of MI-based biology instructional materials has proven effective in strengthening students' scientific literacy through diverse, collaborative, and meaningful learning activities.

Research on the development of MI-based biology instructional materials has shown a significant upward trend over the past decade. This trend is characterized by the dominant use of the Research and Development (R&D) approach, particularly through the application of the 4D and ADDIE models, in producing innovative instructional materials in both print and digital formats. The development of MI-based materials aims to accommodate the diversity of students' intelligence potentials and learning styles, while simultaneously enhancing the quality of biology learning through contextual, collaborative, and student-oriented activities. The implementation of the MI approach is realized through the use of various instructional media, such as e-books, flipbooks, LKPD, and e-LKPD, which are designed to encourage active student engagement through exploratory and context-based learning. The impact of MI-based instructional materials is reflected in improvements in conceptual understanding, critical thinking skills, learning motivation, and student participation, as evidenced by enhanced cognitive learning outcomes, higher-order thinking skills, and increased engagement at both individual and group levels.

Conclusion

This review concludes that the development of Multiple Intelligences (MI)-based instructional materials in biology education has shown a growing trend in recent years and has been consistently deemed feasible for implementation based on expert validation and limited-scale practicality testing. The application of the MI approach has been shown to contribute positively to conceptual understanding, learning motivation, and critical thinking skills. However, most studies have only integrated selected types of intelligences and have not conducted individual mapping of students' dominant intelligence profiles. A key finding of this review is that only one study implemented the MI approach in a comprehensive manner by explicitly incorporating all nine intelligences and presenting contextualized learning activities, indicating that full-scale MI implementation remains very limited. In addition, the majority of studies did not conduct long-term evaluations, did not examine affective aspects in depth, and did not integrate interactive digital media to support differentiated learning. Therefore, future research should focus on the development of MI-based instructional materials that are more comprehensive, adaptive, and digitally enriched, and that are tested across more diverse learning contexts and on a larger implementation scale.

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