



# Development of Three Part Cards Montessori Learning Media on Biodiversity for Grade X Students at SMAN 5 Balikpapan

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**Abstract:** This study aimed to develop and evaluate the Three Part Cards Montessori learning media for teaching Biodiversity to tenth-grade students at SMAN 5 Balikpapan. The development followed the 4D Model (Define, Design, Develop, Disseminate), including validation by experts, practical trials and effectiveness testing. Data were collected through expert assessments, student responses, and learning outcomes including critical thinking skills. The result showed that the Three Part Cards Montessori media was feasible, practical and effective. Expert Validation scores were high, students responded positively, and significant improvement was observed in students learning outcomes and critical thinking abilities. This study suggests that Three Part Cards Montessori is a promising alternative learning media to enhance conceptual understanding and critical thinking in biology education

**Keywords:** Biodiversity; Critical tinkng; Learning media; Montessori; Three part cards

## Introduction

From the perspective of Ki Hajar Dewantara, education is not merely a process of knowledge transmission, but a continuous effort to shape character and internalize cultural values within learners. In the context of globalization, education in Indonesia is expected not only to prepare individuals who are able to compete academically, but also to equip students with the ability to navigate cultural acculturation wisely. The rapid influence of global culture does not necessarily pose a negative threat as long as students are capable of selecting constructive values while filtering out those that are less appropriate (Winata et al., 2022). This perspective highlights the increasingly important role of education in fostering not only academic achievement, but also critical thinking, problem-solving abilities, and other essential 21st-century skills. Therefore, learning in the globalization era should be designed to promote

deep and sustainable conceptual understanding. This view is consistent with the findings of Hastari et al. (2023), Zahra et al. (2025), Rismanto et al. (2025), and Simpati et al. (2025) who emphasize that strong conceptual understanding is closely related to critical thinking skills, as students with a solid grasp of concepts are better able to analyze and evaluate problems during the learning process.

In senior high school biology education, learning practices often remain theoretical and text-oriented, with limited emphasis on concrete experiences. This condition is particularly evident in topics such as biodiversity, which require strong visualization skills and analytical abilities to identify living organisms, understand their characteristics, and classify them based on similarities and differences. Previous studies have shown that biological concepts are often complex and difficult for students to understand when delivered solely through conventional instructional methods

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(Indah et al., 2024; Navarro-Perez & Tidball, 2012). As a result, students tend to rely on rote memorization rather than meaningful understanding, and they experience difficulties in connecting biological concepts with real-life phenomena. These challenges indicate the need for instructional approaches that are capable of bridging abstract concepts with concrete and visual learning experiences.

One potential solution to address these issues is the use of Montessori-based visual learning media, particularly Three Part Cards. The use of concrete learning media has been shown to support students' understanding of concepts as well as vocabulary development, as learners naturally articulate their understanding through words and visual representations (Isman, 2022; Kastiniwati & Ferdinansyah, 2024; Indahsah & Rosyidiana, 2025). Within the Montessori approach, Three Part Cards consist of picture cards, label cards, and control cards that encourage students to actively observe, match, and associate images with scientific terms and their meanings. Several studies have reported that Montessori-based media enhance concept retention by engaging students in active learning processes that involve observation, classification, and self-correction (Suparno & Ardianto, 2018; Chansaeng et al., 2021; Macia-Gual & Domingo-Penafiel, 2022; Ismaputri et al., 2026).

The main strength of the Montessori approach compared to conventional teaching methods lies in its emphasis on learning by doing and self-directed activity. In biology learning, this approach is particularly relevant because it allows students to construct their own understanding through direct interaction with concrete objects or visual representations. Moreover, the use of Three Part Cards Montessori promotes an enjoyable and meaningful learning experience that can increase students' motivation and engagement. Recent studies indicate that Montessori-based instructional approaches, which focus on manipulative activities and independent exploration, have a positive impact on students' engagement and conceptual understanding across various subject areas (Carver & Hassebroek, 2023). Other research has also demonstrated that card-based learning media within the Montessori framework significantly improve students' learning outcomes compared to conventional methods (Darnis & Dodd, 2021; Surya & Syahpurta, 2017; Hallumoglu et al., 2023). These findings support the potential of Montessori-based concrete media to strengthen conceptual understanding and improve learning outcomes.

The selection of biodiversity as the focus of this study is based on the nature of its concepts, which are visual, concrete, and hierarchical, making them highly suitable for instruction using Three Part Cards. Biology

learning requires students to interpret visual representations in order to develop an understanding of abstract concepts. Newman et al. (2023) and Tegeh et al. (2020) highlight that visual literacy plays a crucial role in supporting students' deeper understanding of biological concepts. Similarly, Punyasettro et al. (2021) found that card-based learning activities in biology are effective in improving students' understanding of the classification of living organisms. Therefore, the use of Three Part Cards Montessori is expected to serve as an effective alternative learning medium for enhancing students' conceptual understanding and learning outcomes in biodiversity topics, particularly in the context of classification of living organisms for tenth-grade students at SMAN 5 Balikpapan.

## Method

This study employed a Research and Development (R&D) approach using the Four-D (4D) development model. The 4D model consists of four systematic stages: Define, Design, Develop, and Disseminate. This model was selected because it provides a structured and sequential framework for developing instructional media and evaluating its feasibility, practicality, and effectiveness in educational settings (Kadir et al., 2018). The research was conducted at SMAN 5 Balikpapan, Indonesia, involving 39 students from grade X during the 2024/2025 academic year.

The define stage aimed to identify instructional needs and establish the foundation for media development. This stage included curriculum analysis, learner analysis, and concept analysis. Curriculum analysis was conducted to ensure alignment with the learning objectives and competencies of the senior high school biology curriculum. Learner analysis focused on students' characteristics, learning difficulties, and prior knowledge related to biodiversity concepts. Concept analysis was carried out to identify key concepts, concept hierarchies, and essential characteristics of living organisms that would be represented in the Three Part Cards.

The design stage focused on planning and structuring the learning media based on the findings of the define stage. At this stage, the structure and format of the Three Part Cards Montessori media were determined, including the selection of images, scientific terms, and descriptions. The media was designed to consist of three components: picture cards, label cards, and control cards, arranged to support concept recognition, matching, and self-correction activities.

The develop stage involved producing the learning media according to the established design, followed by expert validation and product revision. The feasibility of

the developed media was evaluated through expert validation involving media experts and subject matter experts. Media experts assessed aspects related to visual design, layout, and usability, while subject matter experts evaluated content accuracy, relevance, and conceptual correctness.

The feasibility assessment employed a four-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). Validation scores were converted into percentage values using the following formula:

$$P = \frac{\text{Obtained Score}}{\text{Maximum Score}} \times 100\% \quad (1)$$

The resulting percentages were interpreted based on predetermined feasibility criteria in Table 1.

**Table 1.** Criteria for Feasibility and Practicality Assessment

Percentage Range (%)	Category
90-100	Very Feasible/ Very Practical
75-89	Feasible/ Practical
65-74	Fairly Feasible/ Fairly Practical
55-64	Less Feasible/ Less Practical
0<55	Very Unfeasible

Revisions were made according to experts' suggestions and feedback to improve the quality of the learning media. In addition to expert validation, student response questionnaires were administered to assess the feasibility and practicality of the media from the users' perspective. The practicality assessment focused on ease of use, clarity of instructions, attractiveness, and usefulness of the media during learning activities. Data obtained from expert validation and student questionnaires were analyzed descriptively to determine the level of feasibility and practicality of the Three Part Cards Montessori media.

The disseminate stage involved implementing the validated learning media in a real classroom setting to examine its effectiveness. The effectiveness of the learning media was measured using a pretest-posttest design to assess students' learning outcomes and critical thinking skills. Students completed a pretest prior to the implementation of the media and a posttest after the learning activities.

Improvement in students' learning outcomes and critical thinking skills was analyzed using the normalized gain (N-Gain) formula as follows:

$$\text{N-Gain} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Maximum score} - \text{Pretest score}} \quad (2)$$

The N-Gain calculation results were presented as percentages using the following criteria in Table 2.

**Table 2.** N-Gain Interpretation Criteria

N-Gain Value	Category
$g > 0.70$	High
$0.30 \leq g \leq 0.70$	Medium
$g \leq 0.30$	Low

The N-Gain values were interpreted to determine the effectiveness level of the developed media based on the criteria presented in Table 3. This analysis was used to evaluate the extent to which the Three Part Cards Montessori media contributed to improvements in students' learning outcomes and critical thinking abilities.

**Table 3.** Interpretation of N-Gain Effectiveness

Percentage (%)	Category
$g < 40\%$	Not Effective
$40\% \leq g < 55\%$	Less Effective
$56\% \leq g \leq 75\%$	Moderately Effective
$g < 76\%$	Effective

This study utilized both quantitative and qualitative data. Quantitative data were obtained from expert validation scores, student response questionnaires, and pretest-posttest results, and were analyzed using descriptive statistical techniques. Qualitative data consisted of comments, suggestions, and feedback from experts, which were analyzed descriptively to support product revision and refinement. Both types of data were analyzed complementarily to assess the feasibility, practicality, and effectiveness of the developed learning media.

## Result and Discussion

### Results

Montessori-based learning media in the form of Three Part Cards was successfully developed as a concrete, visual, and student-centered instructional tool designed to improve students' learning outcomes and critical thinking skills in biodiversity learning. This media consists of several key components such as image cards containing photographs of organisms accompanied by brief descriptions, label cards presenting the names of organisms, and control cards that integrate images, descriptions, and labels to support students' self-correction during independent learning activities. These components facilitate hands-on learning through matching, grouping, and classification tasks.

The learning media was developed based on Montessori principles, emphasizing active engagement, independence, and sensory-based learning. Through the use of Three Part Cards, students are guided to observe morphological characteristics, analyze similarities and differences among organisms, and classify biodiversity

at the genetic, species, and ecosystem levels. These activities encourage students to actively construct knowledge, evaluate information, and draw conclusions, thereby supporting the development of critical thinking skills alongside conceptual understanding. The inclusion of local Kalimantan organisms, such as proboscis monkeys, orangutans, black orchids, mangroves, and hornbills, further enhances contextual learning.



Figure 1. Visual desain of three part cards montessori

The developed media can be implemented flexibly in individual and small-group learning settings, allowing students to engage in independent or collaborative learning both inside and outside the classroom. Figure 1 presents the structure and appearance of the developed Three Part Cards Montessori learning media.

The feasibility, practicality, and effectiveness of the developed Three Part Cards Montessori media were evaluated through several stages. Feasibility was assessed through expert validation involving media experts and content experts to determine the appropriateness and quality of the developed learning media. The results of the feasibility assessment are presented in Table 4.

The findings indicate that the developed learning media satisfied the feasibility criteria, with an overall

average score of 84.64, categorized as feasible. The consistency of the media design, accuracy of the learning content, and clarity of presentation suggest that the developed Three Part Cards Montessori media can be effectively implemented in classroom learning.

Table 4. Expert Validation Result of Google Sites-Based Learning Media

Validator Type	Average Score	Percentage	Category
Media Expert	15	95.8%	Very Feasible
Content Expert	9	73.44%	Fairly Feasible
Average	12	84.64%	Feasible

In addition to expert validation, the feasibility and practicality of the Three Part Cards Montessori learning media were also evaluated through student response questionnaires as the end users of the media. This evaluation aimed to assess students' perceptions regarding the suitability and ease of use of the developed learning media. The results of students' responses on media feasibility and practicality are presented in Table 5.

Table 5. Students Responses on Media Feasibility and Practicality

Aspec Evaluated	Percentage (%)	Category
Feasibility	88.25	Feasible
Practicality	87.56	Practical

Based on Table 5, the Three Part Cards Montessori learning media obtained a feasibility score of 88.25%, which is categorized as very feasible. This result indicates that the media is appropriate for classroom implementation and meets students' learning needs. In terms of practicality, the media achieved a score of 87.56%, which falls into the practical category, indicating that the media is easy to use and supports students during the learning process.

The effectiveness of the Three Part Cards Montessori learning media was determined by analyzing students' learning outcomes and critical thinking skills after the implementation of the media in learning activities on Kalimantan biodiversity. Effectiveness was measured using learning achievement tests and critical thinking assessment instruments, which were administered before and after the learning process. The results of students' learning outcomes and critical thinking skills are presented in Table 6.

Table 6. Effectiveness of the Three Part Cards Montessori Learning Media

Aspect Evaluated	Component	Average	N-Gain	Category
Learning Outcomes	Pretest	64	0.60	Moderately Effective
	Posttest	84		
Critical Thinking Skills	Pretest	64	0.7	Moderately Effective
	Posttest	90		

Based on Table 6, the effectiveness of the Three Part Cards Montessori learning media was evaluated through students' learning outcomes and critical thinking skills using pretest and posttest scores. For learning outcomes, the average pretest score was 64, which increased to 84 in the posttest. The obtained N-Gain value of 0.60 falls into the moderately effective category, indicating that the use of the Three Part Cards Montessori media was effective in improving students' understanding of biodiversity concepts.

Similarly, students' critical thinking skills showed a significant improvement after the implementation of the media. The average pretest score increased from 64 to 90 in the posttest, with an N-Gain value of 0.70, which is categorized as moderately effective. This result suggests that the media effectively supported the development of students' analytical and reasoning abilities during the learning process.

Overall, the findings demonstrate that the Three Part Cards Montessori learning media is moderately effective in enhancing both learning outcomes and critical thinking skills, particularly through hands-on activities, visual classification tasks, and self-correction features embedded in the Montessori-based media.

### *Discussion*

The development of the Three Part Cards Montessori learning media followed the 4D model (Define, Design, Develop, and Disseminate) to ensure pedagogical relevance and suitability for biodiversity learning. The needs analysis conducted at the Define stage revealed that biodiversity concepts—particularly genetic, species, and ecosystem diversity—are abstract and highly visual in nature, making them difficult for students to understand through text-based instruction alone. This finding supports previous studies emphasizing the importance of concrete and visual learning materials in biology education to enhance conceptual understanding (Sabudu, 2025; Putri & Gamayo, 2025).

The Three Part Cards Montessori were therefore designed to provide concrete visual representations that facilitate observation, comparison, and classification activities. The inclusion of local Kalimantan biodiversity examples was intended to contextualize learning and increase student engagement by linking biological concepts to students' real environments. Contextual and locally relevant learning materials have been shown to improve student motivation and support meaningful learning transfer (Pratama & Sumardi, 2022).

At the Design stage, the structure of the media was aligned with core Montessori principles, consisting of image cards, label cards, and control cards to support independent learning and self-correction. The simple visual layout, clear morphological images, and control-

of-error mechanism were deliberately implemented to maintain student focus and encourage autonomous learning. Previous studies indicate that Montessori-based manipulatives with clear visual consistency and self-correction features effectively support cognitive development and classification skills (Lestari & Rahmawati, 2021; Saputra, 2025; Faizah et al., 2023).

During the Develop stage, expert validation highlighted the importance of aligning learning objectives with the Merdeka Curriculum, particularly in fostering critical thinking skills. Revisions were made to strengthen analytical and classification-based activities embedded within the media. This aligns with findings that well-designed visual classification media can stimulate higher-order thinking processes such as analysis, comparison, and reasoning (Sari & Yuliani, 2021; Setiawan & Supardi, 2022).

The feasibility of the Three Part Cards Montessori learning media was determined through expert validation involving media and content experts, as well as student response questionnaires as the end users of the media. Expert validation results indicated that the media achieved a very valid category in terms of visual appearance and a sufficiently valid category for content accuracy, suggesting that the media was appropriate for trial implementation.

Positive evaluations of the visual design confirm that the use of clear images, simple layouts, and white backgrounds aligns with fundamental Montessori principles that emphasize minimal visual distraction and focus on key learning objects. This finding is consistent with Kayili (2021) and Prianto et al. (2025), who reported that Montessori-based learning media are considered feasible when they employ simple, object-centered designs that support students' attention and conceptual focus. Clean and proportional images have been shown to enhance visual comfort and students' perceptions of media quality.

From the implementation aspect, students provided highly positive responses toward the use of the Three Part Cards Montessori, indicating that the media was easy to use and suitable for learning activities. This suggests that the media met feasibility standards as a biology learning tool for Grade X students, particularly for biodiversity topics. Ease of use is a critical factor in determining media feasibility, as learning tools that do not hinder instructional flow are more readily accepted by students. This result aligns with Santoso et al. (2022), Lismayani et al. (2017), and Indah et al. (2024), who emphasized that visual classification media are considered feasible when they can be used independently by students without requiring complex technical instructions.

The practicality of the Three Part Cards Montessori learning media was assessed based on the extent to

which the media could be used easily and efficiently by students during the learning process. Student response questionnaire results indicated that the media achieved practical to highly practical categories across all practicality indicators. High scores on ease of use and card-matching activities suggest that students experienced minimal difficulty in operating the media during learning activities.

The practicality of the media is closely related to its physical design and presentation structure. The proportional card size, clear visual display, and easily recognizable images and text allowed students to use the media independently without repeated technical guidance from the teacher. This finding aligns with Widodo et al. (2021), who stated that learning media are considered practical when they can be used autonomously by students with minimal teacher assistance.

In addition, the self-correction (control of error) feature embedded in the Three Part Cards Montessori further enhanced practicality by enabling students to check their own work independently, thereby reducing reliance on teacher intervention and increasing learning efficiency. This result is consistent with findings by Novianti et al. (2023), Winarti et al. (2022), Sergi et al. (2023), Okita (2014), and Lestuny et al. (2024), who emphasized that learning media providing independent feedback improve practicality and learning effectiveness.

The results of this study indicate that the Three Part Cards Montessori learning media was moderately effective in improving students' learning outcomes and critical thinking skills in biodiversity learning. This effectiveness is reflected in the increase in students' posttest scores compared to pretest scores, with moderate N-Gain values for learning outcomes and high N-Gain values for critical thinking skills.

The improvement in learning outcomes (N-Gain = 0.60) suggests that the use of visual and manipulative media supports students' conceptual understanding by transforming abstract biodiversity concepts into concrete representations. Activities such as matching images and labels help students recognize morphological characteristics, compare organisms, and understand biodiversity levels more systematically. This finding is consistent with Kayili (2021), who emphasized that Montessori-based visual manipulatives enhance conceptual understanding through meaningful cognitive engagement.

The effectiveness of the media was more pronounced in the development of critical thinking skills, as indicated by a high N-Gain value (0.73). The learning activities embedded in the Three Part Cards Montessori encouraged students to observe, analyze, classify, and justify their decisions during the

classification process. Such activities align with findings by Santoso et al. (2022), who reported that visual classification tasks effectively promote analytical and reasoning skills in biology learning.

## Conclusion

This study resulted in the development of a Three Part Cards Montessori learning media for biodiversity learning that was designed using the 4D development model. Based on expert validation and student responses, the developed media was categorized as feasible and appropriate for classroom implementation. The practicality assessment showed that the Three Part Cards Montessori learning media was easy to use, efficient, and supportive of independent learning, as indicated by positive student responses. The simple visual design, clear instructions, and self-correction features enabled students to use the media with minimal teacher assistance. Furthermore, the effectiveness analysis demonstrated that the use of the Three Part Cards Montessori learning media led to an improvement in students' learning outcomes and critical thinking skills, with moderate effectiveness for learning outcomes and high improvement in critical thinking skills. These findings indicate that the media not only supports conceptual understanding of biodiversity but also promotes higher-order thinking through classification and analytical activities. Overall, the Three Part Cards Montessori learning media can be considered a feasible, practical, and effective instructional tool for enhancing biology learning, particularly in biodiversity topics at the senior high school level.

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## Author Contributions

V.W.A.V.: conceptualized the research, research procedures, analyzed the data and wrote the article; S.L., Y.H., L.S, D.T, A.H, E.T, V.M: supervised the writing of the article, reviewed and validated the research instruments used.

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## Conflicts of Interest

The authors declare no conflict of interest.

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