

Educational Media Design for Organic Waste Management through Black Soldier Fly Maggot Cultivation

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ABSTRACT

The increasing volume of organic waste in residential areas remains a significant environmental issue, particularly due to limited public understanding of proper waste management methods. The lack of effective visual educational media has become a key challenge in supporting community understanding of organic waste management using Black Soldier Fly (BSF) maggots in Mojosongo, Surakarta. This study aims to design an educational e-book as a visual communication medium to address this issue. The research applies the Design Thinking method, consisting of empathize, define, ideate, prototype, and test stages, to develop a user-centered design. The resulting e-book integrates structured content with visual elements to enhance clarity and comprehension. Evaluation through beta testing involving 25 respondents shows a feasibility score of 87.6%, indicating high suitability. The findings indicate that the e-book is feasible and has strong potential to support community understanding.

INTRODUCTION

The increase in waste volume, particularly organic waste, remains a significant environmental problem in residential areas. Organic waste constitutes the largest proportion of household waste; however, its

management has not been optimized. If not properly handled, organic waste can lead to environmental pollution, unpleasant odors, and public health issues. Various studies highlight the importance of appropriate organic waste treatment approaches to reduce waste volume while promoting sustainable waste management practices (Choerunnisa et al., 2024; Umamah, et al., 2021 Windianingsih & Kahar, 2023).

In response to these challenges, Karya Salemba Empat (KSE) of Sebelas Maret University Surakarta, in collaboration with the Food Security and Agriculture Agency (Dispangtan) of Surakarta City, initiated a community service program focused on organic waste management. This program was implemented in the Mojosongo neighborhood of Surakarta, Central Java, an area with a high potential for household waste generation. The method applied in this program involves the use of Black Soldier Fly (BSF) larvae or maggots, which have been proven effective in decomposing organic waste and can be implemented at both household and community levels (Almuharami et al., 2024; Mutmainnah et al., 2025).

However, the success of BSF maggot-based organic waste management is not solely determined by the availability of the method, but also by the level of public understanding regarding its processes and benefits (Gold et al., 2018). Technical information related to BSF maggots, including their life cycle, cultivation procedures, and post-harvest utilization, is often difficult for the general public to comprehend when delivered without an appropriate communication approach. Therefore, there is a need for an educational medium that can bridge complex technical information with community understanding in a more accessible and contextual manner (Izhar et al., 2022).

Although previous studies have examined organic waste management using BSF larvae and the use of e-books as educational media, most of these studies primarily focus on technical implementation or general learning effectiveness (Mertenat et al., 2019). Limited research has specifically explored the design of visual educational media using a Design Thinking approach tailored for community-based learning contexts. In particular, there

remains a lack of studies addressing how visual communication design can translate complex technical information about BSF maggot cultivation into accessible and user-centered content for non-expert audiences. This gap highlights the need for a design-oriented approach that integrates user needs, visual communication principles, and practical applicability in real community settings (Mayer & Fiorella, 2021).

Based on this approach, this study proposes the design of an e-book as a visual educational medium for organic waste management using BSF maggots in the Mojosongo community. The selection of an e-book as a design solution is based on its ability to integrate visual and textual information in a structured and accessible format, which has been proven effective in improving comprehension and learning engagement in digital environments (Indrawan et al., 2023). Previous studies indicate that both e-books and printed media contribute positively to learning outcomes, with e-books offering advantages in terms of flexibility and accessibility, while also supporting effective information delivery through integrated visual and textual elements (Santoso et al., 2018). Therefore, this study aims to design and evaluate an educational e-book that can effectively support community understanding of BSF-based organic waste management. The research focuses on how visual communication design can translate technical information into accessible content and how the resulting media performs in terms of usability and effectiveness.

RESEARCH METHOD

This study employs a qualitative descriptive approach combined with the Design Thinking method as the main framework for the research and media design process. Data were collected through observations, interviews, questionnaires, and literature studies to understand community needs and challenges in organic waste management. Design Thinking is a human-centered approach that emphasizes understanding user needs and developing solutions through iterative processes (Peng, 2022; Wang, 2022). This approach is considered suitable for this study as it addresses the gap in

community understanding of BSF-based organic waste management by focusing on user experience and communication effectiveness. The Design Thinking process consists of five stages: empathize, define, ideate, prototype, and test, which are applied systematically in this research.

Empathize

The empathize stage serves as the initial phase of the Design Thinking process, aiming to gain an in-depth understanding of users' needs, experiences, and challenges through direct engagement (Haddadian et al., 2019). In this study, this stage was operationalized through a qualitative approach involving purposive sampling of key stakeholders, including two Mojosoongo residents responsible for managing the local maggot facility, members of the KSE student organization at Universitas Sebelas Maret actively involved in community outreach, a technical coordinator from the Department of Agriculture, Food Security, and Fisheries of Surakarta, and a staff member from the Environmental Communication and Community Empowerment Division of the Surakarta Environmental Agency. Data were collected using semi-structured interviews, participatory observation, visual documentation, and literature review to capture both experiential and contextual insights. This combination of participants and methods enabled the identification of gaps in community understanding, particularly in comprehending technical aspects of BSF maggot cultivation, while also revealing communication barriers related to the lack of structured and accessible educational media. These findings served as a critical foundation for defining user needs and guiding subsequent design decisions.

Define

The define stage focuses on synthesizing findings from the empathize phase into a clear problem formulation and design direction (Umamah et al., 2021). In this study, qualitative data from interviews and observations were analyzed to identify key patterns in user understanding, revealing three main issues: limited public knowledge about BSF maggots, insufficient understanding of cultivation processes (including feeding, maintenance, and harvesting), and a

lack of clarity regarding post-harvest handling and distribution. These findings indicate that the core problem lies not only in the availability of information, but in how technical knowledge is communicated to non-expert users. Based on this analysis, the study establishes design requirements that emphasize structured content, clear visual explanations, and a sequential information flow aligned with users' level of understanding. To address these needs, an educational e-book was selected as the design solution due to its flexibility, accessibility, and ease of distribution, allowing for the integration of visual and textual elements in a structured format that makes complex information more accessible and easier to understand, while also serving as the foundation for the development of design concepts in the subsequent ideation phase.

Ideate

The ideate stage focuses on exploring and developing design solutions based on the problem formulation identified in the define phase (Rösch et al., 2023). In this study, several media alternatives were initially considered, including posters, leaflets, and banners, primarily aimed at attracting public attention during socialization activities. However, an educational e-book was ultimately selected as the main solution due to its high accessibility, ease of distribution, and suitability for a broad user group aged 17–40 years with adequate digital literacy. The design concept emphasizes a simple, step-by-step learning approach to support users in independently understanding and applying BSF maggot cultivation, particularly for reducing household organic waste. The content structure was organized into three main sections—introduction, cultivation process, and utilization—to ensure a logical and sequential flow of information. Visually, the design adopts simple flat-style illustrations to represent real-world processes in a clear and minimally distorted manner, making complex technical content easier to grasp. This approach is further supported by concise textual explanations, “do and don’t” guidance, and a focus on avoiding overly dense information. Design references were derived from educational books and simplified visual styles inspired by children’s illustrations to enhance clarity and engagement. Overall, this stage

establishes a user-centered design direction that prioritizes simplicity, clarity, and structured information delivery as the foundation for prototype development.

Prototype

The prototype stage involves translating the selected design concepts into a tangible form that can be tested and evaluated (Jones, et al., 2024). The prototype was developed as a digital educational e-book with a layout adapted from the A5 format to ensure practicality and comfortable readability across devices. The design integrates a structured three-chapter organization, introduction, cultivation process, and utilization, to support a sequential learning experience. Typography selection plays a key role in enhancing readability, with Agrandir Grand used for chapter titles to provide a strong and modern visual emphasis, while Codec Pro is applied for subheadings and body text due to its high legibility and clean sans-serif form. The visual design is reinforced through a color scheme dominated by green and earthy tones to reflect environmental themes and strengthen contextual relevance. Illustrations were created using Sketchbook to visually represent step-by-step processes, supported by Adobe Photoshop for refinement and layout composition. Additionally, a QR code was generated to facilitate easy access and distribution of the e-book, allowing users to engage with the content across digital platforms. Overall, this prototype reflects the integration of visual communication elements and user-centered design principles, resulting in a structured and accessible educational medium ready for evaluation in the testing stage.

Test

The test stage aims to evaluate the effectiveness and usability of the design solution through user feedback, focusing on aspects such as efficiency, effectiveness, and user satisfaction (Syamala et al., 2025). The evaluation was conducted using a beta testing method involving 25 participants, consisting of community members, program coordinators, and students who are relevant to the target users. Data were collected using a structured questionnaire

distributed via Google Forms, comprising five key statements designed to assess the feasibility of the e-book. Each statement measures user responses related to readability, clarity of illustrations, ease of understanding, logical content structure, and suitability of the e-book as a practical guide for maggot cultivation. The use of a structured questionnaire allows for consistent data collection and facilitates quantitative analysis of user perceptions. The results obtained from this evaluation were then used to determine the overall feasibility level of the e-book and to identify areas for refinement before final implementation.

RESULT AND DISCUSSION

The e-book on maggot-based organic waste management was developed as a visual educational medium for the Mojosongo community, Surakarta, targeting individuals aged 17–40 years. This design addresses the increasing volume of organic waste and the limited public understanding of community-based waste management methods by translating technical information on maggot cultivation into a structured and accessible visual format. Based on findings from the empathize and define stages, the main challenge identified was the community’s difficulty in understanding technical processes due to the lack of systematic visual educational media. Therefore, the design process focused on simplifying complex information through visual communication strategies that emphasize clarity, structure, and accessibility.

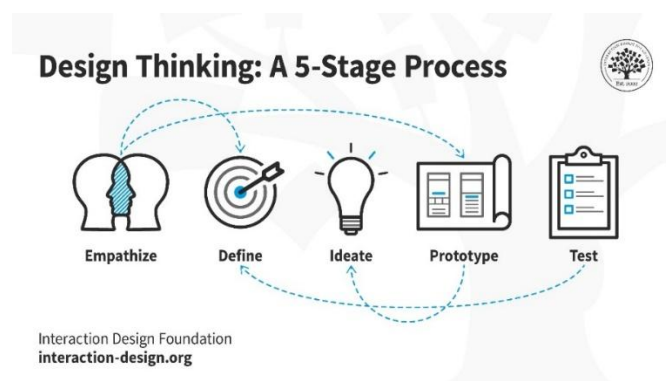


Figure 1. Design thinking method
Source: interaction-design.org



Figure 2. KSE with Mojosongo's community
Source: author's documentation 2026

One of the key outcomes of the ideation process is the development of a structured content framework consisting of three main chapters: (1) introduction to maggots, (2) maggot cultivation procedures, and (3) post-harvest utilization and distribution. This structure is intentionally designed to align with users' learning needs identified in the define stage, particularly the need for a gradual and systematic understanding of technical information. The first chapter provides foundational knowledge to address users' limited familiarity with BSF maggots, while the second chapter focuses on step-by-step cultivation processes to support practical implementation. The third chapter extends this understanding by explaining post-harvest handling and distribution, which were previously identified as areas of confusion among users. This sequential organization reflects a progressive learning approach, enabling users to move from basic concepts to applied knowledge in a structured manner. Such an approach is consistent with principles of instructional design that emphasize the importance of organized and scaffolded information to enhance comprehension and reduce cognitive overload (Mayer & Fiorella, 2021). The results of the user evaluation further support this design decision, as indicated by high scores in the clarity of content structure, suggesting that the three-chapter framework effectively facilitates user understanding.

Table 1. E-book Framework

No	Chapter	Subchapter
1	Understanding the Origins of Maggots (An Introduction to Maggots for the Community)	<ol style="list-style-type: none"> 1. What is a maggot? 2. The Maggot Life Cycle 3. The Advantages of Maggots
2	Maggot Cultivation Procedures (Answering questions from the public regarding maggot cultivation procedures and	<ol style="list-style-type: none"> 1. Understanding the 3 Phases of Maggot Cultivation 2. Phase 1: Egg Hatching 3. Phase 2: Feeding 4. Phase 3: Harvesting 5. Effective media for feeding
3	Utilization of Maggots and Distribution Methods (Answering questions from the public regarding where the maggots will be taken after harvesting and what they will be processed into)	<ol style="list-style-type: none"> 1. Maggot Processing 2. Maggot Distribution Flow Chart 3. Profile of Dispangtan and KSE 4. Contact Numbers

Source: author's documentation 2026

These design considerations were explored and visualized during the ideation stage through the development of moodboards and visual references.



Figure 3. Moodboard
Source: author's documentation 2026

The e-book applies an integrated visual communication approach through the combination of layout, typography, illustration, and color. A grid-based layout establishes a clear structure and visual hierarchy, guiding user navigation and supporting efficient information processing (Hullman & Diakopoulos, 2017). Typography selection further reinforces readability, with Agrandir Grand applied to chapter titles to create strong visual emphasis and Codec Pro used for subheadings and body text due to its high legibility and clean sans-serif characteristics. This combination ensures that information remains clear and comfortable to read across digital formats.

Table 2. E-book Beta Test Results

No	Statement	Strongly Agree	Agree	Slightly Disagree	Disagree	Strongly Disagree
1	The layout, text size, and color selection in this book make it easy to read.	14	9	3	0	0
2	The illustrations shown help you understand the maggot cultivation process.	19	6	0	0	0
3	The content of this book is easy to understand, especially for beginner readers.	12	12	1	0	0
4	The division of chapters and the sequence of material are logical and not confusing.	17	8	0	0	0
5	In your opinion, is this book suitable for use as a guide to cultivating maggots on a household scale?	17	5	2	1	0

Source: author's documentation 2026

The results of the beta testing provide important insights into the effectiveness of the e-book as a visual educational medium. Overall, the e-book achieved a feasibility score of 87.6%, indicating a high level of suitability based on user evaluation. A closer analysis of each assessment aspect reveals how specific design decisions contribute to this outcome. The high score in readability suggests that the combination of structured layout, appropriate text size, and clear typography effectively supports comfortable reading. Similarly, the strong agreement on illustration clarity indicates that the use of simplified flat-style visuals successfully aids users in understanding the maggot cultivation process, particularly in conveying step-by-step procedures.

Furthermore, the positive response to content clarity reflects the effectiveness of organizing information into a sequential three-chapter structure, which allows users to build understanding progressively from basic concepts to practical application. The high rating for logical content flow also confirms that the structured arrangement of material reduces confusion and supports intuitive navigation. In addition, users' perception of the e-book as a suitable practical guide demonstrates that the integration of visual and textual elements not only facilitates comprehension but also supports real-world application. These findings suggest that the design approach, emphasizing clarity, structure, and visual simplification, plays a significant role in enhancing user understanding. However, these results should be interpreted as indicative of perceived effectiveness rather than definitive proof of learning improvement, given the scope and scale of the evaluation.

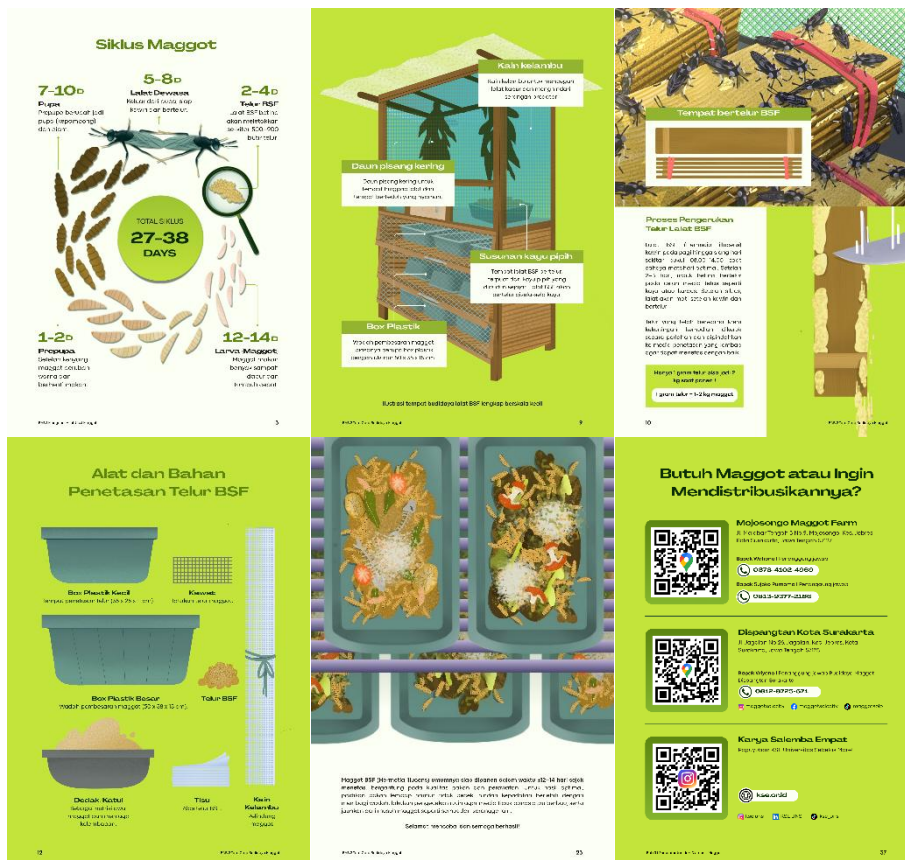


Figure 5. Examples of several pages from E-book
 Source: author's documentation 2026

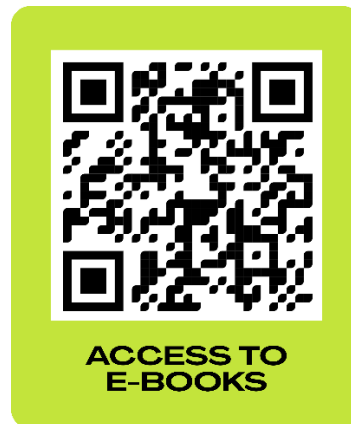


Figure 6. E-book QR Code
Source: author's documentation 2026

To enhance accessibility and dissemination, the e-book is distributed through a QR code linked to the Instagram account *maggotfarmm9*, integrated into supporting media such as posters and infographics. This strategy extends the reach of the educational content and aligns with contemporary digital communication practices, enabling information to be accessed quickly and widely across different platforms.



Figure 7. Maggot cultivation guide infographic with qr code attached to the announcement board in mojosongo village
Source: author's documentation 2026

Overall, the findings indicate that the designed e-book serves as a feasible visual educational medium for supporting community understanding of BSF-based organic waste management. The integration of structured content, step-by-step information flow, and simplified visual elements

contributes to clearer information delivery and more accessible learning for non-expert users. The relatively high evaluation scores across content clarity, visual presentation, and usability suggest that the applied design approach aligns well with user needs identified in earlier stages. These results highlight the importance of combining visual communication principles with user-centered design methods in developing educational media for community contexts. However, it is important to note that the findings are based on user perceptions within a limited sample and therefore should be interpreted as indicative of potential effectiveness rather than definitive evidence of learning improvement. Future studies may further explore the long-term impact of such media on behavioral change and learning outcomes across broader user groups.

CONCLUSION

This study aimed to design and evaluate an educational e-book as a visual communication medium to support community understanding of BSF-based organic waste management using a user-centered Design Thinking approach. The results indicate that the e-book is feasible, as reflected in high evaluation scores across content clarity, visual presentation, and usability. The integration of structured content, step-by-step information flow, and simplified visual elements contributes to making technical information more accessible for non-expert users. These findings suggest the potential of visual communication design to support community-based environmental education, particularly in translating complex information into more understandable formats. However, this study is limited by the relatively small sample size and its focus on a specific community context. Therefore, future research is recommended to involve a broader population and examine the long-term impact of such media on learning outcomes and behavioral change, as well as to explore the integration of more interactive digital features.

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