Promoting Green Campus Awareness through BIOMAGIC: User Evaluation of a Black Soldier Fly Educational Flipbook among Biology Students at Universitas Negeri Makassar

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Abstract.
Green Campus initiatives emphasize sustainable waste-management practices as an important component of institutional sustainability. Black Soldier Fly (BSF; Hermetia illucens) bioconversion has emerged as a promising approach for converting organic waste into value-added products while reducing environmental burdens. To support sustainability education and promote awareness of BSF-based organic waste management, BIOMAGIC (Bio-Maggot Innovative Guide for Green Integrated Campus) was developed as a digital flipbook integrating concepts of organic waste management, BSF bioconversion, and Green Campus implementation. This study aimed to evaluate the educational feasibility and user acceptance of BIOMAGIC among undergraduate biology students at Universitas Negeri Makassar (UNM). A developmental evaluation approach was conducted during a socialization activity held in June 2026. Data were collected using Google Forms through pre-test and post-test knowledge assessments and a perception questionnaire. A total of 35 participants completed the pre-test, whereas 21 participants completed the post-test and user evaluation questionnaire. Participants demonstrated high baseline knowledge regarding BSF-based organic waste management, with mean pre-test and post-test scores of 95.10% and 95.24%, respectively. Knowledge related to BSF biological characteristics and cultivation showed higher post-test percentages, whereas sustainability-related concepts exhibited comparatively lower scores. User evaluation indicated favorable responses toward BIOMAGIC, with an overall mean perception score of 4.46 on a five-point Likert scale. Visual design received the highest ratings, while qualitative feedback highlighted accessibility, systematic content organization, and support for independent learning as major strengths. The findings support BIOMAGIC as a feasible and well-accepted digital learning resource for promoting awareness of BSF-based organic waste management and Green Campus concepts among university students.

Keywords: *Black Soldier Fly, digital flipbook, environmental education, Green Campus, organic waste management, sustainability awareness.*

I. INTRODUCTION

Higher education institutions play an important role in advancing sustainable development through the implementation of Green Campus initiatives. The Green Campus concept promotes resource conservation, energy efficiency, environmental protection, and sustainability education to improve institutional environmental performance and foster environmentally responsible behavior among campus communities [1,2]. The growing commitment of universities to sustainability is reflected in their participation in the UI GreenMetric World University Rankings (https://uigreenmetric.com/), an international assessment framework established in 2010 to evaluate sustainability performance across several dimensions, including setting and infrastructure, energy and climate change, water, transportation, education, and waste management [3]. In its 16th edition, UI GreenMetric included 1,745 institutions from 105 countries, making it the largest global ranking system dedicated to institutional sustainability assessment. Among the evaluated dimensions, waste management emphasizes the development and implementation of practical strategies to

prevent, reduce, and manage campus-generated waste [4].

Despite increasing efforts to implement Green Campus programs, waste generation remains a major environmental challenge in higher education institutions. Routine activities conducted by students, lecturers, and administrative staff generate substantial quantities of waste, particularly organic waste derived from food consumption and campus maintenance activities [5]. Inadequate management of organic waste may contribute to environmental degradation, increase disposal burdens, and reduce the effectiveness of campus sustainability programs. As a result, sustainable waste-management approaches have become an important component of Green Campus implementation.

One of the promising strategies for organic waste management is the use of Black Soldier Fly (BSF; *Hermetia illucens*) larvae for bioconversion. Previous studies have demonstrated the effectiveness of BSF larvae in reducing organic waste while producing valuable biomass and nutrient-rich frass in universities. At Universitas Indonesia (UI), BSF larvae reduced cafeteria food waste by approximately 75% while generating larval biomass rich in protein and lipids [6]. Similarly, studies at Universitas Diponegoro (UNDIP) reported that BSF bioconversion was more effective in degrading biodegradable organic waste than conventional microbial decomposition approaches [7]. In addition, a study at Universitas Gadjah Mada (UGM) highlighted that effective Green Campus implementation requires integrated waste management systems and active stakeholder participation to reduce waste disposal and enhance resource recovery [8]. These reports indicate that BSF-based bioconversion has considerable potential to support sustainable waste management and resource recovery within university environments.

Universitas Negeri Makassar (UNM) is among the state universities in Indonesia that has adopted the Green Campus concept. However, unlike several universities in South Sulawesi that have been included in the UI GreenMetric rankings, i.e., Universitas Hasanuddin, Universitas Muhammadiyah, Makassar, Makassar Tourism Polytechnic, and Makassar Maritime Polytechnic, UNM is still strengthening various sustainability initiatives. A prior assessment identified five major categories of waste generated within the university environment, namely solid waste, liquid waste, hazardous waste, domestic waste, and slaughterhouse waste [9]. Among these, solid waste, particularly food waste generated from various campus activities, represents a major environmental concern. To address this issue, BSF-based bioconversion has been introduced as a sustainable waste-management approach. Nevertheless, the successful implementation of such programs depends not only on technical feasibility but also on the awareness, understanding, and participation of campus stakeholders, particularly students.

To support sustainability education and promote awareness of BSF-based organic waste management, BIOMAGIC (Bio-Maggot Innovative Guide for Green Integrated Campus) was developed as a digital flipbook integrating concepts of organic waste management, BSF bioconversion, and Green Campus implementation. Digital learning media have increasingly been utilized to support environmental education because they enable flexible access to information and promote learner engagement. Previous studies have demonstrated that digital flipbooks can enhance environmental literacy, ecological competence, and digital literacy through the integration of interactive and visually structured learning materials [10–12]. As biology students represent a key stakeholder group with potential involvement in environmental management and sustainability programs, understanding their perceptions toward such educational media is essential. Therefore, this study aimed to evaluate the educational feasibility and user acceptance of the BIOMAGIC flipbook as a digital learning resource for BSF-based organic waste management among undergraduate biology students at UNM.

II. METHODS

2.1. Study Design

A developmental evaluation approach was employed to assess user responses toward BIOMAGIC (Bio-Maggot Innovative Guide for Green Integrated Campus), a digital flipbook developed to support sustainability education related to Black Soldier Fly (BSF)-based organic waste management. The evaluation was conducted during a socialization activity held in May 2026 at the Biology Campus, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, Southeast Sulawesi, Makassar, Indonesia.

2.2. Development of Educational Media

BIOMAGIC was developed as a digital flipbook containing educational materials on organic waste management, BSF (*H. illucens*) bioconversion, frass utilization, and Green Campus implementation. The flipbook was created and published using the FlipHTML5 platform, enabling online access through desktop and mobile devices without requiring software installation. The content was compiled from scientific literature and institutional sustainability references related to BSF cultivation and organic waste management. The material was organized sequentially, beginning with campus organic waste issues, followed by BSF biological characteristics, bioconversion processes, product utilization, and the contribution of BSF technology to sustainable campus waste-management programs. Visual components, including photographs, illustrations, diagrams, and graphical layouts, were incorporated to facilitate comprehension and improve readability.

2.3. Participants and Socialization Activity

The evaluation involved undergraduate students enrolled in the Biology Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Makassar, who voluntarily participated in the BIOMAGIC socialization activity. Participants represented potential stakeholders in campus sustainability and environmental management initiatives. During the activity, information regarding organic waste management, BSF bioconversion technology, and Green Campus principles was delivered using the BIOMAGIC digital flipbook as the primary educational medium.

2.4. Data Collection

Data were collected using structured questionnaires distributed through Google Forms before and after the socialization activity. The evaluation consisted of three components: (1) a pre-test administered before the socialization session to assess participants' prior knowledge of organic waste management, BSF biology, bioconversion processes, frass utilization, and Green Campus concepts; (2) a post-test administered following exposure to the BIOMAGIC flipbook and socialization materials; and (3) a user perception questionnaire designed to evaluate participant responses toward the content, visual presentation, clarity of information, practicality, learning support, and overall usability of the flipbook. The knowledge assessment consisted of 14 multiple-choice questions (Q1–Q14), whereas the perception questionnaire comprised 21 statements (Q16–Q36) measured using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). A total of 35 respondents completed the pre-test, while 21 respondents completed the post-test and perception questionnaire. All responses were automatically recorded and exported from Google Forms for subsequent analysis.

2.5. Data Analysis

Data obtained from Google Forms were exported to Microsoft Excel ver. 2016 for tabulation and descriptive analysis. Knowledge assessment results were summarized using percentages of correct responses for individual questions and overall scores. Mean, median, minimum, and maximum scores were calculated to describe participant performance before and after the socialization activity. Responses to the perception questionnaire were analyzed using frequency distributions, percentages, and mean scores for each statement. Internal consistency of the perception instrument was evaluated using Cronbach's α coefficient, with values greater than 0.70 considered indicative of acceptable reliability. Reliability analysis was performed using Minitab Statistical Software ver. 19.0.

III. RESULT AND DISCUSSION

3.1. Knowledge Assessment across BSF Biology, Waste, and Green Campus Topics

The BIOMAGIC socialization activity combined field observation and classroom-based instruction (**Fig. 1**). Participants were first introduced to BSF cultivation facilities and organic waste bioconversion practices, followed by a socialization session in which concepts of organic waste management, BSF bioconversion, and Green Campus implementation were delivered using the BIOMAGIC digital flipbook as the primary educational medium. A total of 35 participants completed the pre-test assessment, whereas 21 participants completed the post-test assessment (**Table 1**).

Fig. 1. Documentation of the BIOMAGIC socialization activity. (A) Introduction to BSF cultivation facilities and operational components; (B) Observation of BSF bioconversion units and organic waste processing materials; (C) Demonstration and discussion of BSF-based organic waste management practices; and (D) Classroom-based socialization session using the BIOMAGIC digital flipbook as an educational resource on organic waste management, BSF bioconversion, and Green Campus implementation.

Table 1. Descriptive statistics of pre-test and post-test knowledge scores following the BIOMAGIC socialization activity

Parameter	**Pre-test (*n* = 35)**	**Post-test (*n* = 21)**
Number of questions	14	14
Mean score	13.31	13.33
Standard deviation	0.96	0.86
Median	14	14
Minimum score	10	11
Maximum score	14	14
Mean percentage of correct response (%)	95.10	95.24

Table 2. Percentage of correct responses to knowledge assessment items administered before and after the BIOMAGIC socialization activity

Question (Q)	**Pre-test (%)**	**Post-test (%)**	**Change (%)**
Q1	100.0	95.2	-4.8
Q2	100.0	100.0	0.0
Q3	97.1	100.0	+2.9
Q4	97.1	100.0	+2.9
Q5	100.0	100.0	0.0
Q6	85.7	95.2	+9.5
Q7	82.9	85.7	+2.8
Q8	100.0	100.0	0.0
Q9	97.1	100.0	+2.9
Q10	100.0	100.0	0.0
Q11	94.3	90.5	-3.8
Q12	100.0	95.2	-4.8
Q13	77.1	71.4	-5.7
Q14	100.0	100.0	0.0

Results from the descriptive analysis indicated that participants possessed a high level of prior knowledge regarding organic waste management and BSF cultivation before participating in the BIOMAGIC socialization activity. The mean pre-test score was 13.31 out of 14 points (95.1%), while the mean post-test

score was 13.33 (95.24%). Median scores remained at 14 in both assessments, whereas the minimum score increased from 10 in the pre-test to 11 in the post-test. Although total score differences were small, item-level analysis revealed variation among individual knowledge indicators (**Table 2**, **Fig. 2**).

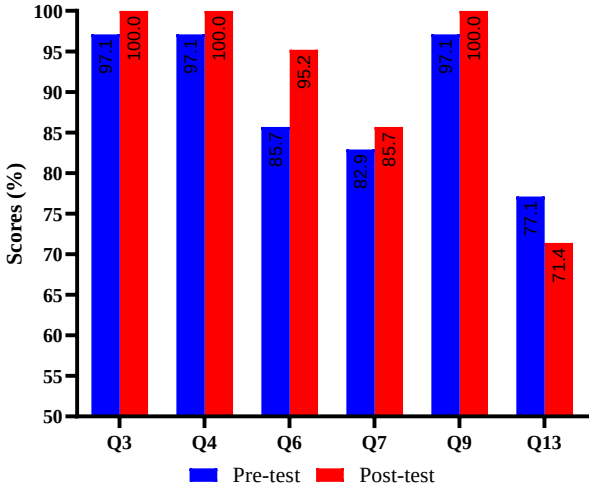

Fig. 2. Percentage of correct responses for knowledge assessment items showing positive changes (Q3, Q4, Q6, Q7, Q9) and the largest decline (Q13) following the BIOMAGIC socialization activity.

The limited difference between pre-test and post-test scores is interpreted in relation to the high baseline performance observed among participants. A prior study has reported that substantial prior knowledge may reduce the magnitude of observable changes in post-intervention assessments because of ceiling effects, even when educational materials reinforce existing concepts and increase topic awareness [13]. In the present study, the high pre-test scores suggest that participants were already familiar with several concepts related to BSF-based organic waste management before exposure to the BIOMAGIC flipbook. The largest increase was observed for Question 6 (Q6), which increased by 9.5% in the post-test assessment. Additional increases were observed for Questions 3, 4, 7, and 9. These questions were primarily associated with BSF biology and cultivation practices, indicating higher post-test response accuracy for several technical aspects of BSF-based waste management. Similar observations have been reported in sustainability education programs in which digital learning resources were used to reinforce environmental concepts and facilitate learner engagement [14]. In contrast, several items displayed lower post-test percentages, with the largest decline observed for Q13, which addressed sustainability and Green Campus concepts. This pattern may indicate that broader sustainability-related topics were more challenging for participants than questions associated with technical aspects of BSF cultivation and bioconversion. Sustainability concepts often involve multiple environmental, social, and institutional dimensions that require systems-based understanding and contextual interpretation from students [15].

Table 3. Participant knowledge levels across thematic content categories before and after the BIOMAGIC socialization program at UNM

Content Category	Question(s)	Pre-test (%)	Post-test (%)
Organic waste knowledge	P1–P3	99.0	98.4
BSF biological characteristics	P4–P7	91.4	95.2
BSF maggot cultivation	P8–P10	99.0	100.0
Frass utilization	P11–P12	97.2	92.9
Green Campus and sustainability-related concepts	P13–P14	88.6	85.7

Note: Percentages represent the mean proportion of correct responses within each thematic content category.

When knowledge indicators were grouped into thematic categories, the BSF cultivation component exhibited the highest post-test performance, reaching 100% correct responses (**Table 3**). Knowledge related to BSF biological characteristics also showed higher post-test percentages. In contrast, indicators related to frass utilization and sustainability principles demonstrated comparatively lower performance. These understandings show that future revisions of BIOMAGIC may benefit from additional explanations

regarding the role of frass as an organic fertilizer and its contribution to circular resource management [16]. Greater emphasis on these topics may strengthen participants' understanding of the relationship between waste bioconversion, resource recovery, and Green Campus implementation.

3.2. User Acceptance and Educational Feasibility of the BIOMAGIC Flipbook

Validity testing was performed using Pearson correlation analysis between the score of each questionnaire item and the total questionnaire score (**Table 4**). The results indicated that all items in the BIOMAGIC flipbook evaluation questionnaire (Q16–Q36) had calculated correlation coefficients (r) greater than the critical correlation value (r = 0.433) at the 5% significance level (n = 21).

Table 4. Validity and reliability test results of BIOMAGIC flipbook

Parameter(s)	Result(s)
Number of items	21
Number of respondents	21
Critical r-value ($\alpha = 0.05$)	0.433
Item validity	All items were valid (r-calculated > r-critical)
Corrected Item–Total Correlation	> 0.30
Cronbach's α	0.767
Reliability category	Good
Interpretation	The instrument was valid and reliable

Reliability analysis indicated that the perception questionnaire possessed acceptable internal consistency for evaluating participant responses toward the BIOMAGIC flipbook. The instrument yielded a Cronbach's α coefficient of 0.767, exceeding the commonly accepted threshold of 0.70 for educational and behavioral study [17]. In addition, all corrected item-total correlation values exceeded the recommended minimum threshold, indicating that each statement contributed adequately to the overall construct being measured. The reliability coefficient decreased when individual items were removed, supporting retention of the complete questionnaire structure. The interface and visual content of BIOMAGIC flipbook is presented in **Fig. 3**. A QR code was provided to facilitate direct access to the flipbook through smartphones and other mobile devices, supporting accessibility and independent learning. Participant responses indicated favorable perceptions of the flipbook as a digital learning resource for BSF-based organic waste management. The overall mean perception score was 4.46 with visual design received the highest ratings (**Fig. 4**).

Fig. 3. Interface and selected content pages of the BIOMAGIC (Bio-Maggot Innovative Guide for Green Integrated Campus) digital flipbook developed using the FlipHTML5 platform (https://online.fliphtml5.com/cfwpmf/Draft-Flipbook-BIOMAGIC-uEPi/index.html).

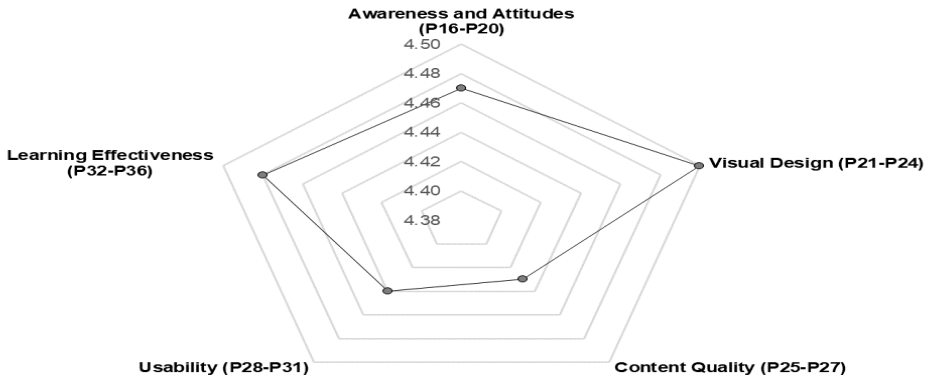

Fig. 4. Radar chart illustrating the mean perception scores of undergraduate biology students toward the BIOMAGIC flipbook across five evaluation dimensions

Participants reported that the illustrations, layout organization, and visual presentation facilitated understanding of the content presented in the flipbook. Similar observations have been reported in studies of digital learning media, where visual elements contribute to information delivery and learner engagement, particularly when communicating environmental and sustainability-related topics [18]. High mean scores were also recorded for content quality and usability. Participants considered the information relevant, understandable, and applicable to issues related to organic waste management and BSF utilization. The positive responses observed in these dimensions are consistent with the prior study indicating that digital learning resources can support independent learning by providing flexible access to educational materials across various digital devices [19].

Accessibility through smartphones, tablets, and computers may have contributed to the favorable evaluations reported in this study. The highest-rated statement was associated with increased awareness of organic waste management, followed by support for implementing BSF-based waste-management programs within the university environment. These findings suggest that participants perceived the information presented in BIOMAGIC as relevant to campus sustainability initiatives. Stakeholder awareness and participation are widely recognized as important components of Green Campus implementation and Education for Sustainable Development (ESD), which emphasize the development of knowledge, attitudes, and engagement related to environmental stewardship [20]. Sustainability-oriented educational interventions were associated with increased environmental awareness and positive attitudes toward environmental management practices [21].

Variation in perception scores was observed among respondents for the individual questionnaire statements (**Fig. 5**). The statement related to increased awareness of organic waste management (Q16) received the highest mean score (4.67), followed by support for the implementation of BSF-based waste management on campus (Q19; 4.62). Several other aspects, including visual design, accessibility, learning effectiveness, and understanding of Green Campus concepts, also received high ratings (4.52). In contrast, the lowest scores were recorded for statements related to prior understanding of BSF (Q18; 4.24) and interest in the topic presented (Q17; 4.29), although both remained within the very good category.

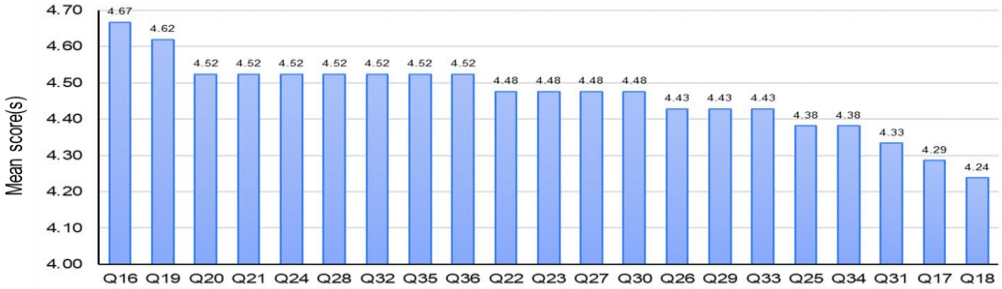

Fig. 5. Ranking of mean participant perception scores for BIOMAGIC evaluation items based on a 5-point Likert scale.

Items Q15 and Q37–Q40 were analyzed qualitatively because they consisted of open-ended questions and were not included in the scoring procedure. Responses to item Q15 indicated that all participants considered BSF-based organic waste management to be potentially applicable within the UNM campus environment. The most frequently cited reason was the availability of abundant organic waste generated from cafeterias, food residues, and various campus activities that could serve as substrates for BSF cultivation. Participants also highlighted the potential benefits of BSF technology in reducing organic waste volume while generating value-added products, including larval biomass for livestock or aquaculture feed and frass for use as an organic fertilizer.

Responses to item Q37 revealed that the primary strengths of the BIOMAGIC flipbook were its attractive visual presentation, accessibility through electronic devices, systematic organization of information, and its ability to facilitate understanding of organic waste management and BSF cultivation concepts. Several participants further noted that the integration of text, images, and visual elements supported independent learning. Responses to item Q38 suggested that the flipbook was generally considered well designed and required only minor revisions. The most common recommendations involved improving readability through adjustments to font size, refinement of page layout, enhancement of illustration quality, and condensation of selected content sections to improve readability and information delivery. Responses to item Q39 indicated that several participants considered the existing material sufficiently comprehensive. Nevertheless, additional suggestions included the incorporation of case studies on BSF implementation, examples of practical applications in daily life, information related to economic and entrepreneurial opportunities, cost-benefit analyses, a glossary of technical terms, and evaluation exercises to reinforce learning outcomes. Regarding future development (Q40), the most frequently proposed improvements focused on increasing interactivity through the inclusion of quizzes, demonstration videos, practice exercises, audio narration, highlighting features, links to supplementary learning resources, and offline-accessible versions of the flipbook. Participant feedback was directed primarily toward improving interactivity and user experience rather than making substantial modifications to the educational content presented. Hence, the findings indicate that BIOMAGIC was well received by undergraduate biology students and may serve as a supporting educational resource for sustainability-related learning activities. By integrating information on BSF bioconversion, organic waste management, and Green Campus principles into a digital format, BIOMAGIC provides an accessible learning medium that can support environmental awareness initiatives within higher education settings.

Several limitations should be considered from this study. First, the evaluation was conducted among undergraduate biology students from a single university, which may limit the flexibility and applicability of the digital module to other academic disciplines, institutions, or stakeholder groups. Second, participant responses were assessed primarily through knowledge assessments and perception questionnaires administered during the socialization activity. Therefore, the current activity reflect short-term responses to the BIOMAGIC flipbook and do not provide information regarding longer-term application of the knowledge or continued engagement with BSF-based waste-management practices.

IV. CONCLUSION

BIOMAGIC demonstrated potential as a digital learning resource for introducing concepts of organic waste management, Black Soldier Fly (*Hermetia illucens*) bioconversion, and Green Campus implementation to university students. Participant responses indicated favorable acceptance of the flipbook, particularly regarding its visual presentation, accessibility, and content organization. The integration of sustainability-related content with practical waste-management concepts suggests that BIOMAGIC can support environmental education and sustainability awareness initiatives within higher education institutions. Further development incorporating interactive learning features and broader evaluations across diverse student populations may enhance its educational utility and applicability in Green Campus programs. Future studies may incorporate larger and more diverse participant groups from multiple institutions to provide a broader evaluation of digital sustainability-learning resources. In addition, longitudinal assessments could be conducted to examine changes in environmental awareness, waste-management practices, and participation

in campus sustainability initiatives following exposure to BIOMAGIC. Those approaches would provide a more comprehensive understanding of the role of digital educational media in supporting sustainability-related learning and engagement within higher education settings.

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