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Enhancing Eco-Facilitator Competencies through Interactive E-Workbook Development: A Study Using the ADDIE Model

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ABSTRACT

This study evaluates the effectiveness of an interactive e-workbook designed to enhance the competencies of eco-facilitators in environmental education. Using a pretest-posttest design, we assessed improvements in key competencies, including facilitating sustainable behaviors, practical environmental skills, and theoretical knowledge. The results show significant increases in posttest scores across all measured domains, with the greatest gains observed in facilitating eco-friendly learning activities and designing sustainable projects. Statistical analyses, including paired t-tests and Cohen's d, confirmed a substantial impact, with an effect size of 39.63, highlighting the e-workbook's practical significance in skill enhancement. User satisfaction and usability assessments revealed high engagement with the content and functional accessibility, though minor areas for improvement were identified. These findings underscore the potential of interactive e-learning tools in supporting eco-facilitators to promote environmental literacy and sustainable practices. This research provides valuable insights into digital education strategies for environmental professionals and suggests opportunities for further refinement and broader application in diverse educational settings.

INTRODUCTION

Environmental issues such as climate change, pollution, and waste accumulation have escalated into global challenges that demand active community participation, particularly in adopting eco-friendly practices at the household level (Shen et al., 2020; Cheng et al., 2022). Eco-facilitators play a vital role within households, guiding and promoting sustainable behaviors that encompass education, program development, and monitoring. Studies indicate that practice-based and interactive digital approaches can significantly influence eco-friendly behaviors by supporting independent learning (Lee & Lee, 2020; Kleinlogel et al., 2023).

Despite numerous educational initiatives, accessible and practical resources for eco-facilitators remain limited, posing a barrier to the consistent implementation of sustainable household practices. The development of interactive e-workbooks that combine text, visual simulations, and feedback mechanisms has been suggested as a practical solution to engage users in eco-friendly practices more effectively (Lipschitz et al., 2019; Fox & Wogowitsch, 2021). By integrating the ADDIE model (Analysis,

Design, Development, Implementation, Evaluation), structured e-workbooks can deliver tailored content, facilitate user engagement, and support hands-on eco-literacy training (Dewy et al., 2024). This study aims to create an interactive e-workbook leveraging the ADDIE model to enhance eco-facilitator competencies in environmental sustainability, encompassing knowledge, practical skills, and evaluation capabilities.

The shortage of user-centered educational resources specific to eco-facilitators challenges efforts to foster household-level environmental sustainability. While digital resources exist, they frequently lack relevance for eco-facilitators, who require practical guidance on implementing and leading eco-friendly initiatives (Balińska, 2022; Champine et al., 2023). Moreover, the scarcity of empirical research on the effectiveness of these resources for household eco-facilitation emphasizes the need for tools specifically designed to support the competencies required in promoting sustainable practices.

To address these limitations, this study proposes an interactive e-workbook based on the ADDIE framework, providing a structured and user-focused platform for eco-facilitators. This e-workbook integrates knowledge and practical activities with multimedia elements that guide users through environmentally responsible practices, enhancing both their understanding and capabilities in eco-facilitation (McCarthy et al., 2024; Zhuang & Wu, 2019). By incorporating features that address practical applications, user engagement, and eco-feedback, the e-workbook aims to facilitate a deeper commitment to sustainable household practices.

The ADDIE model has shown considerable success in structured digital learning interventions, particularly where content needs to be adaptable, interactive, and user-centered. Applying the ADDIE model to interactive learning materials like e-storybooks has proven effective in promoting engagement and comprehension, indicating its suitability for eco-facilitation training tools (Hendratno et al., 2022). The structured approach of ADDIE—incorporating stages of analysis, design, development, implementation, and evaluation—ensures that the e-workbook content aligns with the specific needs of eco-facilitators, supporting both knowledge acquisition and practical application (Dewy et al., 2024).

Eco-feedback mechanisms have also demonstrated efficacy in influencing sustainable behaviors, especially when coupled with real-time interactive feedback. For instance, gamified systems and mission-based storytelling effectively reinforce eco-friendly actions, making these suitable for integration into e-workbooks aimed at fostering sustainable behaviors at the household level (Plichta et al., 2023; Shen et al., 2020). Such tools help bridge the gap between knowledge and action by offering practical insights into energy consumption and other sustainable behaviors.

In addition, green pedagogy, which emphasizes emotional engagement and value exploration, is instrumental in motivating pro-environmental actions (Fox & Wogowitsch, 2021). Incorporating green pedagogy within the ADDIE framework enhances the e-workbook's effectiveness by aligning educational content with the personal values of eco-facilitators. Through scenario-based learning, the e-workbook

encourages users to reflect on their environmental impact, ultimately fostering long-term sustainable behaviors (Lushyn & Sukhenko, 2023).

Although interactive e-workbooks have demonstrated promise in educational fields, their specific impact on eco-facilitator competency remains underexplored. There is limited empirical evidence directly assessing the effectiveness of e-workbooks in improving the skills and practices of eco-facilitators, as most digital interventions focus on broader educational domains rather than specific environmental education contexts (Lipschitz et al., 2019). The lack of targeted research on eco-facilitators creates a gap in understanding how digital tools can be optimized to support eco-friendly household behaviors sustainably.

Further, existing studies emphasize the importance of user engagement in the success of digital learning tools, but how eco-facilitators can be effectively engaged in sustainable household practices through e-workbooks remains inadequately studied (Cheng et al., 2022; Shen et al., 2020). There is also a scarcity of research addressing the environmental impact of digital versus traditional educational tools, highlighting the need to consider the sustainability of e-workbooks from a lifecycle perspective (Kang et al., 2021).

Lastly, despite the potential of immersive and interactive digital tools, the socio-economic and digital literacy disparities among eco-facilitators could impact the practical adoption of e-workbooks. Thus, future research must address these gaps by developing tools that are accessible, engaging, and adaptable to different user needs, ensuring the long-term efficacy of eco-facilitator training (Deng, 2024).

The primary objective of this research is to develop and evaluate an interactive e-workbook based on the ADDIE model, designed to enhance eco-facilitators' competencies in fostering pro-environmental practices within households. This e-workbook integrates educational content with interactive activities, aiming to improve eco-facilitators' knowledge, attitudes, and practical skills in environmental sustainability. By specifically targeting eco-facilitators, this study addresses a previously overlooked area within environmental education, enabling these individuals to lead and model eco-friendly practices effectively.

This study offers novelty through its integration of the ADDIE model and green pedagogy principles within the e-workbook, providing a structured, interactive, and emotionally engaging platform tailored to eco-facilitators. The scope of the study includes eco-facilitators across diverse household settings, with outcomes measured through pre- and post-tests on knowledge, attitudes, and practical environmental skills. Additionally, the e-workbook leverages digital feedback mechanisms and immersive simulations, expanding beyond conventional learning materials to foster sustainable behaviors. This study ultimately contributes to the field of environmental education by introducing a replicable, digitally accessible model for training eco-facilitators, aligning with broader sustainability goals.

METHOD

Materials

The development of the interactive e-workbook for eco-facilitators followed a structured approach based on the ADDIE model—Analysis, Design, Development, Implementation, and Evaluation. This model provided a systematic framework to ensure that each phase of the instructional design process addressed the needs of eco-facilitators.

In the **Analysis** phase, materials were collected based on input from environmental experts and a review of existing literature on household waste management, energy conservation, and sustainable product usage (Sulistyaningrum, 2023). Additionally, interviews with eco-facilitators and community leaders helped ensure that the topics included were context-specific and aligned with practical environmental education goals (Arshad, 2024).

During the **Design** phase, the e-workbook was created with a strong emphasis on user experience. Tools such as Canva and Figma were employed to design an intuitive, visually appealing interface. Workshops with design experts were conducted to integrate interactive elements that would enhance usability and engagement (Daurrohmah, 2023; Azzahrah et al., 2022). The e-workbook incorporated multimedia elements, such as images, videos, and text, to cater to diverse learning styles, which have been shown to be essential for effective e-learning (Fatimah, 2023).

Sample Preparation

The **Analysis** phase also identified the core competencies required by eco-facilitators, which informed the selection of materials for inclusion in the e-workbook. Key topics, such as sustainable household practices, waste reduction techniques, and eco-conscious behaviors, were prioritized to ensure their relevance to the daily practices of eco-facilitators (Bakhrun, 2021). The content was organized to cover both theoretical knowledge and practical skills, making it directly applicable to eco-facilitators' roles in community-based environmental initiatives (Chen & Liu, 2020).

In the **Design** phase, prototypes of the e-workbook were developed and subjected to preliminary testing. This testing focused on navigability and accessibility, allowing for refinements in layout and interactive features to better align with the needs of eco-facilitators (McGuinness & Fulton, 2019). The aim of this phase was to optimize the content structure, ensuring that it facilitated easy comprehension and the practical application of environmental principles.

Experimental Set-up

The **Implementation** phase involved a selected group of eco-facilitators recruited through environmental organizations and local community networks. Participants engaged with the e-workbook over a specified training period, applying the content to community-based environmental projects (Arshad, 2024; Nurhasanah et al., 2022). Training sessions included both individual and group activities, allowing eco-facilitators to practice the competencies they had learned in real-world contexts. Guided exercises reinforced the practical application of these competencies (Putra, 2023).

The e-workbook's interactive features, including quizzes, multimedia content, and discussion prompts, were designed to support active learning and knowledge retention. The technical functionality of the e-workbook was tested across various devices and internet speeds to ensure that all participants could access and benefit from the content, regardless of their location or available technological resources (Azzahrah et al., 2022; Holcomb & Greer, 2020).

Parameters

The primary parameters measured in this study included the usability of the e-workbook, user satisfaction, and improvements in the competencies of eco-facilitators. **Usability** was assessed using the System Usability Scale (SUS), providing quantitative data on the intuitiveness and accessibility of the e-workbook (Bhattacharjya, S., et.al, 2021). **User satisfaction** was measured through surveys that evaluated the relevance of the content, the integration of multimedia elements, and the overall learning experience (Gantasala, V. P., 2021).

Competency improvement was evaluated using pretest and posttest assessments that focused on key areas such as waste management knowledge, eco-design skills, and eco-friendly facilitation techniques. This approach allowed for an analysis of specific competencies, such as facilitation skills and the design of sustainable activities, which align with previous studies on competency development through e-learning (Kim, K., 2021).

Statistical Analysis

To assess the effectiveness of the e-workbook, **paired t-tests** were conducted to compare pretest and posttest scores, providing insight into statistically significant improvements in eco-facilitator competencies. **Cohen's d** was used for effect size analysis, enabling the evaluation of the practical significance of the observed improvements, thereby highlighting the impact of the e-workbook on competency enhancement (Amador-Alarcón et al., 2022). Additionally, qualitative feedback was collected to assess user satisfaction and identify areas for improvement. This feedback provided valuable insights for the iterative refinement of the e-workbook based on user experiences (Adeoye, 2024).

RESULT AND DISCUSSION

Construction of the main content of the E-Workbook

The evaluation of the e-workbook's design and content highlights its effectiveness in enhancing the competencies of eco-facilitators, particularly in promoting sustainable behaviors at the household level. The e-workbook's content is organized into distinct sections, which range from foundational environmental knowledge to advanced skills in facilitation and evaluation, providing a comprehensive learning experience.

Sections 1 to 4 cover basic ecological concepts, attitudes towards sustainability, and practical environmental skills. These sections allowed eco-facilitators to engage with critical topics such as sustainability, plastic pollution, and waste management. The

inclusion of interactive and case-study-driven content was highly valued by users, as it facilitated the application of theoretical knowledge to real-world scenarios.

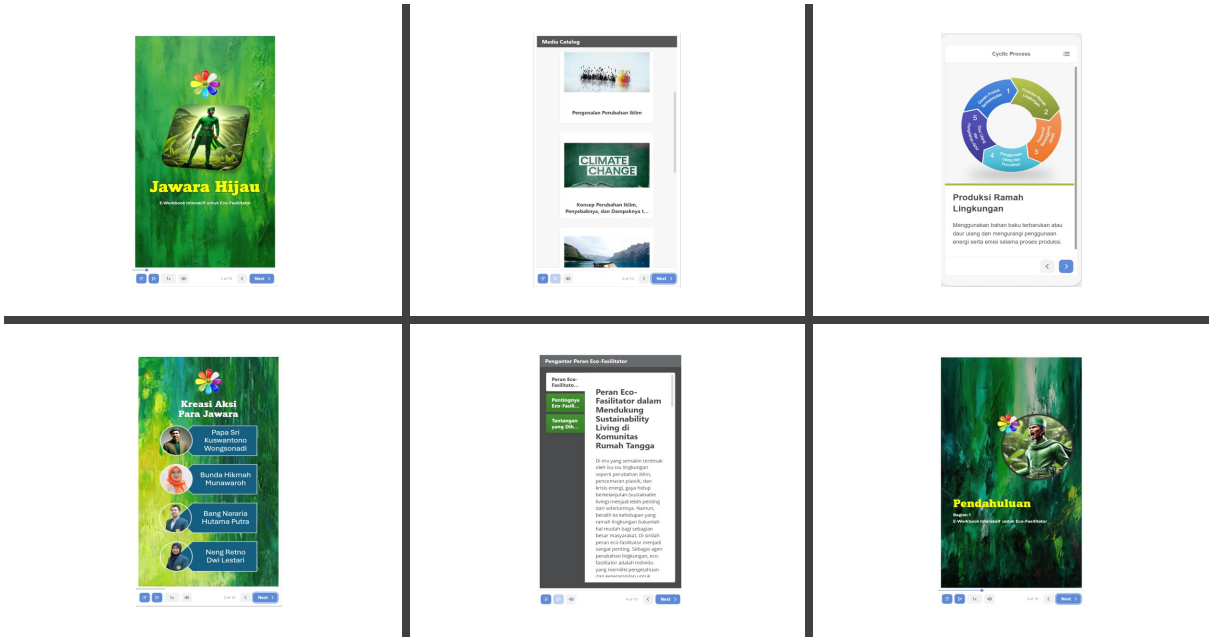

Figure 1. Interactive E-workbook Design

Sections 5 to 8, which focus on competencies related to designing and facilitating environmental activities, equipped eco-facilitators with the necessary tools for effective program implementation. Participants rated the practical exercises within these sections—such as designing sustainable activities and evaluating the effectiveness of environmental programs—highly. These sections emphasized the principles of Green Pedagogy, integrating interdisciplinary approaches and reflective practices that encouraged deeper engagement with sustainability topics. The structure of the e-workbook supported both the development of personal competencies and the practical application of skills in households and communities, in line with findings from previous studies (Rahayu et al., 2022; Cheng & Shiu, 2020).

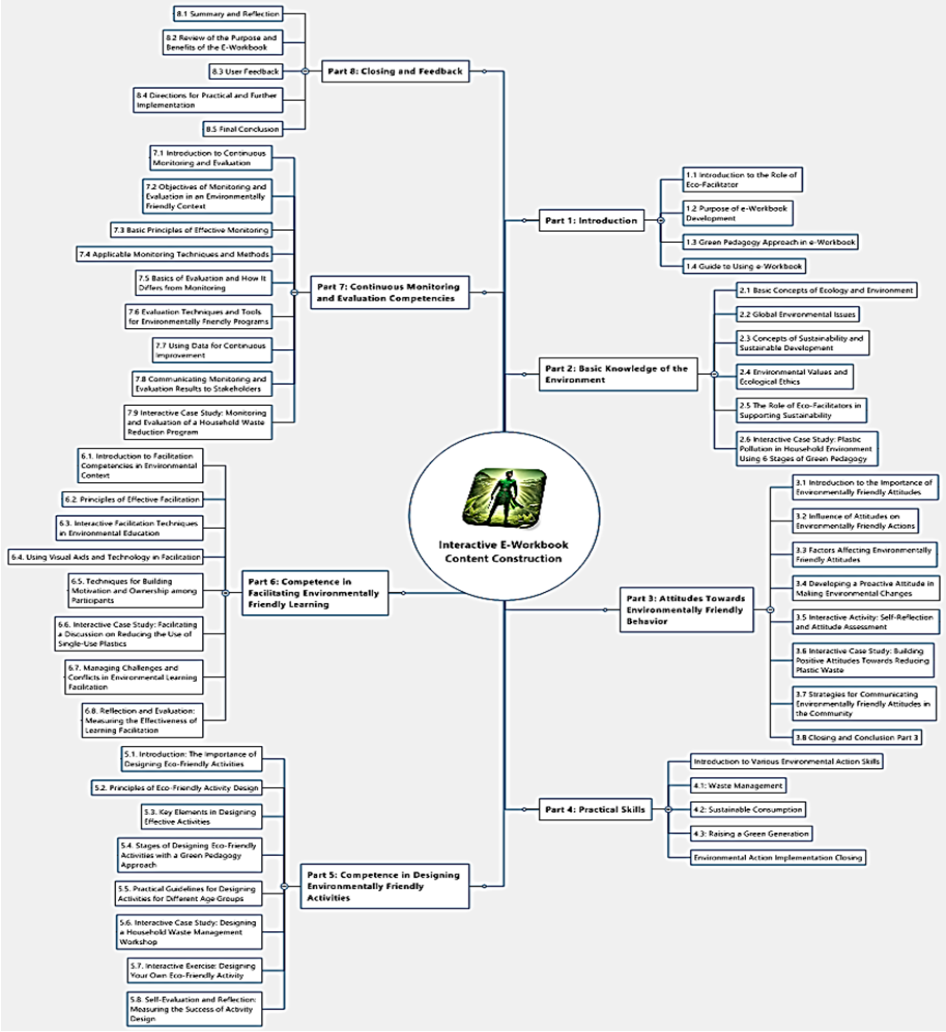

Figure 2. Interactive E-Workbook Content Construction

Results of filling out the Expert Review Checklist and Heuristic Evaluation Form for Eco-Facilitator Interactive E-Workbook

The Expert Review Checklist for the interactive Eco-Facilitator e-workbook revealed significant improvements following two rounds of revisions. In the initial review, the experts identified several weaknesses, including unclear technical language (rated 3), layout issues (rated 3), and poor accessibility (rated 2). The first round of revisions focused on simplifying the language and incorporating illustrations, which enhanced content clarity. Additionally, design adjustments, such as increasing font size and improving image resolution, were made to enhance visual consistency.

Following these changes, the second round of expert evaluations showed substantial improvements. Ratings for clarity and user experience increased to 5, reflecting a more intuitive and user-friendly design. Accessibility was also improved through the addition of better navigation features and support for users with special needs.

The **Heuristic Evaluation** indicated similar progress. In the first round, key usability issues were identified, including low visibility of system status (rated 3), inadequate error prevention (rated 3), and poor user guidance during errors (rated 2).

These issues negatively impacted the user experience, particularly for new users and those with disabilities. After revisions in the second round, improvements were made, including the addition of progress indicators, enhanced error prevention mechanisms, and a more consistent interface design. As a result, usability ratings for these aspects improved significantly.

Usability dan Kepuasan Pengguna

The **System Usability Scale (SUS)** assessment for the interactive e-workbook yielded an average score of 66.19, indicating a moderate level of usability. **Figure 3** shows that statements such as "I am confident that most people can use this e-workbook quickly and easily" and "Various functions in this e-workbook are easy to understand" received some of the highest scores, close to 2.75. This suggests a high level of user confidence in navigating the e-workbook, supporting independent use among participants.

However, lower scores were noted in statements relating to the perceived need for technical support or initial learning, with averages around 2.5. This indicates that further refinements are necessary to simplify the user experience and improve accessibility for new or less tech-savvy users.

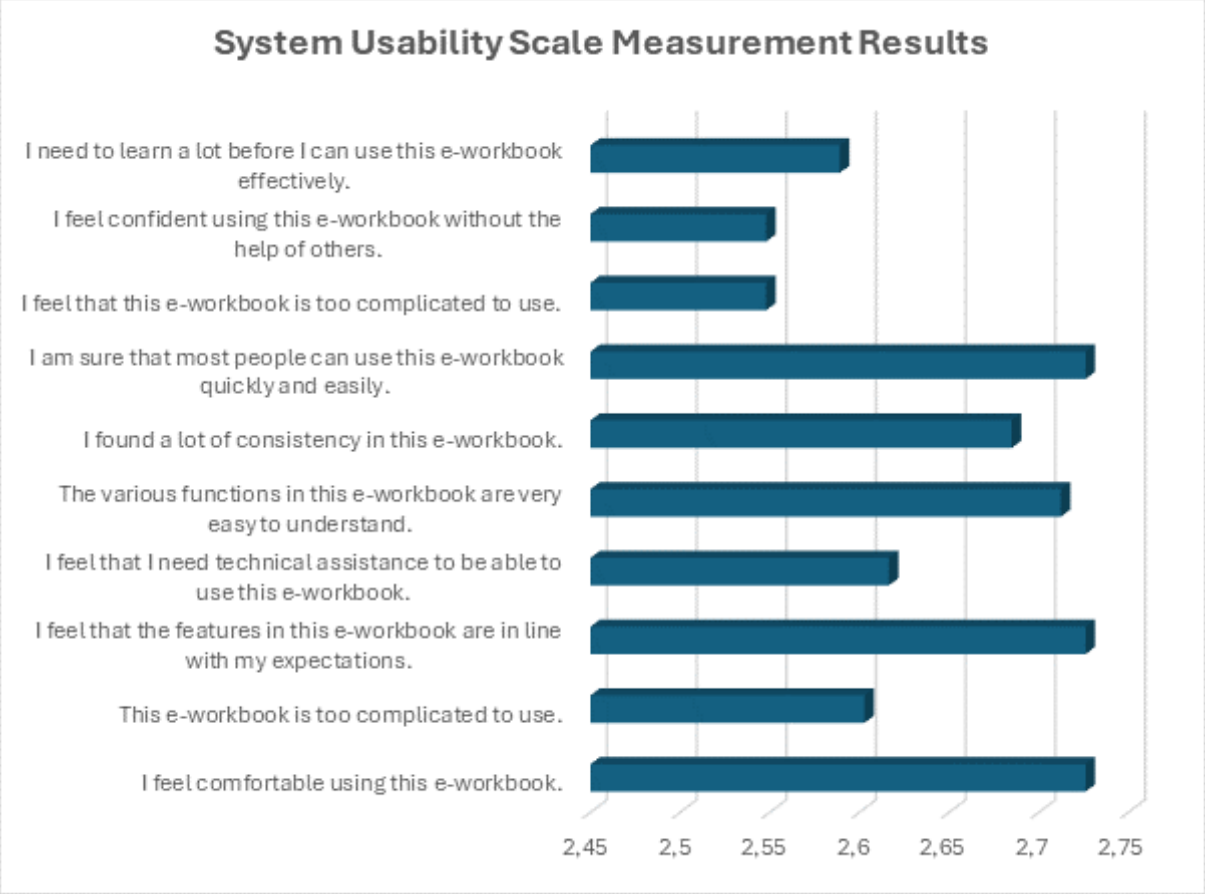

Figure 3. System Usability Scale Measurement Results

User feedback indicated that while most participants found the e-workbook manageable for independent use, some aspects still posed challenges. This aligns with findings in the literature, which emphasize the importance of user-centered design in e-learning tools to achieve a balance between usability and accessibility, especially given the increasing prevalence of online learning platforms (Al-Azawei et al., 2023; Idkhan, 2023). Refining the interface to reduce perceived complexity could make the e-workbook more intuitive and accessible for a wider range of users, improving the overall learning experience (Yudiawan et al., 2022).

The **User Satisfaction** scores for the interactive e-workbook averaged 3.07, indicating a relatively high level of user satisfaction (**Figure 4**). The content aspect received the highest score, around 3.14, reflecting strong approval of the quality and relevance of the material. Functionality also received positive feedback, suggesting that the e-workbook's features effectively supported the user experience. However, **Accessibility** and **Overall Satisfaction** scored lower (2.98 and 3.00, respectively), indicating areas that could benefit from further improvement, particularly in enhancing accessibility for a broader range of users.

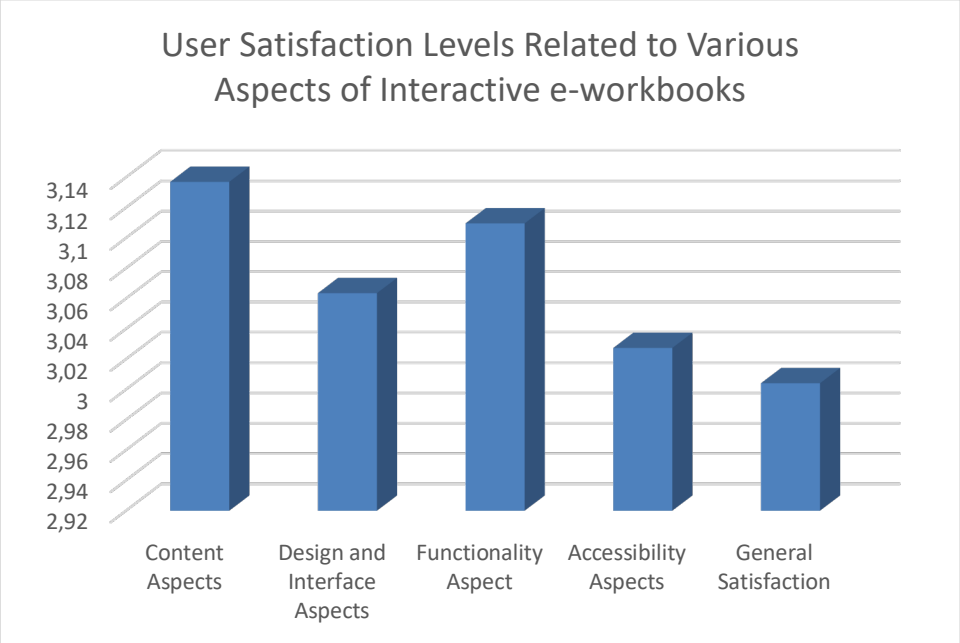

Figure 4. User Satisfaction Levels Related to Various Aspects of Interactive e-workbooks

Interactive E-Workbook Impact Level: Pretest and Posttest

The pretest and posttest analyses demonstrated a substantial improvement in eco-facilitators' competencies following their use of the interactive e-workbook, as shown in **Figure 5**. Posttest scores showed a significant increase across various competency areas, highlighting the effectiveness of the e-workbook as a training tool.

The most significant improvement was observed in the competency of "Facilitating Learning on Environmentally Friendly Practices," which increased from 1.59 in the pretest to 2.58 in the posttest. This suggests that eco-facilitators gained greater

confidence and skill in promoting environmentally responsible behaviors, a critical aspect of their role in community education.

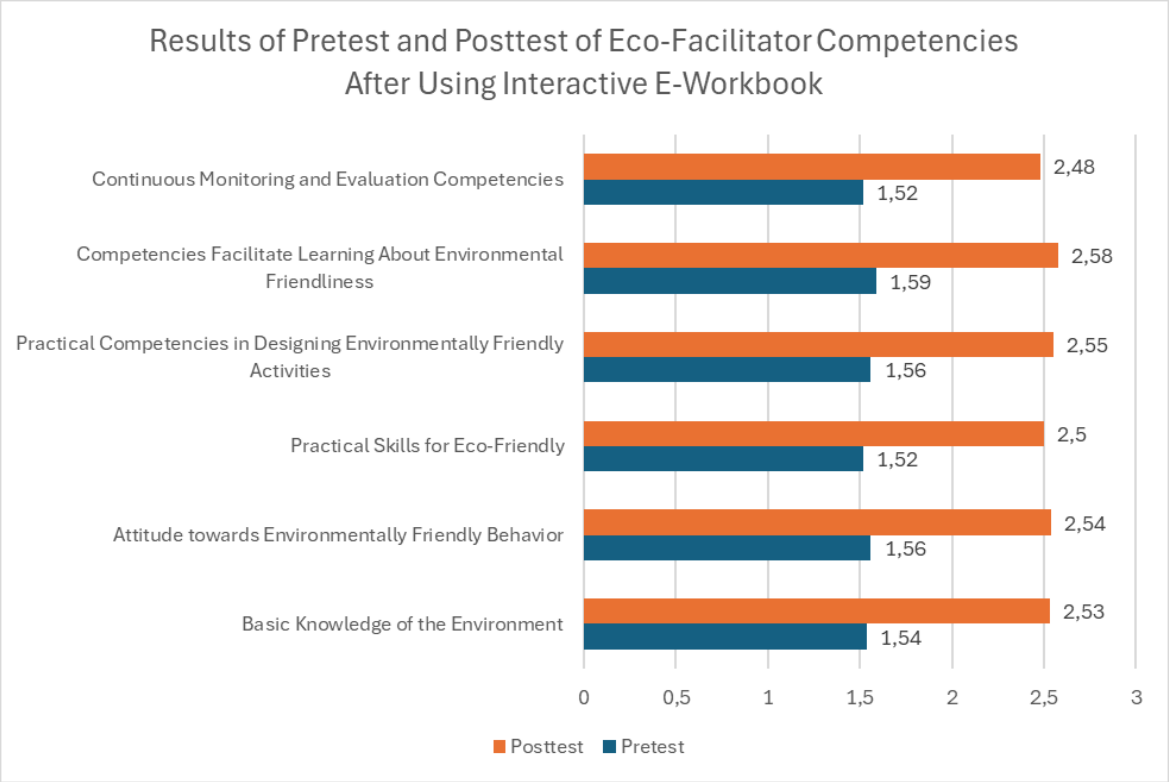

Figure 5. Results of Pretest and Posttest of Eco-Facilitator Competencies After Using Interactive E-Workbook

Similarly, the competency of "Designing Environmentally Friendly Activities" showed significant improvement, with scores rising from 1.56 to 2.55. This increase indicates that eco-facilitators' ability to create engaging, sustainable activities was enhanced. These findings are consistent with research supporting the effectiveness of interactive e-learning tools that integrate real-world simulations and practical exercises in developing essential skills for sustainability (Ozis et al., 2022; Gavrilas, 2024).

Overall, the results underscore the potential of interactive digital tools, such as the e-workbook, not only for conveying theoretical knowledge but also for enhancing the practical competencies required for effective environmental education and community facilitation.

DISCUSSION

Aligning Interactive E-Workbook Design with Green Pedagogy and Eco-Innovation

The design and implementation of the e-workbook align closely with the principles of Green Pedagogy, emphasizing learner-centered and interdisciplinary approaches to environmental education. This study demonstrates that interactive e-workbooks offer an effective platform for eco-facilitators to engage learners in content that is both stimulating and tailored to their needs (Rahayu et al., 2022). Previous research

has highlighted the ability of digital workbooks to promote collaboration and critical thinking, which are crucial for fostering sustainable behaviors at the household level (Rahayu et al., 2022). By embedding concepts like sustainability and eco-innovation into the e-workbook's framework, eco-facilitators are equipped to offer not only theoretical knowledge but also actionable solutions to everyday environmental challenges, in line with findings by Ilic et al. (2022) and Cheng & Shiu (2020).

The interactive and adaptive nature of the e-workbook distinguishes it from other digital tools in environmental education. Whereas some previous studies have emphasized the importance of static content delivery, this e-workbook encourages active learner participation through dynamic elements like simulations and reflective exercises, thus enhancing engagement (Burkhart & Craven, 2020). Furthermore, the e-workbook's flexibility in accommodating diverse learning styles is integral to fostering long-term behavioral changes (Khadka, 2023). These features, combined with the principles of Green Pedagogy, position the e-workbook as a robust tool for advancing eco-innovation and nurturing pro-environmental behaviors within households.

From both a scientific and practical perspective, these findings are significant for the advancement of environmental education. The e-workbook's success in engaging eco-facilitators and improving their competencies underscores the potential of interactive digital tools to catalyze behavioral change at the household level. Scientifically, this study contributes to the growing body of literature on the role of digital tools in promoting sustainable practices (Burkhart & Craven, 2020; Khadka, 2023), demonstrating the positive impact of e-learning on engagement and knowledge retention. Moreover, by integrating Green Pedagogy and eco-innovation, the e-workbook enhances ecological understanding and empowers learners to implement sustainable practices, such as waste management and energy conservation, in their daily lives.

On a practical level, the e-workbook presents a scalable solution for eco-facilitators, enabling them to reach a broad audience with customized, self-paced learning materials. Its emphasis on collaboration, experiential learning, and reflective practice provides a strong framework for engaging household members in sustainability discussions. The personalized learning paths offered by the workbook ensure that eco-facilitators can address the unique challenges faced by households in different socio-economic contexts, thereby enhancing its applicability across diverse local settings. This adaptability, coupled with a focus on promoting eco-innovation, positions the e-workbook as a valuable resource in ongoing efforts to reduce environmental impact at the household level (Martínez et al., 2020; Shahbaz et al., 2022).

Enhancing E-Learning Tools for Environmental Education and Engagement

The findings from this study align with broader trends in the development of e-learning tools, particularly within the field of environmental education. Previous research, such as that by Madani et al. (2017), underscores the importance of clarity in educational content, a factor that was significantly improved in this study through language simplification and the incorporation of illustrative elements. This aligns with Beça et al. (2022), who assert that such adjustments can improve user engagement by making

material more accessible. The enhancement of interactivity, particularly through practical exercises and simulations, echoes the work of Vázquez-Vílchez et al. (2021), who note that interactive features not only deepen learning but also foster critical thinking—skills that are essential for addressing environmental challenges.

The improvements in usability, such as enhanced navigation and system status visibility, are consistent with usability principles outlined by Ismail et al. (2022), who emphasize the importance of intuitive design to reduce cognitive load and improve user experience. Unlike earlier designs that relied on static content, the interactive e-workbook features dynamic elements, such as simulations and quizzes, which actively engage users and support critical thinking. This user-centered approach is in line with McCarthy et al. (2021), who advocate for tailoring digital tools to meet diverse learner needs. Additionally, the inclusion of accessibility features, such as text resizing and high-contrast modes, aligns with the best practices suggested by Meskhi et al. (2019), highlighting the need for inclusivity in educational technology.

This study demonstrates the importance of iterative design and usability testing in creating effective e-learning tools. The significant improvements in content clarity and usability indicate that the revisions addressed key issues that hindered user engagement and comprehension. These enhancements—such as the addition of interactive elements and improvements to accessibility—make the tool more effective for a broader audience, ensuring that it aligns with the best practices in environmental education. The results emphasize that thoughtful design, such as simplifying language, improving visual clarity, and optimizing navigation, can significantly improve the user experience.

The practical implications of these findings extend beyond the specific context of the Eco-Facilitator e-workbook. The study provides valuable insights for the design of other interactive educational tools aimed at fostering environmental awareness and action. Clear content, engaging interactions, and accessibility features are all critical for reaching a wide audience, including users with disabilities. These design improvements are likely to enhance the retention of environmental knowledge and promote greater pro-environmental behaviors, as supported by Barnason et al. (2022). In summary, this study contributes to the growing body of knowledge on effective e-learning design in environmental education and underscores the significance of continuous refinement through user feedback and heuristic evaluation.

User Satisfaction and Usability Insights for Interactive E-Workbook Improvement

User satisfaction with the interactive e-workbook was measured with an average score of 3.07, indicating generally high satisfaction among users. The content aspect scored the highest, with an average of 3.14, suggesting strong approval of the workbook's quality and relevance. This aligns with the importance of high-quality content, which enhances user engagement and educational impact (Fauziah, 2023; Yunior, 2024). The functionality of the e-workbook also received positive feedback, indicating that its features effectively support the learning experience.

However, aspects related to accessibility and overall satisfaction received slightly lower scores (approximately 2.98 and 3.00, respectively), signaling areas for further

improvement. These findings are consistent with research that emphasizes the need for accessibility in e-learning platforms to ensure inclusivity and enhance user retention (Idkhan, 2023; Sandiwarno, 2021). Improving accessibility features, such as adjustable fonts, alternative text, and high-contrast modes, could make the e-workbook more inclusive and improve engagement for diverse user groups.

Insights derived from the System Usability Scale (SUS) evaluations suggest several actionable improvements. Lower scores in areas like perceived complexity and the need for technical support indicate that simplifying navigation and providing clearer visual cues could reduce user confusion (Pal & Vanijja, 2020). By enhancing intuitive navigation and streamlining content organization, developers can improve user satisfaction and reduce reliance on external assistance, making the tool more accessible for a wider range of users (Deshmukh, 2024).

The feedback further underscores the value of adaptive improvements. For example, continuous monitoring of SUS scores can guide iterative development, addressing usability gaps and improving user-friendliness over time (Junaedi, 2023). Implementing training resources or tutorials may also alleviate user difficulties with specific functions, thus creating a smoother, more accessible learning experience. This adaptive approach aligns with best practices in e-learning design and can contribute to sustained user satisfaction and engagement (Arinze, 2023; Hyzy et al., 2022).

Competency Improvements and Statistical Validation of Interactive E-Workbook Effectiveness

All measured competencies showed improvement following the use of the interactive e-workbook, although the magnitude of these improvements varied across different areas. For instance, "Competency in Monitoring and Continuous Evaluation" displayed a relatively modest increase from 1.52 in the pretest to 2.48 in the posttest. While statistically significant, this suggests that eco-facilitators may require additional training or resources to fully develop their skills in monitoring and evaluation, which are vital for assessing the effectiveness of environmental education programs. This aligns with existing research that underscores the complexity of monitoring and evaluation in environmental education (Chan et al., 2020).

Other competencies, such as "Practical Environmental Skills," "Attitude Towards Environmental-Friendly Behavior," and "Basic Environmental Knowledge," improved by approximately one point from pretest to posttest. This consistent improvement across competencies suggests that the e-workbook effectively provides a holistic approach to environmental education, enhancing both theoretical knowledge and practical skills (Abbad, 2021). This comprehensive development indicates that the e-workbook is a valuable tool for preparing eco-facilitators to address various aspects of environmental education, from foundational knowledge to skill application.

Statistical analysis, including a paired t-test, further confirmed the effectiveness of the e-workbook in improving competencies. The paired t-test results revealed a t-value of -340.90 and a p-value of less than 0.001, indicating a statistically significant improvement from pretest to posttest scores. This high level of significance supports the

conclusion that the e-workbook effectively enhanced participants' competencies. The use of pretest and posttest comparisons is well-established in environmental education research, as it provides a reliable method for assessing knowledge and skill improvements (Banerjee et al., 2021; Wang, 2024).

Moreover, the effect size calculated using Cohen's d (approximately 39.63) is exceptionally high, confirming the substantial impact of the e-workbook in fostering competency improvements. These findings suggest that the interactive e-workbook can be a powerful tool for training eco-facilitators and promoting sustainable behaviors. The statistically significant improvements in competency scores align with previous research showing the positive impact of digital tools on environmental education outcomes (Cochrane, 2022; Wilson et al., 2023).

CONCLUSION

The interactive e-workbook has proven to be a highly effective tool for enhancing eco-facilitators' competencies across various domains of environmental education. Analysis of pretest and posttest results demonstrated statistically significant improvements in key skills, particularly in facilitating environmentally responsible behaviors and designing sustainable activities. These improvements were further validated by a large effect size, underscoring not only the statistical significance of the findings but also their practical relevance, highlighting the substantial impact of the e-workbook on participants' learning outcomes.

Beyond building practical competencies, the e-workbook offered a flexible and accessible training method that effectively meets the needs of facilitators, particularly in diverse and potentially remote settings. By incorporating interactive elements and real-world scenarios, the e-workbook facilitated active learning, enhancing facilitators' confidence and competence in their roles. This study underscores the growing importance of digital tools in environmental education, suggesting that interactive e-learning platforms have significant potential for advancing eco-literacy and fostering sustainable skills on a larger scale.

Future research could explore the broader application of this approach to other environmental competencies and diverse learner groups, further expanding the scope and impact of digital tools in fostering sustainable practices across different contexts.

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