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Implementing gamification-based training for sustainable agriculture: The "Tani Cerdas" application for women farmer groups

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ABSTRACT

This study examined the implementation, user acceptance, and perceived learning benefits of a gamification-based agricultural training application for Women Farmers' Groups (WFGs). An ADDIE-based research and development approach was employed, focusing on implementation and evaluation. Thirty WFG members in Bejiharjo Village, Indonesia, participated in blended learning activities. Data were collected through questionnaires and interviews, guided by Kirkpatrick and CIPP evaluation frameworks, and analyzed descriptively and thematically. Participants reported favorable application usability, with mean scores of 4.55 for navigation, 4.45 for instructional clarity, and 4.35 for visual presentation. All indicators exceeded 4.00 on a five-point scale. Participants perceived improvements in agricultural understanding and readiness to explore sustainable practices. The application demonstrated promising acceptance and potential for supporting non-formal agricultural education. However, self-reported outcomes and the absence of a comparison group limit effectiveness claims, requiring further objective and longitudinal evaluation.

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Introduction

Women Farmer Groups (Kelompok Wanita Tani/KWT) play an important role in household-scale farming, particularly in supporting family food security, utilizing local resources, and maintaining agricultural practices at the village level. Their involvement extends beyond agricultural production to decision-making concerning crop selection, harvest management, and the utilization of household yards for food cultivation. However, the extent to which KWT members can contribute to sustainable agricultural practices depends, among other factors, on their access to relevant learning opportunities and their capacity to apply agricultural knowledge in practice. The Food and Agriculture Organization (2017) emphasizes the importance of strengthening women's access to agricultural knowledge and resources to support their participation in agricultural development. In the context of KWT in Bejiharjo Village, Gunungkidul Regency, the availability and relevance of training, as well as members' understanding and application of sustainable agricultural practices, therefore warrant empirical examination. Investigating these aspects is essential to identifying the learning needs of KWT members and determining how a context-sensitive training model can support their capacity to respond to contemporary agricultural challenges, including environmental sustainability and climate change.

Agricultural training for Women Farmer Groups (Kelompok Wanita Tani/KWT) requires a learning approach that accommodates the specific social, economic, and agricultural contexts in which women farmers participate. As adult learners, KWT members bring diverse farming experiences, practical knowledge, and locally grounded problem-solving strategies that can serve as valuable resources for collaborative learning. However, their learning needs extend beyond the acquisition of agricultural knowledge and technical skills to include the practical application of sustainable farming techniques, household-based agricultural management, product development, and access to marketing opportunities. Furthermore, the combination of agricultural activities with domestic and other productive responsibilities may create time constraints that need to be considered when designing training programs. Research on women farmer groups in Indonesia has highlighted the importance of meaningful participation, access to relevant agricultural information, and opportunities to exchange experiences and develop practical competencies. Suryana et al. (2024), for example, emphasized the importance of strengthening women's involvement in agricultural extension through relevant training, improved information access, and collaborative learning opportunities. Similarly, research by Riski et al. (2025) identified limited training opportunities and difficulties in managing time alongside other responsibilities as factors that can constrain KWT members' participation in agricultural extension activities. These findings suggest that agricultural training for KWT should be designed around learners' existing experiences, practical needs, and opportunities to apply newly acquired knowledge in their everyday farming activities. Accordingly, andragogy provides a relevant pedagogical foundation because it emphasizes the use of learners' experiences, the relevance of learning to real-life situations, and problem-centered learning (Knowles et al., 2015).

Despite these specific learning needs, conventional agricultural training that predominantly relies on one-way delivery of information may not provide sufficient opportunities for KWT members to actively engage in problem-solving, reflect on their farming experiences, and collaboratively develop contextually appropriate solutions. This concern is consistent with research on women's participation in agricultural extension in Indonesia. Fatonah et al. (2024) found that the development of KWT as learning classes, production units, and platforms for cooperation was associated with members' motivation and participation, as well as the roles of extension agents as educators, facilitators, and motivators. These findings underscore the importance of learning environments that go beyond information dissemination and actively support member participation, facilitation, and the practical development of agricultural competencies. In the context of sustainable agriculture, such an approach is particularly important because adopting environmentally friendly farming practices requires not only knowledge acquisition but also changes in attitudes, practical skills, and everyday farming behavior. Therefore, an innovative training model is needed to integrate experiential and participatory learning with contextual agricultural problem-solving. Gamification offers a potential strategy for supporting this approach by incorporating game elements into training activities to encourage active participation, provide feedback on learning progress, and sustain learner motivation. Grounded in adult learning principles, this model is expected to help KWT members connect agricultural knowledge with practical experience and strengthen their capacity to adopt sustainable farming practices.

The advancement of digital technology has created new opportunities for developing more participatory, interactive, and adaptive agricultural training models. One approach that has gained increasing attention is gamification, defined as the integration of game design elements and mechanics into non-game contexts to enhance user motivation, engagement, and learning experiences (Deterding et al., 2011). Beyond its conceptual foundations, empirical studies have demonstrated the potential of gamification in agricultural education and extension. For instance, Osiemo et al. (2025) found that experiential learning through incentivized games increased smallholder farmers' knowledge more effectively than conventional narrative-based extension approaches. Similarly, De Graeuwe et al. (2025) demonstrated that a serious game-based agroecology learning intervention could improve participants' knowledge within a relatively short instructional period. These findings indicate that gamification can serve not merely as an engaging instructional strategy but also as a means of facilitating agricultural knowledge acquisition and experiential learning.

The contribution of gamification to agricultural training can be understood through the interaction between specific game elements and learning mechanisms. Points and achievement systems provide immediate reinforcement and encourage participants to complete learning tasks, while levels and progressive challenges structure the acquisition of knowledge and skills from basic to more complex agricultural practices. Badges can function as indicators of competency achievement, whereas leaderboards and collaborative activities stimulate social interaction, peer learning, and collective participation. When these elements are integrated with contextual agricultural tasks, such as organic fertilizer production, eco-enzyme processing, environmentally responsible cultivation, and digital marketing of agricultural products, participants are encouraged to connect theoretical knowledge with practical decision-making. This mechanism is particularly relevant to sustainable agriculture because competency development requires not only an understanding of environmentally friendly practices but also the ability to apply, evaluate, and maintain these practices in everyday farming activities. Nevertheless,

recent reviews of serious games in agriculture emphasize the need for more systematic assessments of their actual effects on learning and real-world agricultural practices (Dernat et al., 2025).

Despite these developments, empirical evidence concerning the implementation of gamification in community-based agricultural training remains limited, particularly among Women Farmers Groups (Kelompok Wanita Tani/KWT). Existing studies have primarily examined agricultural education, farmer information systems, or serious games in specific learning contexts, leaving the integration of gamification into structured community training models insufficiently explored. Therefore, this study addresses this gap by examining the implementation and evaluation of a gamification-based agricultural training model for KWT to support sustainable agriculture. Specifically, the study investigates the model's implementation, effectiveness, and acceptability in facilitating participants' knowledge acquisition, practical skills development, and motivation to adopt sustainable agricultural practices.

The first-year Research Group (RG) study resulted in a needs analysis of Women Farmers Groups (Kelompok Wanita Tani/KWT), the design of an agricultural gamification-based training model, and the development of an application prototype tailored to the characteristics of adult learners and the local agricultural context. These outputs provided an initial conceptual and technological foundation for the proposed training model. However, the development phase primarily focused on needs identification, model design, and prototype development, while systematic empirical evidence regarding the prototype's validity, feasibility, and usability in actual KWT learning settings remained limited. In particular, the extent to which the application's features, learning content, and gamification mechanisms align with users' needs and support the implementation of agricultural training had not yet been fully established. Consequently, the availability of a developed prototype alone was insufficient to establish the practical feasibility and effectiveness of the training model. Further implementation and empirical evaluation were therefore necessary to examine its applicability under real field conditions, its effectiveness in improving KWT members' knowledge and skills, and its acceptability among target users. Building on the first-year development outcomes, the second-year study focuses on implementing the agricultural gamification-based training model and conducting a comprehensive evaluation of its implementation process and outcomes, particularly in terms of implementation fidelity, learning effectiveness, and technology acceptance.

Based on this background, this study addresses three research questions: (1) how is the agricultural gamification application implemented within the KWT training model; (2) how effective is the training model in improving participants' knowledge and skills related to sustainable agriculture; and (3) how do KWT participants perceive and accept the application and the overall training model? To address these questions, this study employed a Research and Development (R&D) approach using the ADDIE framework (Branch, 2009), with particular emphasis on the Implementation and Evaluation stages. The Implementation stage focused on examining the practical application of the gamification-based training model through training activities, mentoring, and monitoring. This process documented the extent to which the training was delivered as planned, participants' engagement with the application, and challenges encountered during implementation (Davis et al., 2018). The Evaluation stage was designed to address the second and third research questions through formative and summative assessments. Formative evaluation was conducted throughout the training process to identify implementation challenges, monitor participant engagement, and provide feedback for improvement. Meanwhile, summative evaluation assessed training effectiveness by examining changes in participants' knowledge of sustainable agriculture principles and their practical skills in applying relevant agricultural practices. Knowledge improvement was assessed through participants' understanding of sustainable agriculture concepts, including environmentally friendly farming practices, organic fertilizer production, and eco-enzyme utilization. Skills improvement was examined through their ability to apply these practices in relevant training activities. In addition, participants' acceptance and responses to the gamification application and training model were assessed based on their perceptions of usability, clarity of instructions, visual presentation, engagement with gamification features, and perceived benefits for learning and agricultural practices. This methodological integration enabled the study to examine not only the implementation process but also the learning outcomes and participants' acceptance of the developed training model (Landers, 2014).

Research on the application of gamification and game-based learning in agricultural education has demonstrated their potential to support farmer engagement, knowledge acquisition, and the adoption of improved agricultural practices. For instance, Handayati et al. (2021) developed a game-based learning approach to increase rice farmers' awareness of agricultural mechanization and found that its relevance and effectiveness varied according to farmers' educational backgrounds and learning characteristics. Similarly, Sutoyo and Sensuse (2023) explored the integration of gamification into an agricultural information system to encourage farmer participation, highlighting the potential of game elements to address motivational challenges, although the proposed system had not yet been fully implemented. In a broader context, Tham-Agyekum et al. (2025), through a

systematic review of 23 studies published between 2017 and 2024, identified the contributions of gamification in agricultural extension to motivation, engagement, knowledge retention, behavioral change, and collaborative learning. These findings indicate that gamification offers promising opportunities for agricultural learning and extension; however, its implementation requires adaptation to participants' characteristics, learning needs, and local agricultural contexts.

Despite these developments, the existing literature reveals several areas that require further investigation. Studies on gamification in agriculture have predominantly examined specific learning interventions, technology adoption, agricultural information systems, or extension activities, rather than integrating gamification into a comprehensive non-formal training model for community-based women's agricultural groups. Meanwhile, research on the empowerment of Women Farmers' Groups (Kelompok Wanita Tani/KWT) through non-formal education has emphasized capacity development, participation, entrepreneurship, and women's empowerment, with less attention to the integration of digital gamification as a structured learning strategy (Zaetun et al., 2026). Furthermore, the systematic review conducted by Dernat et al. (2025), which examined 237 publications on serious games in agriculture, highlighted the need for stronger empirical assessments of their real-world impacts and contributions to sustainable agricultural transitions. Taken together, these studies suggest a research gap concerning the integration of digital gamification, non-formal education principles, and women's empowerment within a structured agricultural training model, particularly in the context of KWT.

Addressing this gap, the present study focuses on the implementation and evaluation of an agricultural gamification application integrated into a non-formal education-based training model for KWT. Unlike previous studies that primarily examined game-based learning interventions, agricultural information systems, or women's empowerment programs separately, this study investigates their integration within an actual community-based training context. Using the continued application of the ADDIE framework, the study examines the implementation process, training model feasibility in practice, user acceptance, learning experiences, and perceived contributions to participants' knowledge, skills, and motivation toward sustainable agricultural practices. Thus, the study contributes empirical evidence on the applicability of digital gamification as an integrated learning strategy in non-formal agricultural education and provides insights into its potential for strengthening the capacity and empowerment of women farmers.

Building on the development of an agricultural gamification training model and its supporting application, this study focuses on examining how the model is implemented and evaluated in the context of KWT empowerment. While digital technologies and gamification have increasingly been introduced in agricultural learning and extension activities, their integration into structured training models specifically designed for women farmers remains an area that requires further investigation. In particular, understanding how gamification elements can be implemented to facilitate learning, enhance participant engagement, and support the development of knowledge and practical skills related to sustainable agriculture is essential. Therefore, this study investigates the implementation of an agricultural gamification training model among KWT members, focusing on its feasibility in practice, effectiveness in supporting learning outcomes, and acceptability among participants. The findings are expected to contribute empirical evidence to the development of technology-supported agricultural training approaches that are participatory, context-sensitive, and oriented toward sustainable agriculture and women's empowerment.

Method

Research Design

This study employed a Research and Development (R&D) approach guided by the ADDIE framework (Branch, 2009). In the second year, the research focused specifically on the Implementation and Evaluation stages, building upon the agricultural gamification training model developed during the first year. While ADDIE provided the overarching framework for implementing and evaluating the developed model, an empirical evaluation design was incorporated to assess its effectiveness in improving participants' learning outcomes and competencies. The evaluation focused on examining changes in participants' knowledge, practical skills, and learning motivation following their participation in the gamification-based agricultural training program. Data were collected through structured assessments administered before and after the intervention, complemented by observations of the training implementation and participants' responses to the application. In addition, the usability and acceptance of the application were assessed to examine its practicality and relevance as a digital learning medium. This evaluation strategy was intended to provide empirical evidence regarding the feasibility, effectiveness, and acceptance of the developed training model, while distinguishing the contribution of the digital gamification application from the broader effects of the training intervention.

Subjects and Research Location

The participants in this study consisted of 30 members of a Women Farmer Group (Kelompok Wanita Tani/KWT) in Bejiharjo Village, Gunungkidul Regency, Special Region of Yogyakarta. The participants were selected using a total sampling technique, in which all eligible members of the participating group were included in the study. This approach was adopted because the study focused on the implementation and evaluation of an agricultural gamification training model within a specific community-based farming group. The inclusion criteria were active membership in the KWT, involvement in agricultural activities, and willingness to participate in the training and research activities. The training was conducted on April 9, 2026, at the Banyubening II Hamlet Hall. Given that the study involved participants from a single KWT, the findings should be interpreted within the context of the participating group and may not be directly generalized to other KWTs or broader populations. Nevertheless, the findings provide contextual insights into the implementation, acceptability, and potential effectiveness of the gamification-based agricultural training model at the community level.

Research Procedure

The research procedure consisted of five stages, beginning with implementation preparation and followed by training implementation, mentoring and monitoring, formative evaluation, and summative evaluation. The main implementation activities were conducted from April 1–9, 2026, with additional follow-up monitoring designed to examine the sustainability of participants' learning outcomes and behavioral changes after the training.

The first stage involved implementation preparation, including the finalization of training materials, technical adjustments to the application based on the preliminary testing results from the first-year study, coordination with the partner Women Farmers Group (Kelompok Wanita Tani/KWT), and the development of research instruments. These instruments included pre-test and post-test questions, a perception and satisfaction questionnaire, an observation checklist, and a semi-structured interview guide. In addition, a standardized implementation guideline was established to ensure consistency in the delivery of training materials, learning activities, facilitator roles, and application-based assignments across all participant groups.

The second stage involved the implementation of the agricultural gamification training model for KWT members through structured learning sessions combining face-to-face instruction with independent and group-based application activities. Each session was organized according to a predetermined schedule and duration, consisting of material presentation, demonstrations, guided application practice, group discussions, and learning tasks. Participants were encouraged to access and use the application throughout the training period to complete learning activities, respond to challenges, collect points, and progress through the gamification levels. The learning materials focused on sustainable agriculture principles, environmentally friendly land management, the utilization of local resources, and simulation-based agricultural decision-making. Researchers and team members served as facilitators, following the same instructional guidelines and learning procedures to maintain treatment consistency.

The third stage consisted of mentoring and monitoring, which were conducted throughout the training implementation. This stage aimed to assist participants in overcoming technical difficulties and understanding the learning materials while monitoring their engagement and intensity of application use. Monitoring was carried out through direct observation, field notes, activity documentation, and application activity records. These procedures provided information on participants' attendance, task completion, participation in group activities, and engagement with gamification features. Following the completion of the training, follow-up monitoring was conducted to examine the extent to which participants applied the knowledge and skills acquired during the training in their agricultural practices. This follow-up assessment focused on observable changes in agricultural practices, particularly the adoption of environmentally friendly cultivation methods, the utilization of local resources, and the implementation of sustainable agricultural activities.

The fourth stage involved formative evaluation, which was conducted during the implementation process to identify weaknesses in the training model, participants' responses, and technical and pedagogical aspects requiring improvement. The findings were used to document implementation challenges and assess the extent to which the training activities were delivered according to the established guidelines.

The fifth stage involved summative evaluation, conducted after the completion of the training sessions to assess the effectiveness and acceptability of the training model. Participants' knowledge and skills were measured using pre-test and post-test assessments, while their perceptions and satisfaction were examined through a structured questionnaire. Selected participants were also interviewed to obtain more in-depth information regarding their learning experiences, perceived benefits, and challenges in applying the acquired knowledge. The results of these assessments were complemented by follow-up monitoring findings to provide a more comprehensive

understanding of both immediate learning outcomes and the potential sustainability of behavioral changes following the intervention.

Instruments and Data Collection Techniques

Data were collected using a mixed-methods approach involving a structured five-point Likert-scale questionnaire (1 = strongly disagree to 5 = strongly agree), open-ended questions, and semi-structured interviews. The questionnaire was designed to assess participants' perceptions of application usability, instructional material quality, experiences with gamification features, learning motivation, satisfaction, acceptability, and readiness to implement sustainable agricultural practices. To distinguish participants' subjective perceptions from actual learning outcomes, knowledge and skills were assessed separately using learning-related indicators rather than relying solely on self-reported questionnaire responses. Qualitative data obtained from open-ended questions and selected interviews were used to provide further insights into participants' learning experiences, perceived benefits, implementation challenges, and recommendations for application development.

The evaluation framework integrated Kirkpatrick's four-level training evaluation model (Kirkpatrick & Kirkpatrick, 2016) and the CIPP model (Context, Input, Process, Product) (Stufflebeam & Zhang, 2017). The integration was operationalized by mapping evaluation dimensions to specific indicators, data collection instruments, and data sources. Specifically, the reaction level was assessed through participants' responses regarding satisfaction, perceived usability, material quality, and acceptability of the application. The learning level focused on changes in participants' knowledge and skills related to sustainable agricultural practices, measured using learning outcome indicators. The behavior level examined participants' readiness and reported application of the knowledge and skills acquired during training in their agricultural activities. The results level addressed the perceived benefits and potential contributions of the training to sustainable agricultural practices within the Women Farmers Groups (Kelompok Wanita Tani/KWT). Meanwhile, the CIPP model provided a complementary framework for examining the relevance of training needs and objectives (Context), the adequacy of learning resources, application features, and instructional materials (Input), the implementation and participants' engagement during training (Process), and the overall training outcomes (Product).

To strengthen instrument quality, the questionnaire indicators were developed based on the theoretical constructs of the two evaluation models and the specific objectives of the training program. The instrument was subjected to content validation by experts to examine the relevance, clarity, and alignment of each item with the intended evaluation indicators. Its internal consistency was examined using an appropriate reliability coefficient. Furthermore, questionnaire-based findings were interpreted as measures of participants' perceptions, while actual learning outcomes were analyzed separately using learning-related assessment data. The qualitative findings were used to complement and triangulate the quantitative results, thereby providing a more comprehensive understanding of the implementation, effectiveness, and acceptability of the gamification-based agricultural training program.

Data Analysis Techniques

Quantitative questionnaire data were analyzed using descriptive and inferential statistical techniques. Descriptive statistics, including mean scores and standard deviations, were used to summarize participants' responses on the five-point Likert scale. To assess the effectiveness of the training, pre-test and post-test scores were compared to identify changes in participants' knowledge and understanding following the intervention. The normality of the score differences was examined to determine the appropriate statistical procedure. For normally distributed data, a paired-samples t-test was applied, whereas the Wilcoxon signed-rank test was used when the normality assumption was not met. Statistical significance was determined at the 0.05 level.

Qualitative data obtained from interviews and open-ended questionnaire responses were analyzed thematically through a systematic process. First, all qualitative responses were transcribed, compiled, and reviewed repeatedly to achieve familiarity with the data. Second, relevant statements and meaningful data segments were identified and assigned initial codes. Third, codes with similar meanings or conceptual relationships were grouped into categories and developed into broader themes. Fourth, the emerging themes were reviewed and refined to ensure consistency with the original data and the research objectives. To enhance the credibility of the qualitative findings, data from interviews and open-ended questionnaire responses were compared through source triangulation. The interpretation of the findings was also supported by direct participant responses to maintain transparency and ensure that the identified themes accurately represented participants' experiences and perspectives. Finally, the qualitative findings were integrated with the quantitative results to provide a more comprehensive understanding of the training implementation and its outcomes.

Results and Discussion

Implementation of the Tani Cerdas Gamification Application

The implementation of the Tani Cerdas application involved 30 members of Women's Farming Groups (Kelompok Wanita Tani/KWT) in Bejiharjo Village, Gunungkidul Regency, through a blended learning approach combining face-to-face instruction, field-based practice, and independent application-based learning. During the initial stage, participants received assistance with application installation, navigation of application menus, access to learning materials, and an introduction to the gamification mechanisms, including points, levels, badges, and leaderboards. These mechanisms were integrated into learning activities covering sustainable agriculture, organic fertilizer production, eco-enzyme processing, household waste management, agricultural marketing strategies, and the utilization of household yards and garden spaces.

The implementation demonstrated that gamification elements served not merely as complementary application features but as motivational components embedded within the learning process. The points and levels mechanisms provided participants with a structured sense of learning progress, while badges functioned as recognition of their participation and achievement. Meanwhile, the leaderboard introduced a competitive dimension that encouraged participants to remain engaged in learning activities. Unlike conventional learning activities that primarily emphasize the delivery of instructional materials and task completion, the gamified approach provided additional motivational stimuli through progress recognition, achievement feedback, and social comparison. These features offered opportunities to encourage more active participation and sustained interest in the learning process, although their comparative effectiveness requires further investigation through direct observation or a controlled comparison.

Participant responses provided further evidence regarding the perceived contribution of these gamification mechanisms. Based on questionnaire data from 30 participants, the points and levels features received a mean score of 4.48, followed by badges (4.35) and leaderboards (4.26). Motivation to participate in learning activities also received a mean score of 4.48. These findings indicate that participants generally perceived the gamification features positively, particularly in supporting learning motivation and providing recognition of their progress. Furthermore, participants reported positive perceptions of the application's contribution to their knowledge (mean = 4.10) and practical skills (mean = 4.22). Taken together, these findings suggest that integrating gamification into agricultural training can provide motivational support while connecting digital learning activities with practical agricultural competencies.

Regarding learning activity achievement, the blended learning implementation enabled participants to engage with instructional materials through the application and relate the acquired knowledge to field-based agricultural practices. The learning activities addressed several relevant aspects of sustainable agriculture, including organic fertilizer production, eco-enzyme processing, household waste management, and agricultural marketing. The combination of digital materials and practical activities provided opportunities for participants to contextualize the learning content within their everyday agricultural practices. Nevertheless, participants' positive perceptions of the application should be distinguished from objectively measured learning achievement. Therefore, further assessment using application usage logs, task completion records, and practical performance observations would provide stronger evidence of participants' engagement intensity and the extent to which the intended learning activities were successfully completed.

The implementation results show that the application could be used well by most participants, with an average score of 4.55 for ease of finding menus and features, 4.45 for clarity of usage instructions, and 4.35 for the application's visual display, on a five point scale (Table 1).

Table 1. Descriptive Statistics of Tani Cerdas Application Implementation and Learning Experience (n = 30)

Assessment dimensions	Indicators	Mean	Category
Application Usability	Ease of finding menus and features	4.55	Very High
	Clarity of usage instructions	4.45	Very High
	Application visual display	4.35	Very High
Gamification Interaction	Points and levels	4.48	Very High
	Badges	4.35	Very High
	Leaderboard	4.26	Very High
Learning Experience	Knowledge improvement	4.10	High
	Skills improvement	4.22	Very High
	Learning motivation	4.48	Very High

All implementation aspects scored above 4.00, with ease of use receiving the highest rating. The obstacles encountered during implementation were generally technical and external in nature, such as participants' limited time or internet connectivity in certain locations, rather than stemming from the quality of the application itself. This finding was reinforced by interview results.

> *"The instructions were easy to understand, so even though I had never learned through an application like this before, I could still follow the steps."* (SN, 9 April 2026)

Another participant explained that the application helped her learn independently:

> *"If I forget the material, I can just reopen the application. It's easier to remember this way than only listening to the explanation during the training."* (LR, 9 April 2026)

This finding is consistent with the Technology Acceptance Model (TAM) developed by Davis (1989), which explains that perceived usefulness and perceived ease of use are the two main determinants of technology acceptance. The high score for ease of use indicates that participants perceived Tani Cerdas as easy to operate, which has the potential to increase the intention for continued use. Recent research extending TAM by adding user satisfaction as an additional element found that simplicity oriented design can increase perceived usefulness and intention to use by reducing users' cognitive load (Adyaputra et al., 2025); this finding reinforces the argument that Tani Cerdas's simple interface successfully reduced technology adoption barriers among KWT members with limited digital literacy.

The success of implementation was also supported by the fit between the material and the principles of andragogy, since adult learning is effective when participants are actively involved, given direct experience, and provided with material relevant to their real life needs (Knowles et al., 2015). The training material on organic fertilizer production, eco enzyme production, and yard land management directly relates to KWT members' daily activities, as reflected in the high material quality scores: the guide to making organic fertilizer and eco enzyme scored 4.35, while understanding of the difference between conventional and sustainable agriculture scored 4.13. The implementation process also adopted the experiential learning cycle concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 2015) as participants not only learned concepts through the application but also practiced them directly in their own yards, evaluated the results, and refined their cultivation techniques based on the experience gained.

The success of implementation was further supported by KWT's institutional backing as a learning community. Based on Diffusion of Innovation theory, the innovation adoption process is influenced by the characteristics of the innovation, communication channels, time, and the social system (Rogers, 2003); community groups such as KWT function as a social system that accelerates the diffusion of innovation through interpersonal communication and experience based learning. Interaction among KWT members during the training, such as reminding one another to complete the material, was a factor that accelerated application adoption, as expressed by one participant:

> *"We ended up reminding each other so that all members would finish the material, because we wanted our group to be in the top ranking."* (S, 9 April 2026)

Evaluation of Training Model Effectiveness

The implementation evaluation was guided by the Kirkpatrick model (Kirkpatrick & Kirkpatrick, 2016) and the CIPP framework (Stufflebeam & Zhang, 2017), which served complementary purposes in assessing the training program. The Kirkpatrick model was used to examine four distinct dimensions of training outcomes. The reaction level focused on participants' perceptions of the relevance, usefulness, and delivery of the training. The learning level addressed changes in participants' knowledge and understanding of sustainable agricultural practices, while the behavior level concerned the extent to which participants applied the knowledge and skills acquired during the training in their actual agricultural activities. The results level considered broader program outcomes, including the potential contribution of the training to strengthening sustainable agricultural practices within the Women Farmers Groups (KWT). These levels were distinguished conceptually to avoid treating participants' satisfaction, perceived learning, actual behavioral changes, and broader program impacts as equivalent outcomes.

Complementarily, the CIPP framework provided a broader perspective for examining the program through four components: context, input, process, and product. Context evaluation considered the needs and characteristics of KWT participants and the relevance of the training to their agricultural challenges. Input evaluation examined the adequacy of training materials, learning resources, digital application features, and implementation arrangements. Process evaluation focused on the implementation of training activities, participant engagement, and the use of the gamification application. Product evaluation addressed the immediate outputs and perceived benefits of the program, as well as its potential contribution to sustainable agricultural practices.

Importantly, the interpretation of training outcomes was aligned with the available evidence. Participants' questionnaire responses were used to describe their perceptions of the training, perceived learning benefits, and self-reported intentions to apply the acquired knowledge. These responses were not treated as direct evidence of objectively measured knowledge gains, demonstrated skill improvement, sustained behavioral change, or long-term program impact. Such outcomes require additional evidence, including pre- and post-training knowledge assessments, performance-based skill observations, follow-up assessments of agricultural practices, and relevant indicators of program-level outcomes. Accordingly, the evaluation findings were interpreted in terms of implementation quality, participant acceptance, and perceived benefits, while claims regarding training effectiveness and long-term impact were limited to the evidence available. A summary of the evaluation results is presented in Table 2.

Table 2. Evaluation Findings of the Tani Cerdas Gamification Training Model Based on the Kirkpatrick and CIPP Frameworks

Evaluation Framework	Dimension	Evaluation Indicators	Empirical Evidence (Mean Score)
Kirkpatrick	Reaction	Application usability and menu accessibility	4.55
	Reaction	Clarity of application instructions	4.45
	Reaction	Visual appearance of the application	4.35
	Reaction	Motivation through points and levels	4.48
	Reaction	Motivation through badges	4.35
	Reaction	Motivation through leaderboards	4.26
	Learning	Knowledge of sustainable agriculture	4.10
	Learning	Understanding of sustainable agriculture materials	4.13
	Learning	Understanding of organic fertilizers and eco-enzymes	4.35
	Learning	Skills related to sustainable agricultural practices	4.22
	Learning	Understanding of digital marketing	4.06
	Behavior	Intention to implement urban farming practices	4.19
	Behavior	Intention to reuse and recommend the application	Qualitative positive responses
CIPP	Context	Relevance of training content to sustainable agriculture needs	4.13
	Input	Quality and relevance of learning materials	4.35
	Process	Ease of navigation and application accessibility	4.55
	Process	Clarity of learning instructions	4.45
	Product	Achievement of perceived learning outcomes	4.10–4.35
	Product	Development of practical skills	4.22
	Product	Learning motivation through gamification	4.26–4.48

At the reaction level, participants rated application usability and menu accessibility highest (M = 4.55), followed by clarity of instructions (M = 4.45) and visual appearance (M = 4.35). Gamification features were also well received: points and levels (M = 4.48), badges (M = 4.35), and leaderboards (M = 4.26). These results suggest that the application was considered accessible and that its game elements helped create an engaging learning experience.

At the learning level, participants reported positive perceptions of the knowledge and skills gained. Understanding of organic fertilizers and eco-enzymes received a mean score of 4.35, while sustainable agriculture knowledge indicators ranged from 4.10 to 4.13. Perceived practical skill development scored 4.22, and digital marketing knowledge scored 4.06. At the behavioral level, intention to apply urban farming practices scored 4.19. Participants also expressed willingness to reuse and recommend the application. These responses indicate positive intentions, but do not establish actual changes in agricultural behavior.

The CIPP interpretation reinforces these findings. In the context dimension, the training was perceived as relevant to KWT members' learning needs and the promotion of sustainable agriculture (M = 4.13). For input, practical materials on organic fertilizers and eco-enzymes were positively assessed (M = 4.35), alongside the use of application-based resources and gamification. In the process dimension, high ratings for menu accessibility (M = 4.55) and instruction clarity (M = 4.45) indicate that participants found the application relatively easy to

use. In the product dimension, knowledge indicators ranged from 4.06 to 4.35, perceived skill development scored 4.22, and gamification features scored between 4.26 and 4.48. Taken together, these results suggest that the model was positively perceived in terms of relevance, learning resources, implementation, and perceived outcomes. One participant stated:

> *"I became eager to open the next material because I wanted to complete the challenges and earn a badge."* (M, 9 April 2026)

This finding is consistent with Hamari et al. (2014), who concluded that gamification can increase motivation, engagement, participation, and learning outcomes, although its success is strongly influenced by activity design, user characteristics, and the context of application. Balci and Morris (2026), who examined the effects of badges and freedom of choice on intrinsic motivation, found that badges can act as an extrinsic reward that may reduce intrinsic motivation, while freedom of choice indirectly increases intrinsic motivation by satisfying the need for autonomy (Deci & Ryan, 2017) an important implication for the further development of Tani Cerdas, namely balancing extrinsic rewards with participants' autonomy in choosing the sequence of material or activities.

At the second level (learning), the evaluation showed an improvement in participants' understanding of sustainable agriculture concepts, with an average score of 4.10, and an improvement in participants' skill in applying sustainable cultivation techniques, with a score of 4.22. This increase in competence can be explained through Transformative Learning theory (Mezirow, 1991), which holds that adult learning does not merely add new knowledge but also changes a person's frame of reference through critical reflection on experience, resulting in more lasting behavioral change. This transformation was reflected in one participant's statement:

> *"What I felt most was not just gaining knowledge, but becoming more motivated to make use of my yard and reduce household waste."* (R, 9 April 2026)

This shows that learning through the application not only transferred knowledge but also changed participants' attitudes and motivation.

At the third level (behavior), the results show that the application encouraged participants to shift toward more environmentally friendly agricultural practices, with a readiness to apply sustainable practices score of 4.19. Most respondents stated that the first practices they intended to adopt were growing vegetables in their home yards, making organic fertilizer from household waste, processing organic waste into eco enzyme, and expanding the use of polybags and vertical gardens. This finding is consistent with Social Learning theory (Bandura, 1986), which explains that people learn through observation, imitation, and interaction with their social environment (vicarious learning); within the KWT context, group members shared experiences of both successes and failures in applying cultivation techniques, creating a collaborative learning environment that accelerated the spread of innovation. This behavioral change can also be explained through the concept of implementation fidelity (Carroll et al., 2007), which measures a program's implementation success through adherence to procedures, intensity of implementation, quality of delivery, and participant engagement all of which were reflected in participants' high engagement in completing the material and their readiness to apply sustainable agricultural practices.

At the fourth level (results), the evaluation showed a positive impact on strengthening KWT's collective capacity. The high intention of participants to reuse the application and recommend it to other farmer groups indicates a good level of acceptability, consistent with the CIPP model, in which product evaluation aims to measure training success based on learning outcomes, behavioral change, and benefits perceived by participants (Stufflebeam & Zhang, 2017). Combining the Kirkpatrick and CIPP models in this study provided a complementary evaluation approach, in which Kirkpatrick focused on training outcomes while CIPP provided a comprehensive picture from the planning stage through to final program outcomes. Participants also offered a number of development suggestions, including more complete practice videos, a consultation feature with extension officers, a discussion forum among participants, learning reminder notifications, digital marketing material, and an offline mode; one participant remarked:

> *"I think the application is already good and easy to use. But if more complete practice videos were added for example, how to make organic fertilizer or eco enzyme from start to finish it would certainly be easier to understand and practice."* (K, 9 April 2026)

Overall, the implementation and evaluation results show that the Tani Cerdas application is effective as a medium for sustainable agriculture training for KWT members, not only achieving a high level of user satisfaction but also increasing learning motivation, strengthening understanding of sustainable agriculture, and encouraging the application of environmentally friendly practices in participants' daily lives. These findings confirm that integrating the principles of andragogy, gamification, and digital technology can create a more effective

learning experience for adult learners, consistent with gamified learning theory, which explains that gamification can influence learning outcomes through increased motivation and participant engagement (Landers, 2014).

Conclusions

This study demonstrates the feasibility and positive participant acceptance of the "Tani Cerdas" agricultural gamification application integrated into a blended learning model for Women Farmer Groups (KWT) in Bejiharjo Village, Gunungkidul Regency. Mean evaluation scores exceeding 4.00 across all assessed indicators reflected favorable perceptions of application usability, instructional quality, gamification features, learning experiences, motivation, satisfaction, and readiness to adopt sustainable agricultural practices. The study contributes to non-formal agricultural education by integrating andragogy, experiential learning, and digital gamification through points, levels, badges, and leaderboards, supported by the complementary Kirkpatrick and CIPP evaluation frameworks. However, these findings represent perceived benefits rather than objectively verified improvements in knowledge, practical skills, or agricultural behavior, and the independent effects of gamification cannot be established. The small sample size, absence of a comparison group, short evaluation period, reliance on self-reported data, and implementation constraints, including internet connectivity and participant availability, limit the generalizability of the findings. Future research should employ larger and more diverse samples, comparative or quasi-experimental designs, objective competency assessments, and longitudinal evaluations to examine sustained behavioral changes in organic fertilizer use, eco-enzyme production, and environmentally responsible cultivation. Further application development should incorporate instructional videos, discussion forums, consultation services, notifications, and offline accessibility to strengthen the model's potential contribution to women's empowerment and sustainable agriculture.

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