Advancements in Agricultural Development
Volume 6, Issue 1, 2025
agdevresearch.org

Offline Solutions for Agricultural Extension: Integrating Digital Libraries into Train-the-Trainer Programs

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Abstract

Training agricultural extension workers to educate rural farmers on conservation agriculture (CA) techniques is a significant challenge, especially in areas with limited access to the internet. This article evaluates the effectiveness of a train-the-trainer (TTT) approach that integrates an offline digital library and competency-based training to address both the information and skills needs of extension agents in Rwanda. Using Harper et al.'s (2024) TTT framework, the study assesses a TTT workshop conducted with agriculture extension interns, focusing on their ability to train farmers in CA practices. The training combined access to SolarSPELL, a portable offline library, with interactive learning experiences to enhance both technical and interpersonal skills. Post-training survey results indicate that participants found the digital library highly beneficial in overcoming information access challenges, while the competency training equipped them with essential skills for their roles. The findings suggest that integrating digital tools into TTT programs, particularly in rural offline settings, can enhance knowledge dissemination and improve the efficacy of agriculture training programs. The article explores the implications for broader adoption of this approach in other regions and agricultural sectors.

Article History

Received: September 20, 2024
Accepted: December 17, 2024
Published: January 8, 2025

Keywords

conservation agriculture; rural farming; information access; digital literacy; SDG 4: Quality Education

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Introduction and Problem Statement

Many authors have observed that it is difficult to get information about new methods of farming out to farmers, particularly to those in rural communities (Davis et al., 2024; Mugwanya et al., 2024). Training farmers, and turning that knowledge transfer into behavior change, is a gargantuan challenge. Train-the-Trainer (TTT) approaches are commonly used to equip agricultural extension agents with farming practices, with the expectation that they will then train farmers on these practices. Even though TTT approaches are widely used, scholars have long noted the lack of framework to guide the development and evaluation of successful TTT programs (Harper et al., 2024; Orfaly et al., 2005; Poitras et al., 2021).

Some of the main challenges associated with farmer training include scarce or nonexistent training resources and lack of development for agents' competencies (Mugwana et al., 2024). These challenges are not inherently addressed within TTT, they must be thoughtfully incorporated into the training content and design. This article utilized the Harper et al. (2024) framework to interpret findings from a TTT workshop in Rwanda with extension agents tasked with teaching conservation agriculture techniques to small shareholder farmers. This training provided agents with (a) a portable, offline digital library full of relevant digital resources to meet the information needs of farmers, and (b) competency training comprising using the library, training farmers, building digital literacy skills, and building communication skills.

This article utilized a post-TTT survey to explore agriculture agents' perceptions of this (library + competencies) approach to meet their training and information needs. The authors explore the implications of this study for agriculture training in Rwanda and the possibilities for replicability elsewhere.

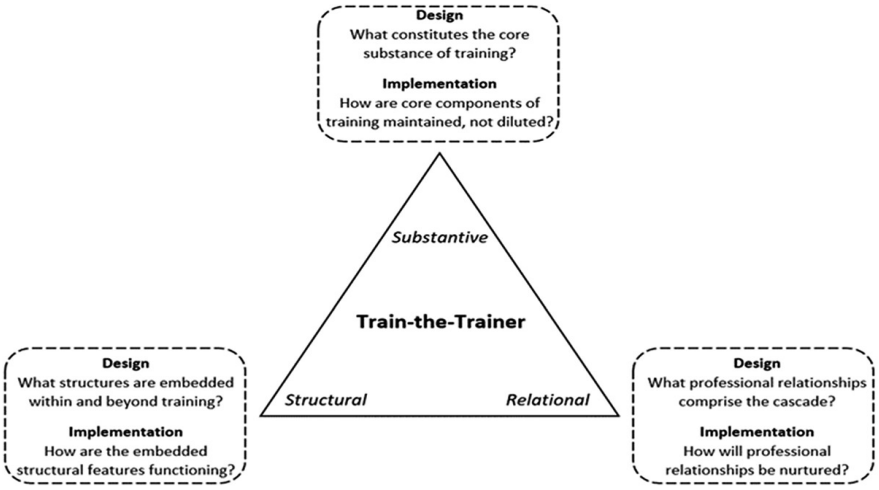
Theoretical and Conceptual Framework

Train the Trainer (TTT) approaches, also referred to as cascade models, have long been used across a breadth of sectors, including health, education, and agriculture, to disseminate knowledge and facilitate professional development at scale. Despite the widespread adoption of TTT and the many studies espousing its success (e.g. Orfaly et al., 2005; Pearce et al., 2012; Piñero et al., 2018), it is also widely acknowledged that there is little in the academic literature to provide theoretical or conceptual frameworks for their development, implementation, and assessment (Harper et al., 2024; Pearce et al., 2012; Piñero et al., 2018; Poitras et al., 2021). This has contributed to lack of consensus on how to define or measure success of a Train-the-Trainer program. Further fracturing this landscape is the reality that each TTT program is unique, making the creation of a unified theoretical framework difficult at best.

Harper et al. (2024) seek to close this conceptual gap by creating a framework to support the development of successful TTT professional development programs. Their framework includes three interconnected domains: substantive (content), structural (delivery), and relational (relationships), derived from their analysis of a TTT program for educators (see Figure 1).

Figure 1

A New Conceptual Framework for TTT (Harper et al., 2024)



This framework is designed to strengthen the fidelity and impact of TTT approaches by ensuring that the content is effectively transmitted without dilution, the delivery mechanisms are robust and supportive of collaboration, and the relationships within the professional development process foster trust and commitment. Though the framework design was born from education research related to teacher training, the authors left it purposefully broad to encompass a variety of fields and practices.

The present article seeks to apply this framework to a new context: evaluating a TTT for the agricultural sector in Rwanda. While Harper et al. (2024) use the framework to describe the planning and execution of the TTT evaluated in their research, we seek to take it a step further by applying it to a TTT and using participant data from a post-training survey to evaluate the training's effectiveness across the domains. Mapping this conceptual framework onto a TTT in a different sector, and using impact evaluation data to assess the strength of each domain, contributes to the academic literature by providing new perspectives that can guide TTT development, implementation, and evaluation.

Purpose

The purpose of this research is to leverage Harper et al.'s (2024) TTT framework to evaluate the effectiveness of a novel TTT approach in training agriculture extension agents. This approach addresses both the information needs (through the provision of an offline digital library) and skills needs (through a Train-the-Trainer workshop). Specifically, the research aims to determine whether this approach successfully meets the needs of extension agents by: (a) Equipping them with a portable offline digital library filled with resources relevant to the farmers they train; and (b) Providing them with the skills through a Train-the-Trainer workshop

to confidently use the library, train farmers on its use, build necessary digital skills, and effectively implement the conservation agriculture (CA) approach in farming.

Methods

The TTT evaluated in the present study was designed, implemented, and evaluated by staff and faculty with the SolarSPELL initiative based at Arizona State University. SolarSPELL is an offline digital libraries and information literacy initiative. The Initiative works with local partners to co-curate purpose-built digital libraries for use in offline settings, and conducts TTTs with partners, as part of its implementation model. The in-country partner on this project was B2R Farms, a Rwanda-based NGO that hosts an internship program for recent university graduates on becoming trainers of CA approaches, in alignment with the official strategy of the Rwanda Agriculture Board (RAB). Leading up to the workshop, the SolarSPELL team worked in close partnership with B2R Farms for two years to conduct needs assessments, build trust, and co-curate the library resources to ensure local relevance. Furthermore, B2R Farms and RAB collaborated to ensure SolarSPELL libraries would be sent out to rural regions where smartphones were being distributed through the Rwandan government's Connect Rwanda Initiative.

The SolarSPELL TTT workshop examined in this article was conducted in a two-day program that took place at the University of Rwanda. The TTT workshop agenda was designed to provide the knowledge and skills necessary for the B2R interns to effectively use and navigate the SolarSPELL digital library in their work training farmers and agriculture extension agents on CA techniques. Training topics included hardware, software, library content, assessing trainees' skills and needs, information and digital literacy training for farmers, communicating with farmers, and interactive activities for participants to practice training.

The target population of the study were 31 Rwandan nationals who had been accepted as interns into a competitive program led by B2R Farms that would task them with training CA techniques to Agricultural Extension Agents and farmers across Rwanda. In total, 31 surveys were collected, with a 100% response rate. All but one of the participants were recent college graduates from an agriculture-related degree program. This population has a higher education level than the average Rwandan extension agent, thus the study population is not a representative sample, presenting a potential limitation of this study.

Data were collected via a paper-based survey developed by the SolarSPELL team and subsequently reviewed by B2R Farms. The instrument was approved by the Institutional Review Board of Arizona State University. The survey consisted of four parts (Demographics, SolarSPELL Implementation, Agriculture-specific, and SolarSPELL Training Feedback) and contained 33 total questions. The questions were a mix of symmetric (5-point) Likert-scale (Joshi et al., 2015), and open-ended qualitative questions (Popping, 2015), designed as a mixed-method study enabling the comparison of qualitative and quantitative data (Creswell, 2003). The qualitative, open-ended questions were analyzed via deductive coding to minimize the introduction of

preconceived notions into the analysis (Dierckx de Casterlé et al., 2012). The survey was administered as a post-training survey, immediately following the completion of the training.

The survey begins with six demographic questions including age, gender, education level, area of study/expertise, title, and work location. Then, they were asked select-all-that-apply questions about their plans for using the library, including with whom they planned to use it and how often they planned to use it. These questions were followed by nine Likert-scale questions where they were asked to gauge their knowledge, skills, motivation, and perceived usefulness of the SolarSPELL library. Qualitative questions about the expected benefits and challenges of using the SolarSPELL library followed. Respondents were then asked a series of yes/no, multiple select, and open-ended questions designed to gauge their perceptions of the SolarSPELL library's application and usefulness to their agricultural work. Finally, the respondents were asked to provide feedback on the training itself in a series of open-ended questions, including any challenges they could foresee in using the SolarSPELL library as part of their future training of extension agents and farmers.

Findings

The findings from the survey responses regarding the overall effectiveness of the training were overwhelmingly positive, with 100% of respondents selecting "strongly agree" or "agree" on five of the eight Likert questions about their skills, motivation, and capacities (see Table 1). All participants either agreed or strongly agreed that, following the training, they have the skills to use the library, can find resources on the library, are motivated to use the library, can use the library to assist them in their learning, and can train others to use the SolarSPELL library. Nearly all participants reported, with only one respondent reporting neutral, that they anticipate the SolarSPELL library will be useful to them in their work and that they can help others improve their information literacy skills. Finally, nearly all participants believed they can use the SolarSPELL library to improve their own information literacy skills, with three neutral responses. No respondents selected disagree or strongly disagree to any of these questions.

Table 1

Likert Question Responses

	Responses (*n* = 31)				
Questions	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I can find resources on the SolarSPELL library.	-	-	-	16%	84%
I am motivated to use the SolarSPELL library.	-	-	-	16%	84%
I can train other people to use the SolarSPELL library.	-	-	-	26%	74%
I have the skills to use the SolarSPELL library.	-	-	-	29%	71%
I can use the SolarSPELL library to assist me in my learning.	-	-	-	32%	68%
The SolarSPELL library will be useful to me in my work.	-	-	3%	29%	68%
I can improve my information literacy skills using the SolarSPELL library.	-	-	10%	22%	68%
I can help others improve their information literacy skills using the SolarSPELL library.	-	-	4%	32%	64%

The following sections will leverage Harper et al.'s (2024) three-pronged framework to delve deeper into the features of the SolarSPELL TTT approach that contributed to its success. These insights can be extrapolated to other entities seeking to leverage TTT approaches with agriculture extension agents to train rural farmers. Additionally, this application of Harper et al.'s (2024) framework serves to validate its application to a different sector. The findings are presented for each distinct but interconnected domain: substantive, structural, and relational, with supporting evidence from the post-training surveys.

Substantive Domain

The ultimate goal of TTT is to present the knowledge in a way that it retains its original meaning as it goes from person to person along the cascade: from expert trainer to new-expert trainee to their intended audience and so on. Harper et al. (2024) describe the substantive domain of TTT as the content and skills being delivered to trainees, including "the mechanisms through which these are codified to become accessible in practice" (p. 5). Thus, the substantive domain not only considers *what* knowledge is being transmitted (i.e. topics, presentations, printed materials), but *how* it is being transmitted.

The main objective of the SolarSPELL TTT is that the trainees will have the skills and motivation to use the SolarSPELL digital library to increase farmers' adoption of CA techniques. To this end, it is important to consider the content delivery strategy during the TTT. While traditional approaches use didactic, lecture-style delivery, evidence indicates that this approach is less effective than interactive approaches (Costa et al., 2007; Meguid & Collins, 2017). Research by Pearce et al. (2012) found that incorporating interactive activities into training was the largest single indicator of success. Not only does this strengthen bonds among participants and between participants and trainers (also strengthening the "Relational domain"), but can increase knowledge retention (Costa et al., 2007; Meguid & Collins, 2017).

The SolarSPELL TTT approach has been designed to be participatory and interactive, providing trainees opportunities to plan, discuss, and reflect on ways that they can use the library to support their goals. In this case, where the trainees are tasked with training farmers and extension workers on CA techniques, the entire second day of training was dedicated to hands-on activities designed to equip trainees with the necessary skills to leverage the SolarSPELL library to train others on CA. For example, trainees were broken into pairs for a role-play activity and given prompts of questions they may encounter in the field (i.e. "How can I find a video about compost?"). In another activity, trainees watched short plays demonstrating what *not* to do, then following a group discussion, participants volunteered to show the group how to do it differently. Importantly, these plays incorporated humor, which has long been recognized as a successful pedagogical tool across multiple disciplines and cultures (Haydon et al., 2023; Kher et al., 1999; Makewa et al., 2011; Ziv, 1988).

The qualitative data collected in this research supports the assertions that interactivity and humor contribute to training success, as participants responded positively to the participatory format of the SolarSPELL training. In response to the open-ended question, "Was there anything during the training that you found particularly helpful?" responses included:

- "The nature of the training: participation."
- "...the way you used to train in games [and] comedies…"
- "The play to show how to approach trainees was helpful to me."

While many trainees expressed appreciation for the interactive nature of the training, in response to the question about how the training could be improved, other trainees expressed that they would have preferred even more opportunities to put these skills into practice. The value of participatory activities in the substantive design of TTT cannot be overstated.

Structural Domain

The structural domain consists of the features of TTT approaches that support short- and long-term training retention and fidelity, including consideration of how the actual transfer of knowledge will occur in the days, months, and years after the training (during the "cascade" of TTT).

One unique structural component of the SolarSPELL TTT is the provision of a SolarSPELL offline digital library to each trainee upon completion of the training. This is an innovative solution to

combat one of TTT's most pressing challenges: dilution of information as it passes from one person to another. With thousands of resources at hand using the library, the trainee no longer needs to remember all the details of new farming techniques. They can simply search the digital library's thousands of resources, then download the content to their device--or the farmer's device--all without internet connection. This increased access to information post-training is a major enhancement to agriculture extension work. In evaluating the qualitative survey responses, access to information was by far the most prominent benefit identified by the training participants, followed by efficiency/ease of use and cost savings (see Table 2).

Table 2

Thematic Analysis of Responses to the Question: "Briefly Describe the Potential Benefits of Using the SolarSPELL Library in your Work"

	Respondents		
Theme	*f*	Percent	Examples
Access to information	20	65%	"Getting information I need easily." "Getting information about work…where there is poor connection." "SolarSPELL library is highly beneficial when someone needs to access some information contained in it"
Efficiency/ Ease of use	11	35%	"SolarSPELL will help me to save time." "It helps me to have good information about what I was looking for and gives me trustworthy information and updated all in one short time" "Quick searching" "Getting information needed easily (searching)."
Cost savings	9	29%	"No spending money for buying [internet] data." "Getting useful information freely without any charges" "...reduction of expenses like money to buy [internet] bundles"
Improve farming practice	4	13%	"Improve the skills in agriculture practice." "Receiving conventional updates according to farming practices, pest and disease management and control information…"
Community impact	4	13%	"...food security will increase." "contributes to increased livelihood in families"
Information or Digital literacy	4	13%	"I will improve my awareness and information literacy." "Helpful in providing security from online"
Training support and/or skill development	4	13%	"Improves on skill development for agriculture worker" "It will help me to train others."

Ensuring that information is not corrupted as it travels from person to person is an issue concerning all TTT developers and facilitators. The SolarSPELL Initiative must address this issue on two fronts: first, trainees need to recall details related to meaningfully using the SolarSPELL library (i.e. how to use search and advanced search); second, trainees must be able to correctly convey the vast amount of knowledge comprising conservation agriculture and how it applies to a variety of crops (i.e. how to make compost). The SolarSPELL library provides resources to aid on both of these fronts. The library includes interactive courses and videos explaining the library functions, which can be used as a refresher by the trainee or shared with new users, and contains thousands of videos, interactive modules, pdfs, and audio files to support CA. This includes local language videos and audio files which can be used by illiterate people, an important consideration in Rwanda, where over a quarter of the general population is illiterate and where illiteracy is more prevalent in rural, agricultural communities (Mtika & Abbott, 2023).

Some scholars have recommended leveraging information and communication technologies (ICTs) to reach rural farmers, and even suggested that using ICTs could help address gender disparities (Zossou et al, 2009; Zossou et al., 2020). While the use of ICTs for farmer training presents many possibilities, there is one overarching challenge: internet connectivity, or lack thereof. Even if an internet connection is available in farmers' communities, it is often prohibitively expensive. This problem is particularly pronounced across Africa, where less than 30% of countries have "affordable" internet available and a single gigabyte of data costs, on average, 5.7% of a person's monthly income (Alliance for Affordable Internet, 2020).

Further, once farmers connect to the internet, they may not know where to look for information, how to search, who or what information to trust: in other words, training farmers in digital or information literacy is something that is rarely addressed in the literature, and seldom addressed in the field, either (Davis et al., 2024). This is where the SolarSPELL library, which functions entirely offline, is uniquely positioned to meet the needs of those interested in training farmers in rural and remote areas.

SolarSPELL (Solar Powered Educational Learning Libraries) are offline digital libraries filled with tens of thousands of open-access resources that are localized for the people and locations using them. Further, they contain training materials, in video, written/pdf, and interactive html (interactive courses), designed to facilitate and reinforce extension agents' training to farmers. Moreover, since all of the library's content is open access, every resource can be downloaded to a user's device, kept with them, and reviewed at any point in time, or shared (via bluetooth or the like) offline, so as not to ever require farmers to use data. In addition to being localized (by geography and language), the content on the libraries has been vetted by, and often provided by, the Ministry of Agriculture, so the farmers and extension agents can feel confident that the information is trustworthy.

Relational Domain

The relational domain, which Harper et al. (2024) argue is the least often considered in TTT development, focuses on the relationships fostered that contribute to successful TTT

workshops. There are many relationships to consider, including: (a) Trainer-experts and trainee-new experts; (b) Trainees' relationships amongst themselves; and (c) New-trainers' relationships with the various people they will ultimately train. As mentioned previously, designing a participatory, interactive training can aid in the relational domain by promoting autonomy and allowing trust to be built both between trainer-trainees and among trainees themselves (Harper et al., 2024). The findings of the importance of interactivity to support the development of successful relationships was emphasized in the Structural Domain section above. The authors would like to add that inter-organizational relationships, such as the relationship between the SolarSPELL Initiative and B2R Farms, are another important relational component to consider in TTT where there are multiple organizations involved.

The SolarSPELL TTT was designed to nurture these relationships throughout the training process, thus fostering a community of practice of SolarSPELL library users (Mercieca, 2017). Communities of practice are groups of individuals who share a common goal, and whose relationships within that community allow for sharing of ideas, troubleshooting, and sparking innovation (Mercieca, 2017). While nurturing a community of practice *during* the TTT is an important training design consideration, maintaining that community of practice *after* the training is a more complex challenge. Harper et al. (2024) lament that most TTT approaches do not make the trainers accessible to the trainees after the initial training. To mitigate this challenge, the SolarSPELL team has explored a variety of solutions, including providing trainees with the team's email addresses and creating a WhatsApp group. However, given that B2R Farms had already set up WhatsApp communication groups among the trainees, SolarSPELL and B2R Farms made a joint decision not to create a new group specifically for this training, thus reinforcing the importance of inter-organizational relationships.

Conclusions, Discussion, and Recommendations

This study demonstrates the effectiveness of a TTT approach that integrates a portable, offline digital library with competency-based training for agricultural extension agents in Rwanda. Participants overwhelmingly perceived both the SolarSPELL library and the associated training as beneficial, particularly for accessing relevant agricultural information, enhancing their skills, and supporting rural farmers in adopting CA techniques. The findings validate Harper et al.'s (2024) framework by underscoring the importance of substantive, structural, and relational elements in a successful TTT program and highlighting innovative ways to strengthen these domains. Furthermore, this research highlights the value of interactive, resource-equipped, and relationship-driven TTT models in agricultural settings.

The present research supports the assertion that utilizing a variety of interactive activities, including peer-to-peer interaction, leads to improved training outcomes (Levinson et al., 2024; Pearce et al., 2012). The interactive design of the SolarSPELL TTT workshop— comprising role-plays, humor, and hands-on practice—was identified as a critical factor in its success. The participatory format not only supports knowledge retention but also fosters relationships among participants, promoting a community of practice. Developing and maintaining strong

relationships has been identified as both a beneficial outcome and a contributing success factor to TTT workshops (Monnier et al., 2023; Mormina & Pinder, 2018; Piñero et al., 2018). These relational aspects are often underemphasized but proved essential in building trust and collaboration, both between the trainees and between the trainees and trainers. Furthermore, the productive working relationship of collaborating organizations, such as SolarSPELL and B2R Farms, is another vital relational component to TTT programs.

The inclusion of an offline digital library is an innovative way to address one of the most pressing challenges in rural farming contexts: the lack of reliable or affordable internet access. Participants indicated that they highly valued the offline digital library, particularly for its ease of use and capacity to provide information in rural settings. This finding supports the importance of the structural domain of Harper et al.'s framework, demonstrating how access to a resource like SolarSPELL can reduce knowledge dilution—a common challenge in cascade models.

To further enhance the impact and replicability of this TTT model in agricultural extension work, several recommendations arise from this study. First, offline approaches should not be overlooked when designing training programs for rural areas. Participants valued the SolarSPELL offline digital library as a critical tool for overcoming connectivity barriers, and its use should be prioritized in similar settings where internet access is limited or unreliable. Second, the TTT approach can be highly effective for training agricultural extension agents, provided they are given the right resources to take into the field. This includes not only the necessary technical tools, such as a digital library, but also the development of essential competencies to engage with, communicate with, and train the farmers they will be working with. Third, many farmers in rural settings are often illiterate or have low digital skills. Thus, in addition to providing content in their local languages, agricultural extension agents need to receive training in how to teach digital literacy. Indeed, in low resource settings, offline approaches can be superior to online, for reasons of affordability, availability, reliability, trustworthiness of content, safety to users, all while building users' skills (Hosman et al., 2020).

Future research should explore the scalability of this TTT approach in other regions and agricultural contexts. While the framework and findings presented in this study offer a replicable model, adapting the content to meet the unique needs of various communities will be critical for broader application. By refining this approach and addressing these recommendations, the TTT model has the potential to transform agricultural training and information dissemination, especially in offline settings, on a global scale.

Acknowledgments

Author contributions: **L. Hosman –** Conceptualization, methodology, writing-original draft, writing-review and editing, investigation, supervision, and formal analysis. **R. Nova –** Conceptualization, methodology, writing-original draft, writing-review and editing, investigation, visualization, supervision, project administration, and formal analysis.

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