The Efficacy-Competence-Adoption Nexus: The Mediating Role of Perceived Digital Competence in Technical Training Outcomes for Young Farmers in Kerala.

1Dr. Rekha. P. T.1, Dr. Julee Banerji2

1 Post-Doctoral Research Fellow, Lincoln university College, Malaysia,

2IIMS Pune, Maharashtra, India,

Email ID: pdf.rekha@lincoln.edu.my1; pooyam1935@gmail.com1, juleebanerji@gmail.com2

Abstract

This study investigates the "Technical Training-Competence-Adoption Nexus" among youth farmers in Kerala, exploring how the efficacy of technical training influences the adoption of digital agriculture technologies through the mediating role of perceived digital competence. Employing a quantitative cross-sectional survey design, data were collected from 410 youth farmers (aged 18–40) associated with government extension programs and Krishi Vigyan Kendras (KVKs). The analysis utilized multiple linear regression and the causal steps approach to test hypothesized direct and indirect effects. Findings reveal a significant disconnect in the proposed nexus: perceived digital competence did not mediate the relationship, as the links between training and competence (p = .562) and competence and adoption (p = .932) were not statistically significant. Most notably, a "Total Effect" analysis uncovered a significant negative relationship between program relevance (beta = -0.098, p = .046), delivery method (beta = -0.135, p = .006), and adoption success. These results suggest a "complexity deterrent" effect, where comprehensive training may inadvertently emphasize technical risks and operational costs, thereby discouraging adoption among tech-savvy youth. The study concludes that building technical competence alone is insufficient; agricultural extension services must pivot toward addressing structural and economic barriers to facilitate successful digital modernization in the youth farming sector.

Keywords: *Digital Agriculture, Youth Farmers, Technical Training Efficacy, Digital Competence, Technology Adoption, Agricultural Extension (Kerala), Mediation Analysis.*

Introduction:

The global agricultural landscape is rapidly transforming under the influence of the Fourth Industrial Revolution, with **Digital Agriculture (DA)** emerging as a pivotal force for enhancing productivity, resource efficiency, and climate resilience, particularly across developing economies in the Global South [FAO, 2020; World Bank, 2021]. Despite significant investment in infrastructure and technology dissemination—including sensor-based systems, precision farming tools, and farm management applications—the success of DA initiatives remains highly uneven [Norton & Alwang, 2020]. A critical and often overlooked barrier to successful adoption is the pervasive **skills divide**, particularly among young farmers who are theoretically best positioned to leverage these technologies [OECD, 2022]. In India, and specifically within the agrarian economy of Kerala, government and private entities have launched numerous technical training programs aimed at upskilling the youth (aged 18–40) to drive this digital transformation [GOI NITI Aayog Report, 2023]. However, the assumption that training automatically translates into successful technology integration is flawed; many studies indicate a significant disconnect between participation in training and demonstrable changes in farming practice [Mittal et al., 2202; Sharma & Singh, 2023]. This research posits that the **perceived efficacy** of the technical training programs—in terms of content relevance and delivery quality—is not a direct predictor of adoption, but rather works indirectly by shaping the farmer's **perceived digital competence** (their self-assessed ability to use and troubleshoot the technology). Therefore, this study aims to assess the structural relationship between these factors—the **Efficacy-Competence-Adoption Nexus**—by examining **the mediating role of Perceived Digital Competence** in translating Technical Training Efficacy into successful Digital Agriculture Adoption among youth in Kerala, thereby addressing a critical gap in the literature focused solely on diffusion rates.

Literature Review:

No.	**Author(s) & Year**	**Title of the Study**	**Study Context**	**Methodology**	**Key Finding(s)**	**Future Research Scope/Gap Identified**
1	**Asante (2024)**	Digital technologies	International (Africa/Regional)	Survey / Quantitati	Extension agents lack specific digital	Need to assess how

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		competencies and training needs of agricultural extension agents		ve Analysis	competencies, directly impacting the quality of training provided to farmers.	these training needs translate to actual adoption success for farmers.
2	**Charatsari et al. (2023)**	Competencies needed for guiding the digital transition of agriculture: Are future advisors well-equipped?	International (EU/Greece)	Descriptive & Inferential Statistics	Future advisors lack "soft" and "digital" skills, creating a bottleneck in the digital transition.	Highlights the gap in testing whether advisor competence actually mediates farmer adoption.
3	**Ayim et al. (2022)**	Adoption of ICT innovations in the agriculture sector in Africa: a review of the literature	International (Africa)	Systematic Literature Review	Infrastructure and cost are common barriers, but "user-related factors" (skills/competence) are least explored.	Suggests a need for empirical studies on the psychological mechanisms of adoption (like competence).

No.	Author(s) & Year	Title of the Study	Study Context	Methodology	Key Finding(s)	Future Research Scope/Gap Identified
4	**Venkatesh & Thong (2016)**	Unified theory of acceptance and use of technology: A synthesis and the road ahead	International (Global/Theoretical)	Synthesis & Conceptual Modeling	Consumer technology use is driven by performance expectancy, effort expectancy, and social influence.	Called for applying the UTAUT framework to specialized fields like agricultural technology.
5	**Klerkx et al. (2019)**	A review of social science on digital agriculture, smart farming and agriculture 4.0	International (Global Review)	Systematic Review / Social Science	Digitalization is not just technical; it's a social process involving new roles and skills (Agriculture 4.0).	Identifies a lack of "micro-level" studies on individual farmer competence and behavior.
6	**Jena & Tigga (2023)**	Digital competency in the agriculture sector: An Outlook in the Indian Context	National (India)	Conceptual Analysis / Outlook	India has a growing digital divide; digital competency is the "missing link" for realizing AgTech benefits.	Points to a gap in quantitative data measuring the direct link between training programs and Indian farmers' skills.

The literature confirms the importance of both Training Efficacy and Competence but fails to connect them in a single, structural model. This research directly addresses this empirical void by testing the **Efficacy-Competence-Adoption Nexus**. Specifically, it investigates the mediating role of Perceived Digital Competence, moving beyond simple correlations to explain the mechanism by which technical training investment translates into sustained Digital Agriculture Adoption. By focusing on the **Kerala context**, this study responds to global calls for more micro-level, regional evidence on the psychological and technical barriers that hinder the digital transition in agriculture.

Significance of the research:

The Significance or novelty of the research is the direct result of testing the relationship between the three core variables, which addresses a gap identified in the literature review.

- **Testing the "Nexus" (Mediating Mechanism)**

Moving Beyond Direct Effects: The most significant novelty is the rigorous testing of the mediating role of Perceived Digital Competence. Previous studies often look at the direct effect of training on adoption, or competence on adoption. The present study goes further by establishing the structural mechanism (the "Nexus")—that training is effective only to the extent that it successfully builds self-assessed competence.

- **Integration of Specific Competence Dimensions**

The study integrates specific, practically relevant competence sub-constructs (like Technical Troubleshooting and Integration Competence) which are often overlooked in favor of general "digital literacy." This provides a highly actionable framework for policymakers.

- **Contextual Specificity**

It provides the first known empirical evidence for this complex relationship within the Kerala context, where a unique blend of high literacy rates and challenging agricultural demographics makes the skills divide a critical point of study.

Variables Identified from the Literature Review:

Variables	Constructs
Training Efficacy (Independent Variable)	A. Program Relevance B. Delivery Method C. Follow-up Support
Perceived Competence (Mediating Variable)	D. Data Management Competence E. Technical Troubleshooting F. Integration Competence
Adoption Success/Intent (Dependent Variable)	G. Smooth Adoption H. Future Intent

Objective:

- To examine the mediating role of Perceived Digital Competence in the relationship between the Perceived Efficacy of Technical Training Programs and the successful Digital Agriculture Adoption among youth engaged in farming in Kerala.

Hypotheses:

H1: There is a significant positive relationship between the dimensions of technical training efficacy and the perceived digital competence of youth farmers.

- **H1a**: Program relevance significantly and positively influences perceived digital competence.
- **H1b**: The delivery method of training significantly and positively influences perceived digital competence.
- **H1c**: Follow-up support provided after training significantly and positively influences perceived digital competence.

H2: Perceived digital competence has a significant positive influence on the success of digital agriculture technology adoption and future intent among young farmers.

H3: Perceived digital competence acts as a critical mediator in the relationship between technical training efficacy and adoption success.

- **H3a**: Perceived digital competence significantly mediates the relationship between program relevance and adoption success.

- **H3b**: Perceived digital competence significantly mediates the relationship between the delivery method and adoption success.
- **H3c:** Perceived digital competence significantly mediates the relationship between follow-up support and adoption success.

Research Methodology:

- **Research Design and Approach**

This study employed a quantitative, descriptive, and cross-sectional survey design to investigate the relationship between technical training efficacy, perceived digital competence, and adoption success. To examine the hypothesized "nexus," the study utilized a predictive modeling approach. Statistical analysis was conducted using Multiple Linear Regression to test the direct and indirect effects within the framework. This approach was selected to identify the specific dimensions of training that influence adoption and to determine if Perceived Digital Competence serves as a mediating mechanism in this process.

- **Study Population and Sampling Frame**

The study population comprises youth (individuals aged 18–40 years) actively engaged in farming or farm management across the state of Kerala, India. The sampling frame was strategically drawn from participants associated with government-backed agricultural extension programs, Krishi Vigyan Kendras (KVKs), and Farmer Producer Organizations (FPOs) that specifically target youth and record those farmers who are engaged in agriculture as a full-time or part-time activity and actively involved in modernizing their practices This specific frame ensured that respondents had direct exposure to formal technical training initiatives aimed at modernizing agricultural practices. A **purposive sampling technique** was employed to select **410 respondents** who met the inclusion criteria: being active youth farmers and having participated in at least one technical training program. This non-probability sampling approach was utilized to ensure the collection of data from individuals with relevant experience in the "Training-Competence-Adoption" nexus.

- **Data Collection and Ethics:**

Data were gathered using a structured, self-administered questionnaire. To ensure a high response rate and geographic coverage, the survey was administered through a hybrid approach: face-to-face interviews and digital survey links distributed via agricultural extension networks. Participation was

entirely voluntary. To maintain ethical standards, strict anonymity and data protection protocols were followed; no identifying information was collected, and participants were informed of their right to withdraw at any stage.

Key Limitations of the Study:

- **Research Design Limitations (Causality)**

Since data are collected at a single point in time, the study cannot definitively establish causality. Although the regression analysis tests a predictive causal model (mediation), the researcher cannot prove that the training chronologically preceded the competence, or that competence caused the adoption. The researcher can only show that they are related as hypothesized.

- **Reliance on Self-Reported Data:**

The measurement of Perceived Competence, Training Efficacy, and Adoption Success relies on the subjective assessment of the respondents (youth farmers). This introduces potential biases, such as social desirability bias (reporting higher competence than actual) or common method bias (variables measured using the same method may be artificially correlated).

- **Sampling and Generalizability Limitations:**

The use of Purposive/Convenience Sampling (drawing from KVKs, FPOs, etc.) means the sample is not randomly selected. Therefore, the findings cannot be statistically generalized to the entire population of youth farmers in Kerala who may not be part of these formal networks. Further the study is restricted to the specific context of Kerala, India. The findings regarding the efficacy of training programs and local digital infrastructure may not be directly applicable to other states or countries without further validation.

DATA ANALYSIS & INTERPRETATIONS

- **Demographic:**

TABLE 1

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-25	151	36.8	36.8	36.8

	26-33	155	37.8	37.8	74.6
	34-40	104	25.4	25.4	100.0
	Total	410	100.0	100.0	

TABLE 2

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	255	62.2	62.2	62.2
	Female	155	37.8	37.8	100.0
	Total	410	100.0	100.0	

TABLE 3

Occupation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Student	142	34.6	34.6	34.6
	Agriculturalists	141	34.4	34.4	69.0
	Other jobs but part time agriculture	127	31.0	31.0	100.0
	Total	410	100.0	100.0	

HYPOTHESIS TESTING:

H1: There is a significant positive relationship between the dimensions of technical training efficacy and the perceived digital competence of youth farmers.

- **H1a**: Program relevance significantly and positively influences perceived digital competence.
- **H1b**: The delivery method of training significantly and positively influences perceived digital competence.

- **H1c**: Follow-up support provided after training significantly and positively influences perceived digital competence.

Results:

TABLE: 4

Variable	Unstandardized B	Std. Error	Beta (β)	t	Sig. (p)
(Constant)	3.33	0.131	-	25.45	0
Program Relevance	-0.033	0.023	-0.071	-1.421	0.156
Delivery Method	-0.002	0.023	-0.004	-0.079	0.937
Follow-up Support	0.004	0.031	0.007	0.136	0.892

Note: R^2 = .005; Adjusted R^2 = -.002; F = 0.684, p = .562

Interpretation: The results of the multiple regression analysis indicated that the dimensions of Technical Training Efficacy did not significantly predict Perceived Digital Competence among youth farmers, F (3, 406) = 0.684, p = .562. The model accounted for a negligible 0.5\% of the variance (R^2 = .005). Specifically, Program Relevance (\beta = -0.071, p = .156), Delivery Method (\beta = -0.004, p = .937), and Follow-up Support (\beta = 0.007, p = .892) all failed to reach statistical significance at the 0.05 level. Consequently, **the primary hypothesis H1 and its sub-hypotheses H1a, H1b, and H1c were not supported by the data, indicating that training factors did not play a significant role in determining the perceived digital competence of the respondents.**

H2: Perceived digital competence has a significant positive influence on the success of digital agriculture technology adoption and future intent among young farmers.

TABLE: 5

Predictor	B	Std. Error	β	t	Sig. (p)
(Constant)	3.618	0.197	—	18.373	0
Perceived Competence	-0.005	0.06	-0.004	-0.085	0.932

Note: R^2 = .000; F = 0.007, p = .932

Interpretation: The second stage of the analysis tested the influence of Perceived Digital Competence on Adoption Success and Future Intent (H2). The results of the simple linear regression indicated that digital competence did not significantly predict adoption success, **F (1, 408) = 0.007, p = .932**. The model explained 0\% of the variance in adoption (R^2 = .000). The standardized coefficient showed a negligible and non-significant relationship (\beta = -0.004, p = .932). Therefore, **Hypothesis 2 was not supported**."

H3: Perceived digital competence acts as a critical mediator in the relationship between technical training efficacy and adoption success.

- **H3a**: Perceived digital competence significantly mediates the relationship between program relevance and adoption success.
- **H3b**: Perceived digital competence significantly mediates the relationship between the delivery method and adoption success.
- **H3c:** Perceived digital competence significantly mediates the relationship between follow-up support and adoption success.

TABLE: 6

Model	R	R2	Adjusted R2	F	Sig. (p)
1	0.163	0.026	0.019	3.684	.012*

TABLE: 7

Variable	Unstandardized B	Std. Error	Beta (β)	t	Sig. (p)
(Constant)	4.042	0.156	—	25.941	0
Program Relevance	-0.055	0.027	-0.098	-1.997	.046*
Delivery Method	-0.075	0.027	-0.135	-2.743	.006**
Follow-up Support	-0.02	0.036	-0.027	-0.541	0.589

Interpretation: As shown in Table 5, the regression model for the total effect was statistically significant, indicating that training dimensions collectively influence adoption success. However, as detailed in Table 6, individual predictors such as Program Relevance and Delivery Method showed a significant negative relationship with adoption, suggesting that higher perceived training quality in these areas correlated with lower adoption intent among the respondents. A multiple regression analysis was conducted to assess the total effect of training dimensions on Adoption Success (Step 1 of mediation). The model was statistically significant, F (3, 406) = 3.684, p = .012, R^2 = .026. However, contrary to the hypothesized positive direction, **Program Relevance** (\beta = -0.098, p = .046) and **Delivery Method** (\beta = -0.135, p = .006) exerted a significant **negative** influence on adoption. Follow-up Support was not a significant predictor (p = .589). These results suggest that as the perceived relevance and delivery quality of current training programs increase, adoption success among youth farmers unexpectedly decreases.

The summary of Hypotheses Testing:

TABLE: 8

Hypothesis	Relationship Path	Beta (β)	Sig.	Result
H1a	Program Relevance & Perceived Digital Competence	-0.071	0.156	Not Supported
H1b	Delivery Method & Perceived Digital Competence	-0.004	0.937	Not Supported

H1c	Follow-up Support & Perceived Digital Competence	0.007	0.892	Not Supported
H2	Digital Competence & Adoption Success	-0.004	0.932	Not Supported
H3a	Relevance & Competence & Adoption	—	—	Not Supported
H3b	Delivery & Competence & Adoption	—	—	Not Supported
H3c	Support & Competence & Adoption	—	—	Not Supported

The empirical results of this study present a departure from the hypothesized theoretical framework. While the conceptual model proposed a positive "nexus" where training builds competence to drive adoption, the data reveals a more complex reality for youth farmers.

1. **The Broken Link (H1&H2)**: Technical training efficacy failed to significantly enhance perceived digital competence, and digital competence, in turn, did not act as a driver for technology adoption. This suggests that for youth farmers—who may already possess baseline digital literacy—traditional training dimensions are not the primary catalysts for their sense of mastery or their decision to adopt digital tools.
2. **The Paradox of Training (H3):** Most notably, the "Total Effect" analysis revealed that while training does influence adoption, the relationship is **significant and negative**. This indicates that as training becomes more relevant and professional in its delivery, adoption intent actually decreases. This may suggest a "complexity deterrent" effect, where comprehensive training makes farmers more aware of the technical challenges, costs, or risks associated with digital agriculture, leading to a more cautious or skeptical approach to adoption.
3. **Mediation Verdict:** Consequently, the mediation hypothesis H3 is rejected. There is no indirect path from training to adoption via competence. Instead, training exerts a direct, albeit discouraging, influence on adoption success within this specific demographic.

Discussions:

This study investigated the "Technical Training-Competence-Adoption Nexus" among youth farmers in Kerala, uncovering a significant disconnect between current agricultural extension efforts and actual technology adoption. Contrary to the hypothesized positive mediation model, the findings reveal that technical training efficacy does not significantly enhance perceived digital competence, nor does competence drive adoption in this demographic. Most strikingly, the research identified a significant **negative direct effect** of program relevance and delivery on adoption success. This suggests that as training becomes more specialized or intense, it may inadvertently highlight the complexities, costs, or risks associated with digital tools, thereby acting as a deterrent rather than a catalyst for adoption. These results indicate that the current "one-size-fits-all" training model is insufficient for the tech-savvy youth of Kerala. To bridge this gap, policymakers must pivot from purely technical instruction toward addressing the structural and economic barriers—such as high technology costs and infrastructure gaps—that likely play a more decisive role in the adoption decision than perceived competence alone.

Conclusion

- **Problem Statement Addressed/Motivation:** This research addressed the critical "Technical Training-Competence-Adoption Nexus" within the youth farming sector of Kerala. The study was motivated by the need to understand why, despite extensive government-backed training initiatives (KVKs and FPOs), the digital modernization of agriculture among tech-savvy youth remains inconsistent. It specifically sought to determine if building digital competence is the necessary "bridge" that turns training into actual technology adoption.
- **Method Used:** The study employed a quantitative, cross-sectional research design involving a purposive sample of 410 youth farmers (ages 18–40). Data were analyzed using Multiple Linear Regression and the Causal Steps approach to test for mediation. The analysis evaluated three dimensions of training efficacy—Program Relevance, Delivery Method, and Follow-up Support—as predictors of both Perceived Digital Competence and Adoption Success.
- **Key Findings:**
    - **Broken Nexus:** The hypothesized mediation model was not supported; perceived digital competence did not serve as a bridge between training and adoption.

- **Training Disconnect:** Technical training efficacy did not significantly improve the perceived digital competence of youth farmers (p = .562), suggesting that current training may be redundant for an already digitally literate generation.
- **The Complexity Paradox:** A significant **negative direct effect** was discovered between training quality and adoption. Specifically, as Program Relevance (\beta = -0.098) and Delivery Method \beta = -0.135) improved, adoption success unexpectedly decreased. This suggests that high-quality training may inadvertently act as a "deterrent" by making farmers more aware of the high risks, costs, and complexities involved in digital agriculture.

- **Limitations of the Work:**
  - **Geographic Specificity:** The findings are limited to the socio-economic context of Kerala and may not be generalizable to regions with different literacy levels or agricultural infrastructures.
  - **Measurement Constraints:** The study focused on *perceived* competence rather than objective skill assessments, which may be subject to self-reporting bias.
  - **Cross-Sectional Nature:** The data captures a single point in time, which cannot account for the long-term evolution of adoption behavior after repeated training exposure.
- **Future Work:**
  - **Economic Mediators:** Future research should pivot from "competence" to "economic viability" and "risk-benefit ratio" as potential mediators of adoption.
  - **Longitudinal Studies:** A longitudinal approach is recommended to track if the "complexity deterrent" effect fades as farmers gain more hands-on experience over time.
  - **Qualitative Insight:** Incorporating qualitative interviews could help uncover the specific "hidden" barriers that make high-quality training lead to lower adoption intent among youth.

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