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Bridging the agricultural extension gap: Insights from the teaching-learning theories and models

Florah Kobusiingye *, Richard Ssembatya, Fred Kaggwa and Annabella Hambinka Ejiri

Faculty of Computing and Informatics, Mbarara University of Science and Tech, Uganda.

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Abstract

This article explores various theories and models that inform the design of teaching-learning frameworks to bridge the agricultural extension gap. It identifies the complexities surrounding the agricultural extension gap, emphasizing the need for a multi-theoretical approach to effectively address the diverse needs of farmers. The theories reviewed include Multimedia Learning Theory, Adult Learning Theory, Social Learning Theory, Theory of Planned Behavior, Social Exchange Theory (SET), Resource-Based View (RBV), Actor-Network Theory (ANT), Information Systems Success Model, Contextual Integrity Theory, and Task-Technology Fit (TTF). The models discussed include the Diffusion of Innovations Model, the Technology Acceptance Model (TAM), and the Unified Theory of Acceptance and Use of Technology (UTAUT). By synthesizing these theories and models, the article provides a comprehensive understanding of how they can enhance agricultural extension services.

Keywords: Agricultural Extension; Teaching-Learning; Theories; Models**.**

1. Introduction

The agricultural extension gap represents a significant challenge in improving agricultural productivity and enhancing farmers' livelihoods, particularly in developing regions. A multitude of theories and models can be employed to understand this gap and identify predictors and possible solutions. Notably, no single theory or model can comprehensively explain the complexities of the agricultural extension gap or provide a complete framework for understanding its causes and potential remedies. This underscores the necessity for a multi-theoretical approach.

In this context, a variety of theories are reviewed, including Multimedia Learning Theory, Adult Learning Theory, Social Learning Theory, Theory of Planned Behavior, Social Exchange Theory (SET), Resource-Based View (RBV), Actor-Network Theory (ANT), Information Systems Success Model, Contextual Integrity Theory, and Task-Technology Fit (TTF). Additionally, several models, such as the Diffusion of Innovations Model, Technology Acceptance Model (TAM), and Unified Theory of Acceptance and Use of Technology (UTAUT), are also examined. Collectively, these theories and models provide a foundational basis for developing a teaching and learning framework that can effectively address the agricultural extension gap.

2. Methodology

This study employs a literature review methodology, synthesizing existing research and theoretical frameworks relevant to agricultural extension and teaching-learning strategies. Various academic sources, including peer-reviewed journals, books, and conference papers, were analyzed to identify the key theories and models that inform the design of effective agricultural extension programs. The frameworks were evaluated based on their applicability, advantages, and disadvantages in the context of agricultural extension services.

* Corresponding author: Florah Kobusiingye

3. Results and discussion

3.1. Theories Guiding the Teaching-Learning Framework

3.1.1. Multimedia learning theory

This study is grounded in Richard Mayer's Cognitive Theory of Multimedia Learning, which posits that students learn more effectively through a combination of images and words rather than words alone (Mayer, 1997). The theory outlines multimedia learning as the integration of text or speech with static or dynamic visuals, emphasizing three key assumptions: the existence of two channels for processing information (audio and visual), the limited capacity of these channels, and the necessity of actively filtering and integrating new information with prior knowledge (Mutlu-Bayraktar et al., 2019).

This theory is particularly relevant for agricultural extension, as it indicates that farmers benefit from a blend of images and words in educational materials (Tayirova, 2023). Benefits include the use of videos for complex concepts, infographics for data, interactive elements for engagement, audio instructions, animations for processes, and social media for communication. However, challenges may arise from resource limitations, lack of expertise, insufficient digital tools, inadequate multimedia environments, and potential distractions from core content (Ozoda & Nigina, 2021). The Multimedia learning theory is presented by the model in Figure 1.

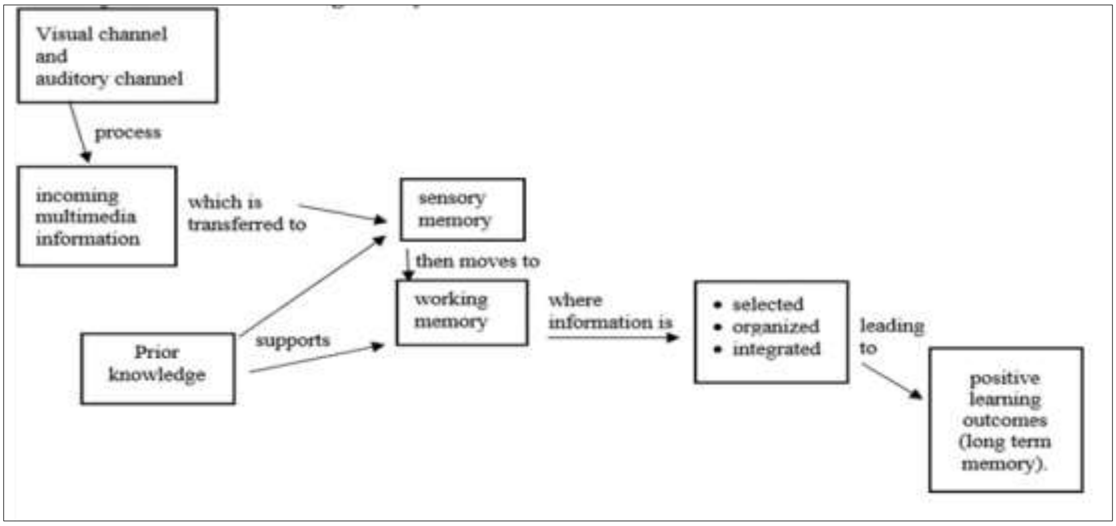

Figure 1 The MMLT model

3.1.2. Adult learning theory

Adult Learning Theory, or Andragogy, developed by Malcolm Knowles in 1968, emphasizes the distinct ways adults learn compared to children, highlighting effective teaching methods for adult learners (Rothwell, 2020). It asserts that adults are motivated to learn when they recognize the immediate benefits to their personal or professional lives. Key assumptions include that adults are self-directed, bring diverse experiences, prefer applicable and task-centered learning, and are driven by internal motivations such as self-esteem (Ferreira et al., 2018). In agricultural extension, andragogy can enhance educational effectiveness by treating farmers as independent decision-makers and valuing their practical experiences (Olaniyi, 2015).

Programs should focus on hands-on training tailored to specific needs and promote problem-solving through interactive learning methods like workshops and digital resources (Tennant, 2019). While andragogy increases motivation and engagement, its limitations include a lack of empirical support, potential neglect of social learning, and ineffectiveness for those lacking motivation or self-regulation (Conlan & Grabowski, 2021; Skidmore, 2023). The Adult learning theory is illustrated in Figure 2.

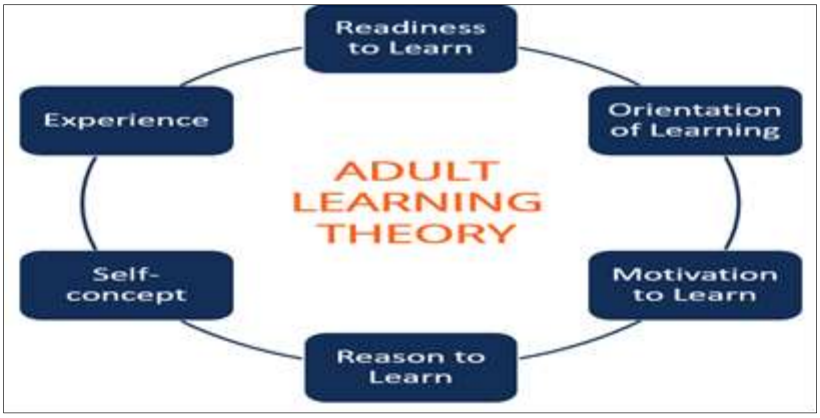

Figure 2 The Adult Learning Theory

3.1.3. Social learning theory

Social Learning Theory, proposed by Albert Bandura in the 1960s and formalized in 1977, posits that humans learn through social interactions by observing others and the consequences of their behaviors (Rotter, 2021). It emphasizes that learning occurs through observation, imitation, and modeling, independent of direct reinforcement (Dooley, 2020). Key assumptions include that individuals learn from role models, are likely to imitate rewarded behaviors, and must pay attention and be motivated to reproduce observed actions (Davis et al., 2017). This theory is particularly relevant in agricultural extension, as it facilitates knowledge acquisition and behavior change through social networks, with extension workers serving as role models to demonstrate best practices (Wojciechowski, 2021).

It supports peer learning and emphasizes the motivational impact of showcasing success stories and the influence of social norms (Allan, 2017). The advantages of Social Learning Theory include its comprehensive approach to learning and applicability to real-world contexts, while its limitations include a focus on observable behaviors that may overlook individual agency and cultural factors (Akers & Jensen, 2017; Albert, 2017; Scavarelli et al., 2021). The social learning theory is illustrated in Figure 3.

Figure 3 The social learning theory model

3.1.4. Theory of Planned Behavior

The Theory of Planned Behavior (TPB), developed by Icek Ajzen in 1985, seeks to understand and predict human behavior through three primary factors: attitude, subjective norms, and perceived behavioral control (Ajzen, 2020; Asare, 2015). These elements interact to shape an individual's intention to perform a behavior, which is the strongest predictor of actual behavior (Zhang, 2018). TPB categorizes beliefs into behavioral, normative, and control beliefs, each explaining variations in the respective factors. It is particularly relevant in agricultural extension, as it helps identify motivations and barriers affecting farmers' decisions to adopt new practices.

By assessing these factors, extension agents can design targeted interventions and communication strategies to promote behavior change (Cheng, 2019; Jokonya, 2017). The advantages of TPB include its comprehensive framework and adaptability across various contexts, making it a versatile tool for promoting agricultural practices (Holdsworth et al., 2019). However, limitations include potential oversimplification of complex decision-making processes, reliance on self-reported data, and a focus on individual determinants that may overlook broader influences (Heuckmann, Hammann, & Asshoff, 2019). The revised Theory of the Planned Behavior model is shown in Figure 4.

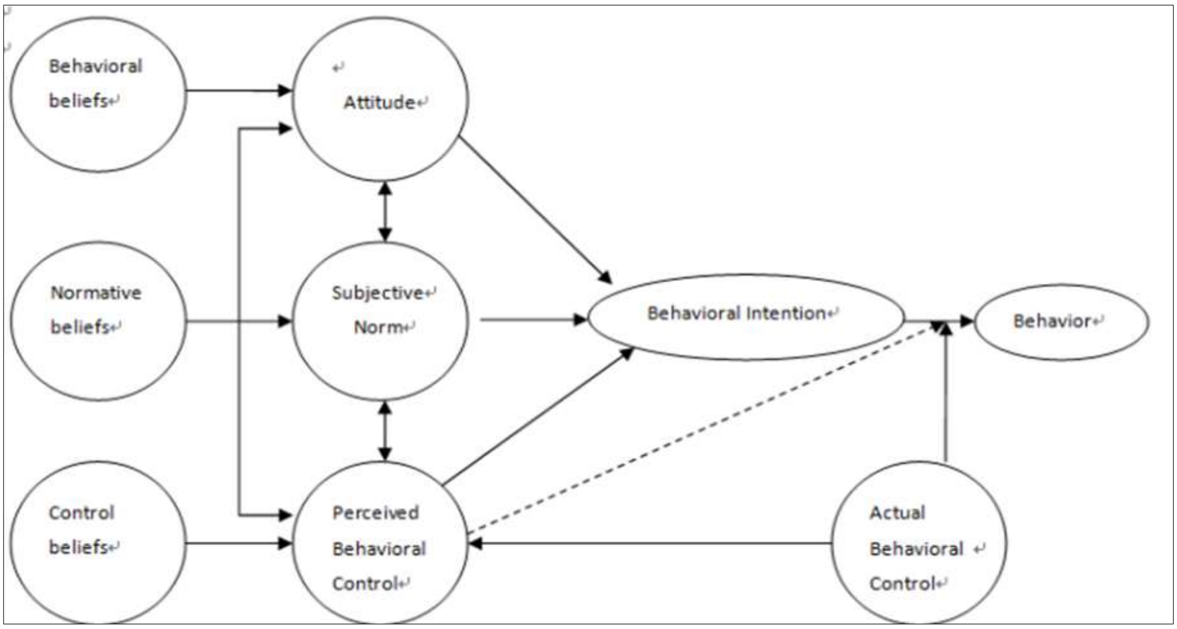

Figure 4 Revised Theory of Planned Behavior model

3.1.5. Social Exchange Theory (SET)

Social Exchange Theory (SET), introduced by Homans in 1958, describes social behavior as a process of exchanging resources where individuals seek to maximize benefits and minimize costs. The theory focuses on cost-benefit analysis and reciprocity, being applied to various interactions, including online communities (Cropanzano & Mitchell, 2017; Thibaut & Kelley, 2018). In the context of a mobile agricultural extension framework, SET encourages collaboration and knowledge sharing among farmers, fostering a supportive community (Eliot, 2019; Saha et al., 2021). Key assumptions of SET include the rationality of individuals in maximizing benefits, the mutual nature of social exchanges, interdependence in relationships, and evaluations based on perceived costs and benefits.

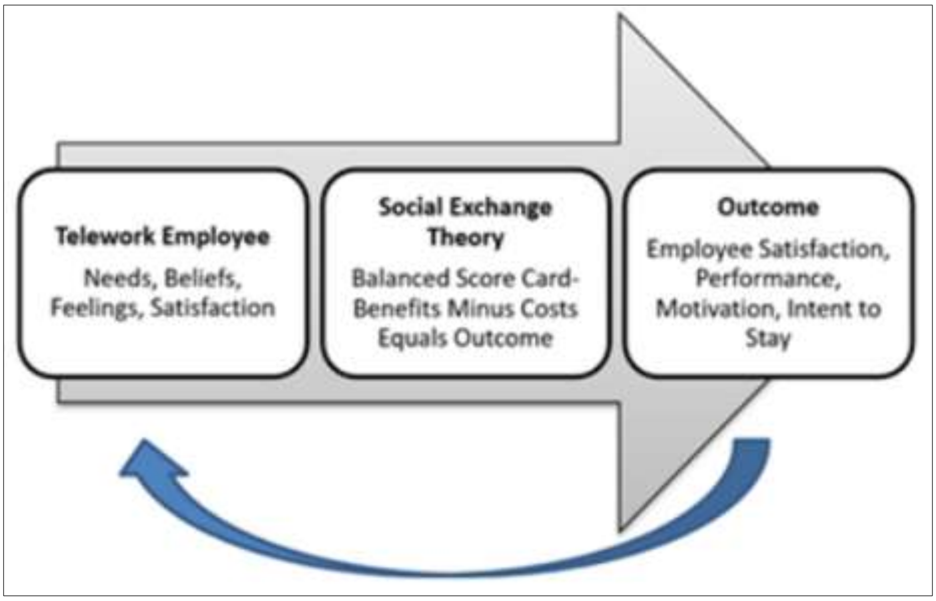

Figure 5 Social Exchange Theory

The model encompasses components such as Inputs (resources and information), Exchange Process (interactions), Outcomes (rewards and costs), Comparison Level (evaluations based on past experiences), and Comparison Level for Alternatives (assessing alternative outcomes). This framework is useful for analyzing farmer engagement with mobile apps, facilitating exchanges that can be measured in terms of costs (e.g., time, effort) and benefits (e.g., improved practices, increased yields). Promoting reciprocal interactions can enhance knowledge sharing and community support. The social exchange theory is shown in Figure 5.

3.1.6. Actor-Network Theory (ANT)

Actor-network theory (ANT), developed by Latour in 1987, views the technology adoption process as a network of both human and non-human actors. ANT emphasizes the relationships and interactions among various entities within a system and has been applied to study the dynamics of innovation adoption and stakeholder roles (Callon, 2021; Janson et al., 2023). In the context of a mobile agricultural extension framework, ANT can be utilized to map the relationships among farmers, extension workers, input suppliers, and researchers, thereby enhancing the understanding of the agricultural ecosystem and improving stakeholder engagement (Katz, 2019; Leach & Scoones, 2022).

The theory posits that social and technical elements are intertwined and equally significant; both human and non-human actors should be analyzed using the same conceptual frameworks; and the process by which actors negotiate and align their interests is central to understanding the network dynamics (Law & Hassard, 2020; Mager & Gubrium, 2023).

The theory involves actors: Human and non-human entities, a Network: The interconnected relationships among actors, and Translation: Processes of negotiation and alignment among actors. ANT is useful for mapping the relationships and interactions among farmers, extension workers, input suppliers, and researchers within the mobile-based framework. Understanding these dynamics can enhance the framework's design and implementation by ensuring all stakeholders' needs and interests are addressed. The Actor-Network Theory is shown in Figure 7.

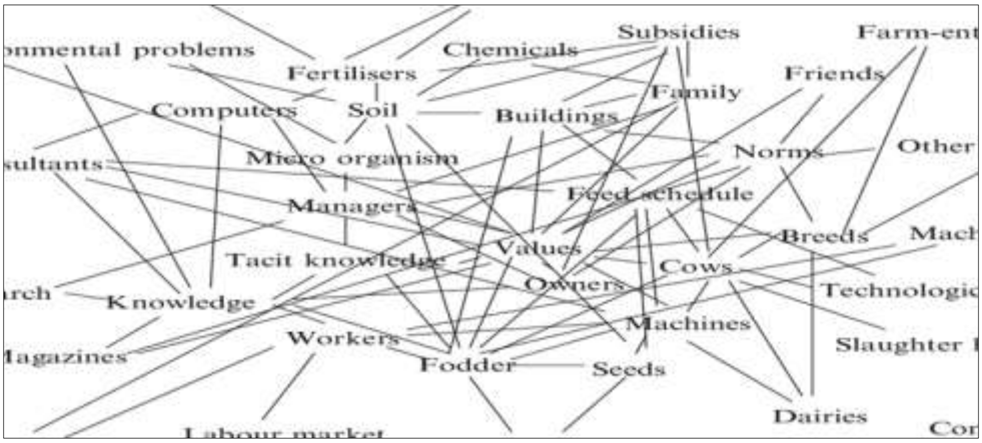

Figure 6 Actor-Network Theory (ANT)

3.1.7. Resource-Based View (RBV) Theory

The Resource-Based View (RBV) of the firm, originally proposed by Barney in 1991, emphasizes the importance of resources and capabilities in achieving competitive advantage. It has been widely used to study organizational strategy and innovation (Teece, 2018; Rook, 2020). In the context of a mobile-based agricultural extension framework, RBV can utilize local resources such as agricultural expertise, extension services, and mobile infrastructure to enhance the app's development and implementation (Ranjan & Read, 2020; Saha & Singh, 2023).

The RBV asserts that firms can gain and sustain competitive advantage by possessing valuable, rare, inimitable, and non-substitutable (VRIN) resources. The theory also assumes that resource heterogeneity is crucial for competitive advantage, as resources are not easily transferable between firms, and that effective management and utilization of resources are essential for sustaining this advantage (Barney, 2021; Peteraf & Barney, 2019). The Resource-Based View theory is shown in Figure 7

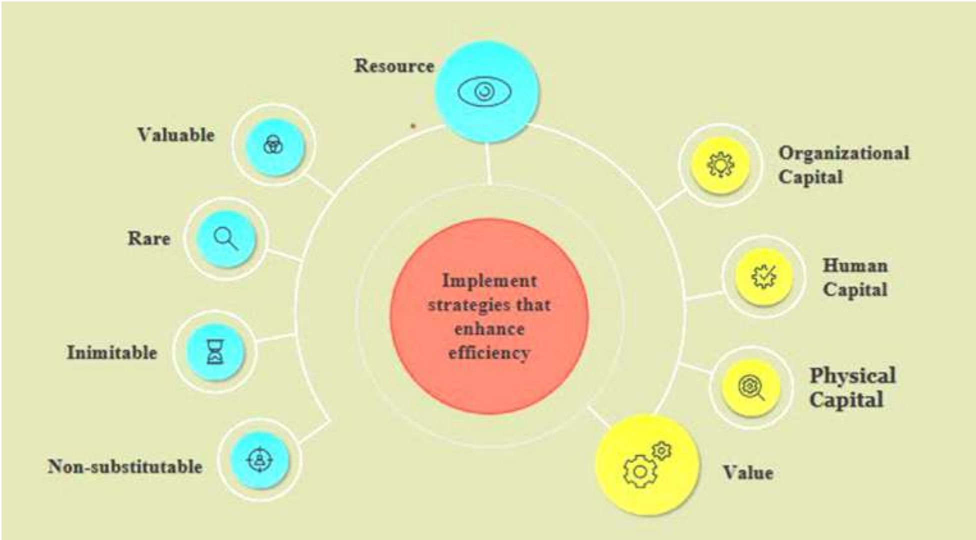

Figure 7 Resource-Based View (RBV) Theory

3.1.8. Information Systems Success Theory

The Information Systems Success Model, developed by DeLone and McLean (1992), identifies key factors contributing to the success of information systems, including system quality, information quality, and service quality. This model has been widely applied in various sectors, such as e-commerce and healthcare, to assess effectiveness (DeLone & McLean, 2016; Urbach & Müller, 2018). In a mobile agricultural extension framework, the model can measure app success through user satisfaction, usage frequency, and net benefits to agricultural practices (Petter et al., 2018; E. D. Johnson, 2020).

It posits that high-quality systems enhance user satisfaction, leading to positive net benefits (DeLone & McLean, 2016; Mahringer & Hopp, 2020). The model's dimensions include System Quality (performance metrics like reliability), Information Quality (accuracy and relevance), Service Quality (support service quality), User Satisfaction (user contentment), and Net Benefits (overall impact on users). Continuous feedback from farmers can enhance these dimensions, improving user satisfaction and agricultural outcomes (Hossain et al., 2021). The Information Systems Success theory is shown in Figure 8

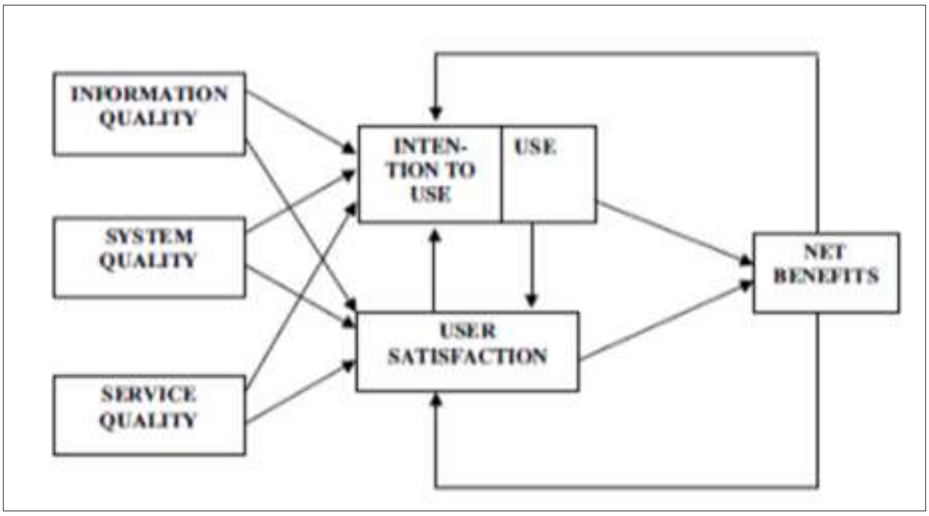

Figure 8 Information Systems Success Theory

3.1.9. Contextual Integrity Theory

Contextual Integrity Theory, proposed by Nissenbaum (2004), highlights the significance of context in understanding privacy issues, particularly in online interactions and information systems (Nissenbaum, 2010). In agricultural extension, addressing farmers' privacy concerns and designing apps that respect local cultural norms is essential for fostering acceptance and trust (Bennett & Raab, 2006). The theory posits that privacy is upheld when information flows adhere to contextual norms, asserting that privacy expectations differ across social contexts, and appropriate information flows must align with these norms. Key components of the theory include the context (specific social setting), norms (rules governing information flows), and information flows (transfer of information within that context). By aligning the mobile app design with local cultural practices, Contextual Integrity Theory can effectively address privacy concerns, enhancing user trust and acceptance. The Contextual Integrity Theory is shown in Figure 9.

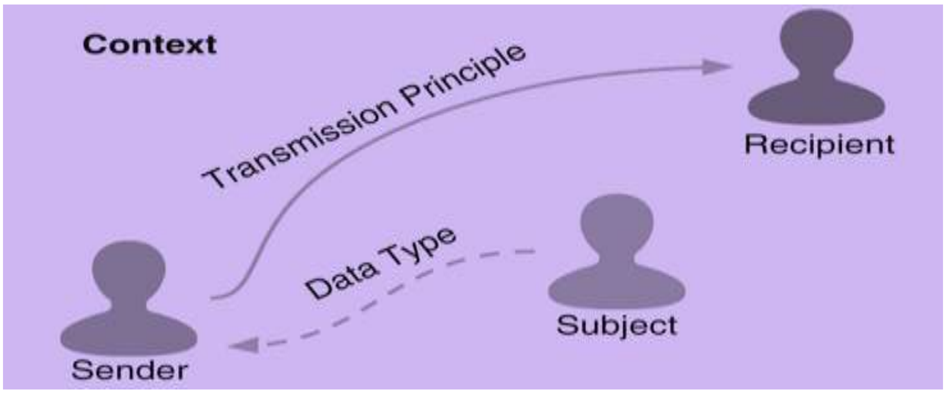

Figure 9 *Contextual* Integrity Theory

3.1.10. Task-Technology Fit (TTF)

Task-Technology Fit (TTF) theory, proposed by Goodhue and Thompson (1995), asserts that technology positively impacts performance when it aligns with the tasks it supports. TTF evaluates how effectively technology meets user task requirements and has been applied in various domains, including enterprise systems and mobile technologies (Davis et al., 2020). In agricultural extension, ensuring that mobile apps address specific farming tasks such as crop management and market information can significantly enhance their effectiveness and adoption (Zhou et al., 2022).

The theory posits that the alignment between task requirements and technology capabilities directly influences performance outcomes. Key components include task characteristics (specific user tasks), technology characteristics (capabilities of the technology), task-technology fit (the alignment between tasks and technology), and performance impact (the effects of this fit on user performance). By designing mobile apps to effectively support farming tasks, TTF theory can enhance user adoption and improve overall agricultural practices (Alharbi et al., 2023). The Task-Technology Fit Theory is shown in Figure 10.

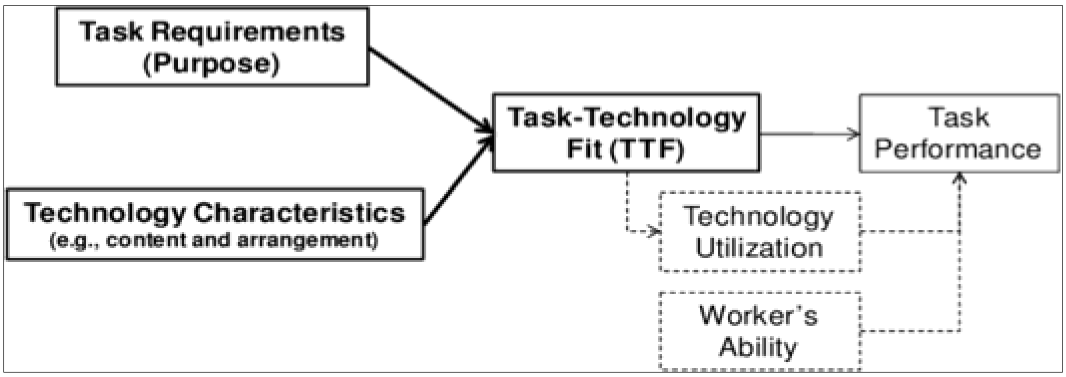

Figure 10 Task-Technology Fit (TTF**)**

4. A Comprehensive Summary of discussed theories

This table summarizes the key theories discussed, highlighting their descriptions, assumptions, and relevance to the study of bridging the agricultural extension gap. Each framework provides valuable insights that can inform the design of effective teaching and learning strategies within agricultural extension programs.

Table 1 The comprehensive summary of the theories described above

Theory/Model	Description	Assumptions	Relevance in this Study
Multimedia Learning Theory	Emphasizes learning through multiple media formats.	Learners benefit from diverse information presentations.	Enhances engagement and comprehension in extension services.
Adult Learning Theory	Focuses on characteristics of adult learners.	Adults are self-directed and bring prior knowledge.	Facilitates relevant, practical learning experiences.
Social Learning Theory	Asserts that learning occurs through observation and interaction.	Social interactions influence learning outcomes.	Promotes peer-to-peer learning networks among farmers.
Theory of Planned Behavior	Suggests that intentions are influenced by attitudes, norms, and perceived control.	Intentions predict actual behaviors.	Helps identify barriers to adopting new practices.
Social Exchange Theory (SET)	Proposes that social behavior results from an exchange process.	Relationships are based on perceived benefits.	Encourages trust and reciprocity in extension relationships.
Resource-Based View (RBV)	Emphasizes the role of resources in achieving competitive advantage.	Local resources can enhance extension effectiveness.	Supports the sustainable use of local agricultural resources.
Actor-Network Theory (ANT)	Explores relationships between human and non-human actors.	All actors, human and non-human, influence outcomes.	Provides a holistic understanding of the extension system.
Information Systems Success Model	Assesses the effectiveness of information systems based on user satisfaction.	User satisfaction is critical for system success.	Evaluates the effectiveness of information dissemination.
Contextual Integrity Theory	Emphasizes the importance of context in information flow and privacy.	Contextual factors influence the appropriateness of exchanges.	Ensures culturally relevant communication strategies.
Task-Technology Fit (TTF)	Focuses on the alignment between tasks and technology.	Successful adoption depends on task-technology alignment.	Enhances the likelihood of technology adoption among farmers.

4.1. Relevant Models

4.1.1. Diffusion of Innovations model

The Diffusion of Innovations model, developed by Everett Rogers in 1962, explains how new ideas, technologies, and practices spread through societies (Dearing & Cox, 2018). Key attributes influencing adoption include relative advantage, compatibility, complexity, trial-ability, and observability (Vagnani & Volpe, 2017). Rogers categorized adopters into five groups: innovators, early adopters, early majority, late majority, and laggards (Dale et al., 2021). The model operates on several assumptions, including that innovations are adopted over time, that diffusion occurs through communication channels, and that it unfolds within a social system (Nemutanzhela & Iyamu, 2015).

It also describes an S-shaped adoption curve and a five-stage decision-making process: knowledge, persuasion, decision, implementation, and confirmation (Kristensson et al., 2020). In agricultural extension, the model helps professionals identify and tailor strategies for different adopter categories, facilitating the adoption of innovative practices (Lutuli, 2019). While the model offers valuable insights, it may oversimplify the adoption process by not accounting for socio-economic and cultural factors, feedback loops, and the dynamic nature of technology adoption (García-Avilés, 2020; Wani & Ali, 2015). The Diffusion of Innovations model is shown in the figure below.

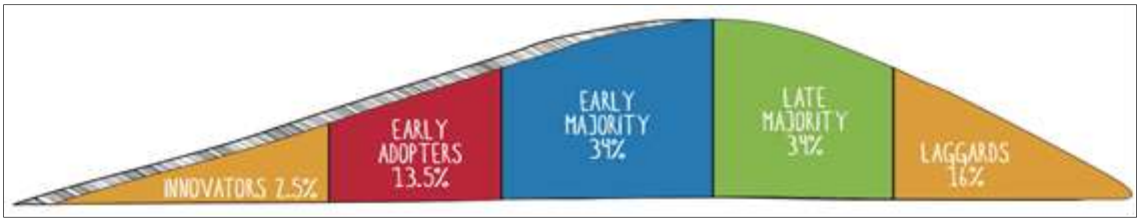

Figure 11 Diffusion of Innovation Model

4.1.2. The TAM Model

The Technology Acceptance Model (TAM), developed by Fred Davis in 1986, predicts users' acceptance of new technologies based on their perceived usefulness and perceived ease of use (Ajibade, 2018). Widely applied in agricultural extension, TAM helps extension agents understand farmers' attitudes towards adopting innovations and tailor interventions to increase adoption rates (Granić & Marangunić, 2019). By assessing perceptions of technology, extension programs can address specific barriers and effectively communicate benefits, ultimately improving agricultural productivity and livelihoods (Fedorko et al., 2018).

Advantages of TAM include its structured framework for predicting technology adoption, identification of influencing factors, guidance for developing effective extension strategies, and insights into technology transfer (Napitupulu et al., 2017). However, TAM has limitations: it may oversimplify the technology adoption process by neglecting socio-economic and cultural contexts, assumes perceived usefulness and ease of use as primary factors, and does not fully account for the influence of social networks and community norms on adoption decisions (Al-Azawei et al., 2017). The TAM model is as shown in shown in Figure 12.

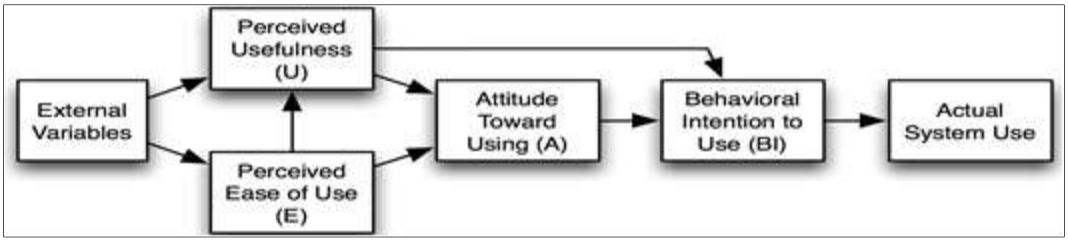

Figure 12 The TAM model.

4.1.3. Unified Theory of Acceptance and Use of Technology (UTAUT) Model

The Unified Theory of Acceptance and Use of Technology (UTAUT), developed by Venkatesh et al. in 2003, is a comprehensive framework that identifies four key factors influencing technology acceptance: performance expectancy, effort expectancy, social influence, and facilitating conditions. Additional variables such as gender, age, experience, and voluntariness of use also affect technology adoption (Marikyan & Papagiannidis, 2021; Tussardi et al., 2021).

In agricultural extension, UTAUT can help identify stakeholders, analyze farmers' attitudes toward new technologies, and tailor programs to meet specific needs (Xie et al., 2022). The model emphasizes social influence, encouraging peer learning to foster trust in technology adoption. It also provides a framework for evaluating the effectiveness of extension programs and adapting interventions based on monitored outcomes (Azmi et al., 2023).

The advantages of UTAUT include its integration of various technology acceptance theories, versatility across different settings, clear framework for understanding drivers of behavior, and adaptability to specific populations (Almaiah et al., 2019). However, its limitations include a focus on individual determinants, overlooking broader contextual factors, emotional influences, and the dynamics of social relationships. Additionally, UTAUT may not fully capture post-adoption behaviors or cultural influences (Barrane et al., 2018; Chao, 2019). The UTAUT model is as shown in shown in Figure 13.

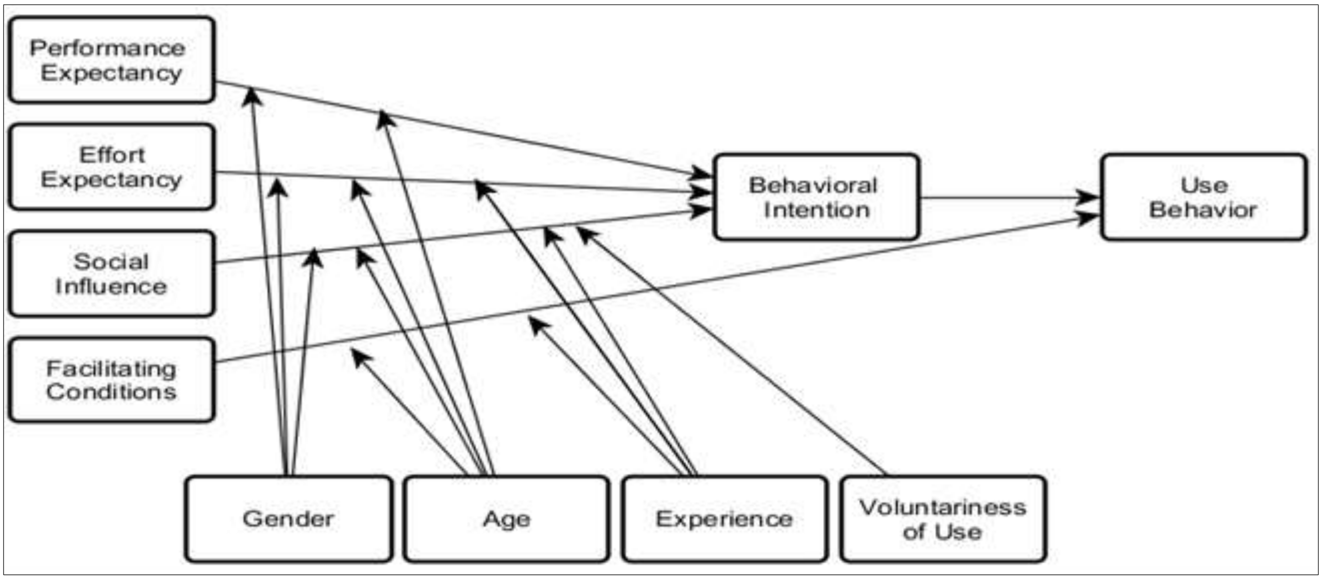

Figure 13 The UTAUT model

4.2. Comprehensive Summary of the Discussed Models

The table below summarizes the key models discussed, highlighting their descriptions, assumptions, and relevance to the study of bridging the agricultural extension gap. Each model provides valuable insights that can inform the design of effective teaching and learning strategies within agricultural extension programs.

Table 2 The comprehensive summary of the theories described above and their relevancy in this study

Model	Description	Assumptions	Relevance in this Study
Diffusion of Innovations Model	Explains the spread of new ideas and technologies.	Innovations diffuse through social networks.	Guides strategies for promoting innovative agricultural practices.
Technology Acceptance Model (TAM)	Posts that are perceived as ease of use and usefulness influence acceptance.	Users' perceptions determine technology adoption.	Provides insights into farmers' technology acceptance.
Unified Theory of Acceptance and Use of Technology (UTAUT)	Integrates multiple factors influencing technology acceptance.	Various constructs affect technology acceptance.	Facilitates a comprehensive approach to understanding adoption behaviors.

5. Discussion

The integration of various theories and models in designing teaching-learning frameworks for agricultural extension highlights the complexity of addressing the agricultural extension gap. Utilizing approaches such as Andragogy emphasizes the importance of recognizing adult learners' experiences and self-directed nature, while the Cognitive Theory of Multimedia Learning advocates for the use of engaging visual and verbal materials to enhance comprehension among farmers.

Additionally, Task-Technology Fit Theory underscores the need for technology that aligns with specific farming tasks to improve adoption rates. The Diffusion of Innovations model aids in understanding how new practices spread within communities, allowing extension services to identify and leverage early adopters for broader acceptance.

Furthermore, the Technology Acceptance Model and the Unified Theory of Acceptance and Use of Technology provide insights into the perceptions and social influences affecting farmers' willingness to embrace new technologies. By synthesizing these theories, agricultural extension can develop effective, context-sensitive educational programs that empower farmers to adopt innovative practices and bridge the gap between research and application, ultimately enhancing productivity and livelihoods.

Recommendations

Tailor Learning Approaches: Design educational programs that accommodate adult learning principles, recognizing farmers' self-directedness and diverse experiences to foster engagement and ownership of the learning process.

Incorporate Multimedia Resources: Utilize a combination of visual aids, videos, and interactive content to support diverse learning styles and enhance understanding of complex agricultural concepts.

Align Technology with Farming Tasks: Ensure that any technology or tools introduced are closely aligned with the specific tasks farmers perform, enhancing practicality and usability for better adoption rates.

Leverage Early Adopters: Identify and engage early adopters within agricultural communities to act as champions for new practices and technologies, facilitating peer-to-peer learning and encouraging wider acceptance.

Emphasize Perceived Benefits: Communicate the advantages and ease of use of new agricultural technologies to address any concerns or misconceptions farmers may have, increasing their perceived usefulness.

Create Supportive Networks: Foster collaborative networks among farmers, extension agents, and researchers to facilitate knowledge sharing, feedback, and support, addressing barriers to adoption collectively.

Evaluate Contextual Factors: Regularly assess socio-economic, cultural, and institutional contexts that influence technology acceptance to ensure that interventions are relevant and effective for specific communities.

Monitor and Adapt Programs: Establish mechanisms for continuous evaluation of educational programs to identify challenges and successes, allowing for timely adjustments to improve effectiveness and impact. Regular assessments of farmers' attitudes and perceptions toward new technologies can inform the design of relevant interventions.

Promote Sustainability: Incorporate long-term sustainability and scalability considerations into the design of agricultural innovations and practices to ensure lasting benefits for farmers and their communities.

Integrate Local Knowledge: Respect and integrate indigenous practices and local knowledge into extension programs to enhance the relevance and acceptance of new technologies among farmers.

Adopt a Multi-Theoretical Approach*:* Agricultural extension programs should integrate various theories to design comprehensive and effective teaching-learning frameworks.

6. Conclusions

Bridging the agricultural extension gap requires a robust understanding of the theories and models that guide teaching and learning frameworks. By employing a multi-theoretical approach, agricultural extension services can design programs that effectively address the diverse needs of farmers, fostering sustainable agricultural development and improving livelihoods. The insights gained from this study can inform future research and practice in agricultural extension, ultimately contributing to enhanced productivity and innovation in the agricultural sector.

Compliance with ethical standards

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I would like to express my heartfelt gratitude to my research supervisors and mentors, Dr. Richard Ssembatya, Dr. Fred Kaggwa, and Assoc. Prof. Annabella Hambinka Ejiri, for their invaluable guidance, support, and encouragement throughout this literature review. Their expertise and insights have significantly contributed to the quality and depth of this work.

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Disclosure of conflict of interest

I confirm that there were no conflicts of interest that could have influenced the conduct or outcomes of this literature review. I also respected privacy and confidentiality, especially in cases involving individual or organizational data, using anonymization where necessary. By upholding these standards, I have ensured the integrity and reliability of this literature review.

Statement of ethical standards

During my review of literature on teaching-learning theories and models for bridging the agriculture extension gap, I observed all necessary ethical standards. I accurately cited all sources, ensuring respect for intellectual property and avoiding plagiarism. Transparency and honesty were maintained throughout, as I aimed to present findings impartially and without selective reporting, ensuring a balanced representation of diverse perspectives.

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