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Competencies and Training Needs of Extension Agents for Educating Farmers on Genetically Engineered Crops in Uganda

N. Mugwanya[1], K. S. U. Jayaratne[2], J. D. Bloom[3], J. L. Donaldson[4], J. Delborne[5]

Abstract

The purpose of this study was to determine the training needs of extension agents in Uganda to lead successful education programs on genetically engineered (GE) crops. This was a descriptive survey research study conducted online with public agricultural extension agents in the eastern agro-ecological zone of Uganda. This study used Borich's method to identify training needs. A survey instrument was designed to determine extension agents' perceived importance and proficiency of 60 competencies organized under the eight Public Issues Education (PIE) framework competency constructs. The survey received 58 usable responses comprising an 83% response rate. All eight PIE competency constructs were perceived by the extension agents to be important. This study identified additional four competencies important for PIE in addition to the eight competencies in the model. Agents' greatest training needs were creating partnerships and designing GE education programs. The lowest training needs were creating an environment of professionalism and managing conflicts. The findings indicate the importance of training extension agents on how to engage with farmers in new ways to educate them on GE technology. This study provides implications for determining the training needs of extension agents in PIE such as educating farmers on GE technology.

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1. Nassib Mugwanya, Doctoral Fellow, Department of Agricultural and Human Sciences, North Carolina State University, Campus Box 7607, Raleigh, NC 27695, nmugwan@alumni.ncsu.edu, https://orcid.org/0000-0002-9029-334X
2. K. S. U. Jayaratne, Professor and State Leader for Extension Evaluation, 240 Ricks Hall, Campus Box 7607, Department of Agricultural and Human Sciences, North Carolina State University, Raleigh, NC 27695, jay_jayaratne@ncsu.edu, https://orcid.org/0000-0001-5591-3905
3. J. Dara Bloom, Associate Professor and Local Foods Extension Specialist, 250 Ricks Hall, Campus Box 7607, Department of Agricultural and Human Sciences, North Carolina State University, Raleigh, NC 27695, jdbloom@ncsu.edu, https://orcid.org/0000-0001-7428-6767
4. Joseph L. Donaldson, Associate Professor and Extension Specialist, Director of Undergraduate Programs, 248 Ricks Hall, Campus Box 7607, Department of Agricultural and Human Sciences, North Carolina State University, 1 Lampe Drive, Raleigh, NC 27695, joseph_donaldson@ncsu.edu, https://orcid.org/0000-0002-9276-3747
5. Jason Delborne, Professor, Department of Forestry and Environmental Resources, Genetic Engineering and Society Center Department of Forestry & Environmental Resources, North Carolina State University, Jordan Hall Addition #5221, Campus Box 8008, Raleigh, NC 27695-8008, jadelbor@ncsu.edu, https://orcid.org/0000-0001-6436-782X

Introduction and Problem Statement

Modern biotechnologies, such as genetic engineering (GE), are widely discussed as potential tools to address food security challenges, especially in the Global South (Fedoroff, 2015; Qaim, 2020). In Uganda, at least five major crops are being developed using GE to improve nutrition and reduce food security threats such as pests and diseases, declining soil fertility, and climate change—with the goal to disseminate GE crops to small farm owners (Kikulwe et al., 2020; Komen et al., 2020; Paul et al., 2017; Yadav et al., 2011). However, GE crop development has generated considerable public concerns and controversy (Lukanda, 2020; Tibasaaga & Mugwanya, 2018).

When educating farmers on GE technology, the traditional top-down technology transfer approach used by extension agents in providing advisory services may not work with GE due to controversies associated with GE (Gay et al., 2017; Singletary et al., 2007). Also, the extension approach has been widely criticized for being ineffective in educating farmers on controversial GE technology (Ahteensuu, 2012; Calo, 2018; Cook et al., 2021; Faure et al., 2012; Hansen et al., 2003; Kamara et al., 2021; Klerkx, 2020; Tarekegne et al., 2017). The major unresolved challenge is how agricultural extension agents should educate farmers on GE technologies so that their advisory services are more relevant and effective (Faure et al., 2012; Klerkx, 2020).

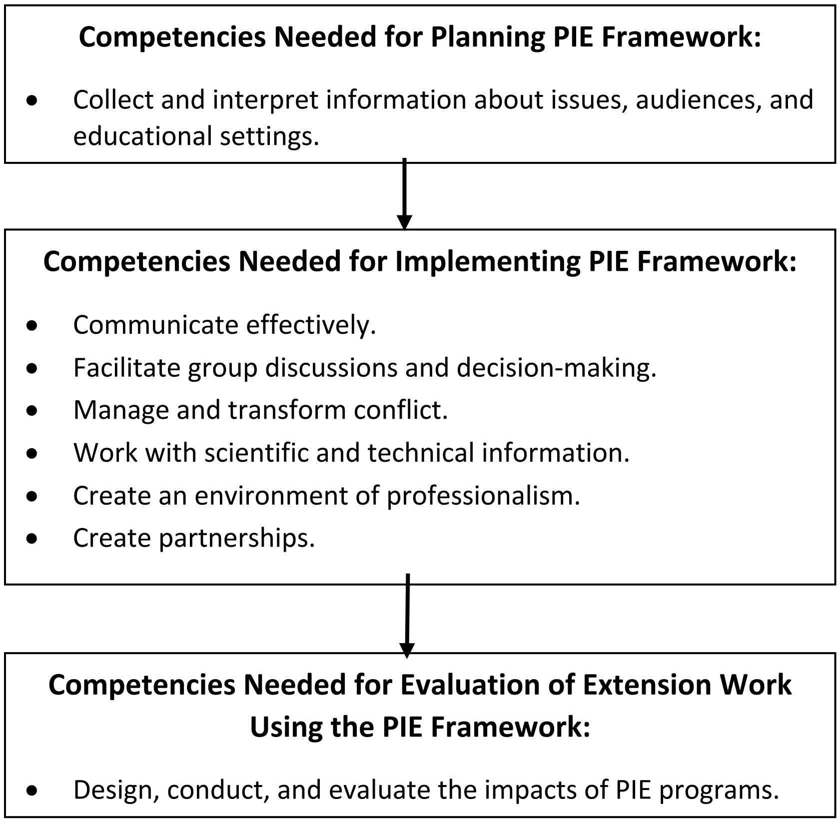
Approaches that are more system-oriented, participatory, and deliberative (unlike knowledge deficit approaches) have been found to be effective at addressing controversial scientific technologies, such as GE crops (Abelson et al., 2003; Barnhill-Dilling et al., 2020; Gay et al., 2017; Kokotovich et al., 2020; Singletary et al., 2007). For extension agents, the public issues education (PIE) framework (Smutko et al., 2002) presents a potential solution for educating farmers about GE technology. However, the competencies and training needs of extension agents to conduct extension programs on controversial topics such as GE crops using the PIE framework in agriculture remain under-investigated in agricultural extension literature.

Conceptual Framework

The PIE framework (Smutko et al., 2002) provided the conceptual foundation for this study. The PIE framework provides one of the most comprehensive frameworks for assessing extension programs on complex and controversial technologies (Smutko et al., 2002). This framework was developed by a national task force of extension professionals in the United States, and they identified a set of 53 core competencies that extension agents need to conduct effective educational programs on complex public issues. These core competencies have been organized under eight broad constructs namely Creating partnerships; Collecting and interpreting data about issues, audiences, and educational settings; Designing public issues education programs; Communicating effectively; Facilitating group discussion and decision-making; Managing and transforming conflict; Working with scientific and technical information; and Creating an environment of professionalism, which can be grouped into extension program planning, implementation, and evaluation as shown in Figure 1.

Figure 1

Public Issues Education Competency Framework



Singletary et al. (2007) used the PIE framework to assess the capacity of extension agents in the United States to conduct PIE, while Grudens-Schuck (2003) explored the evaluation challenges associated with PIE. Others have recommended expanding the PIE framework to include pertinent issues in agriculture and natural resources in different contexts (Gay et al., 2017). Although the PIE framework provides several core competencies for assessing extension agents on conducting education programs on controversial issues, its application to studying GE crops as a controversial issue in agriculture is not documented. Educating farmers on GE crops in Uganda is still a public issue because of the wide public concerns associated with GE crops (Kennedy & Thigpen, 2020), and the dissemination of GE crops requires extension agents to develop public issues education competencies. Therefore, this study adopted the PIE framework to assess the competencies that are important for extension agents to conduct PIE programs on GE crops in Uganda.

Purpose

The purpose of this study was to determine the training needs of extension agents in Uganda to lead successful education programs on GE crops. Specifically, the study sought to achieve the following objectives:

1. To determine which competencies are important for extension agents in Uganda to engage in successful public issues education programs on GE crops.
2. To determine the self-reported proficiency levels of extension agents in Uganda on important competencies for conducting PIE on GE crops.
3. To identify the training needs of extension agents involved in education activities on GE crops in Uganda.

Methods

The population of the study was 70 public extension agents in the eastern agroecological zone of Uganda who had actively participated in biotechnology education and outreach activities with farmers during the 2018-2021 period. The participants were from the districts of Budaka, Iganga, and Kaliro. These districts predominantly produce crops such as maize and cassava, which are among the major crops currently under GE research in Uganda (Komen et al., 2020; Yadav et al., 2011). Noteworthy, this region previously had educational workshops on biotechnology for extension agents organized by public sector scientists involved in biotechnology research (Tibasaaga & Mugwanya, 2018). Because of that, this population may not represent the agriculture extension agents who did not complete any GE training among the 2000 extension professionals in Uganda (GFRAS, 2023). This is a limitation of this study.

We collected data using a web-based survey developed with the online Google Forms software in the summer of 2021. The PIE framework (Smutko et al., 2002) provided the foundation for the instrument development (Abelson et al., 2003; Ahteensuu, 2012), and the instrument was designed to determine extension agents' perceptions of the importance of 60 competencies organized within eight competency constructs for a successful PIE program on GE crops. We modified the initial eight-construct PIE framework with 53 items to include 60 items (Mugwanya, 2022) identified through a review of the literature (Diaz et al., 2020; Harder, 2015; Khalil et al., 2009; Kibwika et al., 2009; Liles & Mustian, 2004; Lopokoiyit et al., 2013; Rothwell et al., 2013; Scheer et al., 2011; Smutko et al., 2002; Singletary et al., 2007) and organized under eight constructs of the PIE competency scale (Table 1). We used the Borich (1980) needs assessment method to develop the instrument because it has been used in similar studies with similar audiences in Africa (Olorunfemi et al., 2020; Shimali et al., 2021) and documented its effectiveness in extension needs assessment. For each item in the survey, we used the term genetically modified organisms (GMOs) as that is the term most used by the audience for GE crops. Participants were asked to first rate their perception of the level of importance of each item in conducting PIE programs on GMOs on a five-point Likert-type scale, *not important* (1), *slightly important* (2), *moderately important* (3), *important* (4), and *extremely important* (5), and to then rate their current level of proficiency in each item on a five-point Likert-type scale, *very low* (1), *low* (2), *average* (3), *high* (4), and *very high* (5). We interpreted the mean values rated 4 and above as important competencies.

Table 1

PIE Competency Constructs

PIE Competency Construct	Number of Competency Items
1. Creating Partnerships	7
2. Collecting and Interpreting Data about GMOs, Audiences, and Educational Settings	15
3. Designing Education Programs on GMOs	6
4. Communicating Effectively	4
5. Facilitating Group Discussion and Decision Making	11
6. Managing and Transforming Conflict	7
7. Working with Scientific and Technical Information	7
8. Creating an Environment of Professionalism	3

In addition to the 60 competency items listed in the scales, respondents were asked to identify any competencies not included in the survey that they felt were extremely important to lead a successful PIE program on GMOs. A panel of four experts in extension education reviewed the instrument to establish the content validity of the instrument. The Cronbach's reliability Alpha values ranged between 0.69 and 0.92 for various constructs of the competency scale, which is a range in which the proportion of a test score attributable to error is minimal (Tavakol & Dennick, 2011). To maximize the response rate, the tailored design method (Dillman, 2014) was incorporated into the survey's design and delivery. There were 58 usable responses to the survey, out of a possible 70, yielding an 83% response rate. To control for non-response error, early and late responders were compared to determine if statistical differences existed (Lindner et al., 2001), with late responders defined as those completing the survey after the third reminder. An independent *t*-test compared early and late respondents with no statistical differences found between the two groups. Data were analyzed using the statistical package for the social sciences (SPSS), version 27. We used Borich's (1980) method and calculated the mean weighted discrepancy scores (MWDS) to identify training needs. Borich's (1980) method calculates the training need for each competency by first subtracting the perceived proficiency level score from the perceived importance level score, producing a discrepancy score that is then multiplied by the mean perceived importance score to give a weighted discrepancy score for each respondent. In the final step, weighted discrepancy scores are summed and divided by the number of responses for each item to produce the mean weighted discrepancy score (MWDS). Higher MWDS values indicate an item has a higher training need than those with lower MWDS values. Mean weighted discrepancy scores were calculated for each of the eight competency constructs on PIE.

Findings

All eight competency constructs were rated important. The overall mean scores for rating their importance ranged from 4.07 (creating partnerships) to 4.36 (communicating effectively). The importance mean scores of 60 specific items ranged from 3.93 to 4.48 (Mugwanya, 2022). Mean scores of individual competency items within each construct were aggregated and then divided by the total number of competency items within the construct to give an overall mean score that allowed for the comparison and ranking of eight PIE competencies. For example, the “building partnerships” construct consisted of seven competency items. When the mean of the “building partnerships” construct was estimated, the means of seven items were aggregated and divided by seven. The construct perceived as the most important was communicating effectively, with a mean score of 4.36. The construct perceived as the least important was creating partnerships as shown in Table 2.

Table 2

Perceived Importance of Competency Constructs

Competency Construct	Mean	SD	Rank
Communicating Effectively	4.36	0.54	1
Managing and Transforming Conflict	4.31	0.57	2
Working with Scientific and Technical Information	4.31	0.51	2
Designing Education Programs on GMOs	4.26	0.54	4
Creating an Environment of Professionalism	4.25	0.67	5
Facilitating Group Discussion and Decision Making	4.24	0.51	6
Collecting and Interpreting Data about GMOs, Audiences, and Educational Settings	4.15	0.38	7
Creating Partnerships	4.07	0.45	8

Note. Scale: *not important* (1), *slightly important* (2), *moderately important* (3), *important* (4), and *extremely important* (5)

The respondents were asked to indicate any other competency they consider as important for PIE in educating the public on GMOs, and six unique responses from nine respondents were received outside of the eight competency constructs included in the instrument. The analysis of these six competency items can be identified into four competency categories namely (a) time management, (b) professional ethics, (c) motivation, and (d) professional flexibility (Table 3).

Table 3

Identified New Competencies Important for Educating Public on GMOs

Number of Responses	Competency Item	Competency Category
3	Should have time management skills	Time management*
1	Be a person of integrity	Professional ethics*
1	Should be transparent	
2	Self-driven to work and promote GMOs	Motivation*
1	Ability to multi-task	Professional flexibility*
1	Ability to move from one area to another to deliver messages on GMOs	

*New competencies not represented in the survey instrument

The proficiency mean scores of 60 specific items ranged from 3.16 to 4.05. Mean scores of specific competencies within each of the eight constructs were aggregated and then divided by the total number of specific competency items within the construct to give an overall mean score that allowed for the comparison and ranking of constructs for proficiency levels. Managing and transforming conflict was the construct in which agents reported themselves as having the highest proficiency, with a mean score of 3.86. Creating partnerships was the construct agents perceived themselves as having the least proficiency, with a mean score of 3.32 as shown in Table 4. The proficiency level mean scores and ranks for each competency construct are listed in Table 4.

Table 4

Perceived Competency Mean Scores, and Rank for Eight Proficiency Constructs

Construct	Mean	SD	Rank
Managing and Transforming Conflict	3.86	1.92	1
Communicating Effectively	3.84	0.54	2
Creating an Environment of Professionalism	3.76	0.77	3
Working with Scientific and Technical Information	3.63	0.64	4
Facilitating Group Discussion and Decision Making	3.60	0.56	5
Designing Education Programs on GMOs	3.56	0.75	6
Collecting and Interpreting Data about GMOs, Audiences, and Educational Settings	3.45	0.58	7
Creating Partnerships	3.32	0.64	8

Note. Scale: *very low* (1), *low* (2), *average* (3), *high* (4), and *very high* (5)

Training needs were identified by the calculation of mean weighted discrepancy scores. At the broader competency construct level, MWDS scores ranged from 1.94 to 3.07. The construct with the highest MWDS and therefore the greatest training need was creating partnerships, with a score of 3.07, while the construct with the lowest training need was managing and transforming conflict, with a score of 1.94. Mean weighted discrepancy scores and training need rank for all competency constructs are listed in Table 5. For comparison, overall mean scores and ranks of the importance level and self-reported proficiency level of each construct are also listed.

Table 5

Comparison of Competency Construct Importance Scores, Rank, and Proficiency Level Scores

Competency Construct	Importance mean	Proficiency Mean	MWDS	Priority Rank of Training Needs Based on MWDS (Ranged from 1=most needed to 8=least needed)
Creating Partnerships	4.07	3.32	3.07	1
Designing Education Programs on GMOs	4.26	3.56	3.02	2
Working with Scientific and Technical Information	4.31	3.63	2.94	3
Collecting and Interpreting Data about GMOs, Audiences, and Educational Settings	4.15	3.45	2.89	4
Facilitating Group Discussion and Decision Making	4.24	3.60	2.73	5
Communicating Effectively	4.36	3.84	2.27	6
Creating an Environment of Professionalism	4.25	3.76	2.08	7
Managing and Transforming Conflict	4.31	3.86	1.94	8

Note. Importance Scale: *not important* (1), *slightly important* (2), *moderately important* (3), *important* (4), *and extremely important* (5)
Competence Scale: *very low* (1), *low* (2), *average* (3), *high* (4), and *very high* (5)

Conclusions, Discussion, and Recommendations

All eight PIE competency constructs were perceived by the extension agents in Budaka, Iganga, and Kaliro districts of Uganda to be important. The findings of this study can be directly applicable to this population and may not apply to other extension agents. This is a limitation of this study. However, this study provides some implications for exploring the training needs of agricultural extension agents in educating farmers on controversial technologies such as GE technology using the PIE competency framework.

These findings are in line with other studies that also found the eight competency constructs to be important for extension programs on PIE (Gay et al., 2017; Singletary et al., 2007). However, this study is unique because it explored the application of PIE in determining the training needs of extension agents for educating farmers on GE crops. The highest and lowest rated constructs, communicating effectively (*M* = 4.36) and creating partnerships (*M* = 4.07), were separated by a 0.29 range on a five-point scale, indicating proximity in the perceived importance of eight constructs.

Professional ethics, time management skills, motivation, and professional flexibility emerged as additional four competency categories useful in PIE (Table 3). Time management and flexibility were also identified as important competencies needed by extension agents to thrive in the 21st century (Lakai et al., 2014). Some studies have explored ethics on the introduction of GMOs in Africa but seldom in an extension context (Komparic, 2015). It is important to have further research to understand how these competencies fit into the PIE framework (Gay et al., 2017). We propose future research to explore how to expand the PIE framework using identified competency items that include professional ethics, time management skills, motivation, and professional flexibility.

Perceived proficiency mean scores of all competency constructs were lower than the importance mean scores. This discrepancy between competency importance and proficiency highlights the priority areas in which extension agents would need training, which is similar to the findings of other studies (Alibaygi & Zarafshani 2008; Cannon et al., 2012).

Training need scores were determined through the calculation of MWDS (Borich, 1980). Applying the Borich needs formula to each of the eight competency constructs revealed agents' greatest training need exists for creating partnerships (*M* = 3.07), followed by designing education programs on GMOs (3.02). The constructs with the lowest training need scores were creating an environment of professionalism (2.08) and managing and transforming conflict (1.94).

These findings suggest the urgent need for extension agents to be specifically trained in how to engage with farmers in new ways to educate them that extend beyond the traditional technology transfer extension methods (Klerkx, 2020). Additionally, these findings emphasize the need for training extension agents to have competencies other than those that only reinforce the expert-oriented technology transfer model—which undermines the controversial sociocultural aspects of GMOs (Ahteensuu, 2012). Wide public concerns associated with GM crops are a major barrier extension agents will have to overcome when promoting GM crops as a means to increase global food security. The major implication of this study is that it tested the application of the PIE approach to determine the training needs of extension agents to educate farmers on GE crops. When in-service training programs are planned, it is necessary to focus on these priority training needs to educate extension agents.

In terms of the use of the Borich needs assessment method, the weighted discrepancy scores are dependent on the use of item means for importance, and respondents provided a single judgment of the importance of a competency, based on an ordinal scale that might not capture responses that have a nuanced judgment of importance (Narine & Harder, 2021). In addition, despite this method's ability to highlight the discrepancies between proficiency and importance score ratings, it is weak in assessing whether the self-reported proficiency ratings reflect agents' perceptions of importance rather than their actual proficiency levels of competency. Therefore, we propose it is necessary to conduct future research using different assessment methods such as supervisor rating of competence rather than self-reported competence to overcome these issues.

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