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A New Perspective on Adoption: Delivering Water Conservation Extension Programming to Nursery and Greenhouse Growers

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Abstract

Extension professionals help important agricultural sectors across the country resolve challenges using science-based practices that enhance environmental and social wellbeing while supporting businesses. Nursery and greenhouse growers comprise one of the largest sectors of U.S. agriculture, and this group is challenged to conserve water without compromising their economic viability. While Extension professionals educate and support nursery and greenhouse growers, there is a deficiency of research on adoption processes within this sector. To better understand this important Extension audience, this research examined the influence of critical thinking and problem-solving style on perceived characteristics of water conservation technologies and in turn the perceived characteristics relationship with their implementation. A route to adoption was established to inform effective Extension activities that promote water conservation. Problem-solving style predicts trialability while critical thinking style predicts none of the five characteristics of innovations. Of the five characteristics of water conservation innovations, relative advantage, trialability, and observability play a role in nursery and greenhouse growers' implementation, and implementation does influence adoption. When designing water conservation programs for nursery and greenhouse growers, Extension professionals should consider participants' problem-solving style and incorporate strategies to increase trialability, relative advantage, and observability.

***Keywords*:** adoption; critical thinking style; Diffusion of Innovations; nursery and greenhouse growers; problem-solving style; water conservation

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Introduction

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Extension professionals are a key source of knowledge and support for nursery and greenhouse growers (Fulcher et al., 2012). Horticulture, the agricultural sector to which landscape and nursery growers belong, is a growth area in United States agriculture (Hall, Hodges, & Haydu, 2006). The U.S. nursery and greenhouse industry contributes nearly $14 billion in annual sales to the economy (U.S. Department of Agriculture, 2016), exceeding the value of some other important agricultural crops (Fulcher et al., 2012). Along with floriculture production, the nursery and greenhouse sector employs over 200 thousand people in the United States (Hodges, Hall, Palma, & Khachatryan, 2015).

The nursery and greenhouse industry produces most of the nation's ornamental plants, growing more than 2,000 ornamental plant species (Lea-Cox et al., 2010). Greenhouses are enclosed and covered environments where growth conditions such as light, humidity, and irrigation can be controlled (Majsztrik, Lichtenberg, & Saavoss, 2017). Nurseries are typically open-air operations and plants may be grown in the ground or in containers (Majsztrik et al., 2017). While providing the vegetation society demands, nursery and greenhouse growers are "typically intense users of resources that are applied to relatively small land areas" (Lea-Cox et al., 2010, p. 509). The nursery and greenhouse industry uses large volumes of water to irrigate more than 660,000 acres across the United States (United States Department of Agriculture, 2013). Water availability is a critical topic among industry members and the Extension and research professionals who serve them (Fulcher, LeBude, Owen, Jr., White, & Beeson, 2016), especially given water availability for growers may decline in the future (Fulcher & Fernandez, n.d.a). Every day, greenhouse and nursery growers make decisions that influence their effective use of irrigation water (Fulcher & Fernandez, n.d.b). A number of barriers can challenge and reduce irrigation efficiency at an operation. For example, the limited substrate (i.e., growth medium) volume held within containers mandates frequent and sometimes excessive irrigation during plant production (Chappell et al., 2013). In addition, salinity of irrigation water may necessitate higher leaching rates to maintain salt levels at or below plant tolerance levels.

More than two billion dollars were invested in improving existing and installing new irrigation systems between 2003 and 2008 among agricultural producers (Schaible & Aillery, 2012) yet there is still much more that can be done. Growers can use more precise irrigation technologies, such as smart irrigation controls or drip irrigation, to supply water in smaller amounts throughout the day, or treat and reuse water onsite (Yeager et al., 2010). Growers have access to water conservation technologies such as wireless sensor networks that can be used to guide irrigation decision-making and automatically control irrigation valves, thereby allowing application of precise amounts of water exactly when and where it is needed (Chappell, Dove, van Iersel, Thomas, & Ruter, 2013; Majsztrik, Lichtenberg, & Saavoss, 2013). Other conservation strategies include modifying plant spacing, grouping plants with similar water needs, modifying growth medium composition, scheduling irrigation appropriately, and using alternative water sources (Fulcher & Fernandez, n.d.a).

As the nursery and greenhouse industry strives to increase production efficiencies while maintaining livelihoods, adoption of water conservation technologies and practices may be hindered if growers perceive inadequate research has been conducted in both controlled and applied settings (Chappell et al., 2013). Majsztrik et al. (2013) suggested as water becomes scarcer, growers would be more willing to recognize the benefits of water conservation technologies. However, tens of thousands of irrigated agricultural operations report they are not making improvements to reduce their water or energy use because of uncertainty about future water availability (United States Department of Agriculture, 2013). Unchanged regulations and existing infrastructure also serve as barriers to the adoption of conservation practices (Fulcher et al., 2016).

Using qualitative methods, researchers have recently reported U.S. nursery and greenhouse growers had positive attitudes toward water conservation. However, growers considered some technologies to be either incompatible with their operation, or too expensive or complicated to use (Lamm, Warner, Martin, White, & Fisher, 2017; Lamm, Warner, Taylor, Martin, White, & Fisher, 2017). Caplan, Tilt, Hoheisel, and Baugher (2014) also applied characteristics of innovations in their qualitative study on grower use of harvesting and pest management technologies and reported that cost and equipment complexity were barriers to adoption. While costs have emerged as an important factor in adoption, we wanted to look beyond financial aspects to other external influences.

Both Lamm, Warner, Martin, et al. (2017) and Lamm, Warner, Taylor, et al. (2017) recommended quantitative analyses be conducted to further explore adoption processes among nursery and greenhouse growers. Caplan et al. (2014) contended that research was needed to further explore the role Extension professionals can play to support the adoption process of nursery and greenhouse growers. Research on effectively engaging nursery and greenhouse growers is very limited. Little is known about how to best support this industry while encouraging the use of water conservation technologies in nurseries and greenhouses. To address this need, we conducted a quantitative study of U.S. nursery and greenhouse growers, and examined how perceived characteristics of innovations, critical thinking style, and problem-solving style influence adoption of water conservation technologies among nursery and greenhouse growers.

Conceptual Framework

Rogers' Diffusion of Innovations outlines the adoption process and explains the influence of five characteristics of innovations: relative advantage, compatibility, complexity, observability, and trialability (Rogers, 2003). Relative advantage is the extent to which something is better than what is currently being used. Compatibility is how an innovation fits with existing processes and values. Complexity refers to how easy or difficult something is to use. Observability is the opportunity to see others using the innovation, and trialability is the opportunity to test an innovation. In the context of the current study, water conservation strategies would be more likely to be adopted among nursery and greenhouse growers if they are perceived as being better than what is currently used, compatible with the operation, easy to use, and available to observe and try out. From their qualitative study of farmers in Indiana, Reimer, Weinkauf, and Propoky (2012) reported strong perceived relative advantage, observability, and compatibility were most important to understanding adoption of agricultural best management practices such as the use of cover crops. In their qualitative study, Lamm, Warner, Taylor, et al. (2017) applied Rogers' (2003) characteristics of innovations and found complexity and compatibility were major factors influencing U.S. grower adoption of water treatment technologies such as chlorination.

While the characteristics of water conservation technologies may influence their adoption, growers' cognitive characteristics, such as critical thinking style and problem-solving style, should also be considered. Perry, Retallick, and Paulsen (2014) discussed the wide range of definitions for critical thinking. Paul (1995) defined critical thinking as purposeful thought integrated with intellectual principles. Lamm and Irani (2011) described critical thinking style as the "way critical thinking is expressed, or performed, or done by an individual" (p. 6). Critical thinking style falls somewhere on a continuum between a preference for seeking out information and engaging with the problem (Lamm & Irani, 2011). Critical thinking style can be measured using the University of Florida Critical Thinking Inventory (UFCTI; Lamm & Irani, 2011). Gorham, Lamm, and Rumble (2014) recommended delivering information to engagers through channels such as opinion leaders and developing quality sources for seekers to personally access information.

Problem-solving style is an additional cognitive characteristic that may be considered along with critical thinking style. Kirton (2011) explained that each individual's problem-solving style falls somewhere on a continuum between adaption and innovation. People who prefer an adaptive problem-solving style like greater levels of structure, while those who prefer an innovative problem-solving approach like fewer boundaries. Those who are more adaptive tend to want to improve on previous solutions while those who are more innovative tend to want to find new solutions (Lamm, Shoulders, Roberts, Irani, Unruh Snyder, & Brendemuhl, 2012). Problem-solving style can be measured using the Kirton Adaption-Innovation Inventory (KAI). A literature review revealed no previous use of the KAI to understand the problem-solving styles of nursery and greenhouse growers, although it has been applied to other agricultural education contexts with mixed findings. Blackburn, Robinson, and Kacal (2015) conducted a small exploratory study and found no relationship between problem-solving style and learning among preservice agriculture teachers. In a study on a school-based agriculture program, Blackburn and Robinson (2017) found students being more innovative was associated with lower levels of success in troubleshooting small engines. In their research with study abroad students, Lamm et al. (2012) created three groups using the KAI: an innovator group, an adaptor group, and a mixed group. Each group was assigned a problem-solving project, and the researchers reported the three groups solved the problem using valuable but distinct approaches. The group comprised of all innovative individuals demonstrated strength in their ability to reflect throughout the process but took some risks in their approach, while the all-adaptor group did not fully solve the problem because they spent a lot of time concerned with the consequences of taking action. The heterogeneous group balanced one another's strengths and weaknesses, reflecting throughout the process and considering risks before taking action. The mixed group's success led Lamm et al. (2012) to conclude agricultural educators need to integrate an understanding of how people problem solve into their programming.

Integrating problem-solving style has demonstrated mixed results in other agricultural education contexts, therefore it is necessary to examine how it may relate to nursery and greenhouse growers' decision-making across a broad range of problems addressed by the profession. For this study, we considered how problem-solving style and critical thinking style could influence growers' perceptions of the characteristics of water conservation innovations and in turn how those perceptions then influenced implementation and adoption (continued use) (Figure 1).

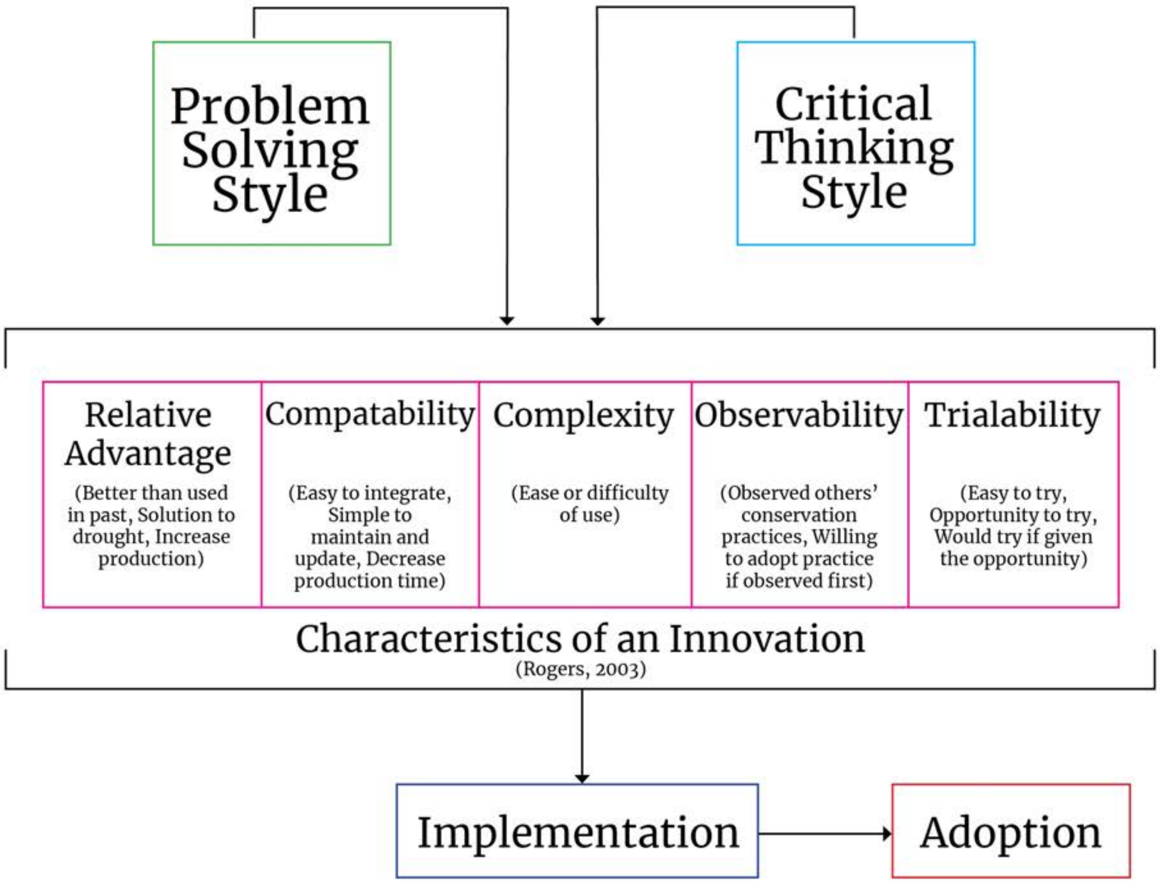

Figure 1. Conceptual model integrating critical thinking style and problem-solving style with characteristics of innovations, implementation, and adoption of water conservation technologies by greenhouse and nursery growers. Implementation refers to the initial use of water conservation technologies while adoption is the continued use of water conservation technologies.

Purpose and Objectives

The purpose of this study was to understand water conservation technology adoption among nursery and greenhouse growers to inform the development of effective Extension activities serving this audience. Specifically, we wanted to examine how problem-solving (Kirton, 2011) and critical-thinking (Lamm & Irani, 2011) styles related to the five perceived characteristics of water conservation technologies (innovations; Rogers, 2003), and how the perceived characteristics predicted implementation and adoption. The specific objectives were to:

1. Examine how problem-solving style and critical thinking style relate to nursery and greenhouse growers' perceived characteristics of water conservation technologies;
2. Determine if there is an association between perceived characteristics of water conservation technologies and nursery and greenhouse growers' level of water conservation technology implementation; and
3. Determine if water conservation technology implementation relates to nursery and greenhouse growers' continued use (adoption) of water conservation technologies.

Methods

Data Collection and Target Population

We collected data during the first half of 2017 as part of a larger, 5-year study of this audience. Our target population was United States greenhouse and nursery growers. We used electronic mailing and participant lists provided by Extension and research professionals who worked with our target audience to secure a nonprobability sample of respondents (*n* = 192). Of those who provided demographic information, the majority of respondents were male (73.6%; *f* = 95); between 55 and 64 years of age (42.6%; *f* = 55); not Hispanic or Latino (98.7%; *f* = 127); and white (60.9%; *f* = 120). More growers said they lived in Florida (19.4%; *f* = 25) and New York (13.2%; *f* = 17) than the other 31 states represented. The most common gross annual sales categories were from $10,000 to $99,999 (44.2%; *f* = 57) and from $1,000,000 to $9,999,999 (20.2%; *f* = 26). More than half held at least a four-year degree (62.8%; *f* = 81).

Instrumentation

We used a researcher-developed survey instrument to achieve the research objectives. The independent variables were compatibility, trialability, complexity, relative advantage, observability, UFCTI, and KAI (see Table 1).

Table 1

Description of Independent Variables

Variable	Real limits	*M*	*SD*	Cronbach's Alpha
Compatibility	1, 5	3.10	.65	.798
Trialability	1, 5	3.15	.89	.612
Complexity	1, 5	3.36	.76	.874
Relative advantage[a]	1, 5			
Observability[b]	1, 5			
UFCTI score	26, 130	77.87	4.10	.938
KAI mean	32, 160	109.01	11.59	.789

Note. Compatibility, trialability, and complexity were continuous variables. Observability and relative advantage were categorical variables. [a]The most common response for relative advantage was *agree* (4). [b]The most common response for observability was *somewhat likely* (3).

Critical thinking style was measured using the UFCTI (Lamm & Irani, 2011). The UFCTI generates scores ranging from 26 to 130, with lower numbers interpreted as a preference for engaging and higher numbers interpreted as a preference for seeking (Lamm & Irani, 2011). We measured UFCTI according to published protocol (Lamm & Irani, 2011), asking respondents to *indicate the degree to which you agree or disagree with the statements as they relate to how you naturally tend to approach situations*. There were 16 statements and responses were measured on a five-point Likert-type scale from *strongly disagree* to *strongly agree.*

We measured problem-solving style using the published KAI protocol (Kirton, 1999). The KAI determines an overall score ranging from 32 to 160, with a lower number indicating an adaptive problem-solving style and a higher number indicating an innovative problem-solving style (Kirton, 1999). The KAI items were provided to respondents as a series of questions about how they solve problems. We asked them to *please use the slider next to each item listed below to indicate how easy or difficult you find it to present yourself, consistently, over a long period as the person each statement represents*. There were 32 items and possible responses ranged from 5 = *very hard* to 1 = *very easy*.

The portion of the instrument that collected perceptions of diffusion characteristics were researcher-developed. Compatibility and trialability items were measured along a five-point Likert-type scale where respondents were asked to indicate their level of agreement ranging from 1 = *strongly disagree* to 5 = *strongly agree*. To measure compatibility, four statements were used (*water conservation technologies are easy to implement into existing facilities*, *water conservation technologies are simple to maintain and update, water conservation technologies will delay the production of goods*, and *water conservation technologies are easy to install*). To measure trialability, three statements were used (*water conservation technologies are easy to try, water conservation technologies are readily available to test before being installed,* and *the opportunity to try water conservation technology is not available to me*).

Complexity was measured using a five-point semantic differential scale where respondents indicated their perception between five sets of adjectives along (*complex* to *simple, easy to understand* to *difficult to understand, clear* to *unclear, confusing* to *straightforward, complicated* to *not complicated*). To measure relative advantage, respondents were asked to indicate their level of agreement or disagreement with the phrase, *current water conservation technologies are better than what I have used in the past* on a five-point scale where 1 = *strongly disagree* and 5 = *strongly agree.*

Two nested questions were used to measure observability. First, we asked, *have you had the opportunity to observe others using or demonstrating new water conservation technologies and practices you are not currently using* and respondents could indicate *yes* or *no*. Only those who answered *yes* received the second question, *how likely are you to adopt the new water conservation technologies or practices you observed someone else using*? For this reason, we had 78 responses (n = 78) for this characteristic. Responses were measured on a five-point scale where 1 = *I will not install the new technology,* 2 = *not very likely*, 3 = *somewhat likely*, 4 = *likely*, and 5 = *very likely*.

To identify implementation of water conservation technologies, respondents were asked whether or not they had implemented eight water conservation technologies (rainwater capture, water reuse, microirrigation, drip irrigation, subirrigation, soil moisture sensors, climate-based irrigation, and irrigation audits) using *yes* or *no* responses. To identify adoption, we asked respondents to *please select those technologies that are still in use at your operation* from a list of any of the eight conservation technologies they indicated they had implemented previously.

We ensured the instrument was audience appropriate, relevant to the objectives of the study, and measuring what it was intended to measure (construct and face validity) by consulting with an expert panel (Ary et al., 2014; Field, 2013; Hardesty & Bearden, 2004; Haynes, Richard, & Kubany, 1995). We selected panel members who were experts in their fields of nursery and greenhouse water management, agricultural and Extension programming, and communication, and survey methods. The panel members all belonged to a large, national research team and had extensive experience developing and promoting technologies across a large geographic scale. The experts understood the scope of the project and its target audience was national in scale and kept this in mind during the expert review. As we worked with the expert panel, we ensured there was agreement that terminologies were appropriate on a national scale among growers with diverse backgrounds. For example, one modification that came out of this process was to use the term *implementation* as the initial use of water conservation technologies and the term *adoption* as the continued use of water conservation technologies. Finally, to ensure face validity, we pilot tested the instrument with students interested in agricultural sciences which include water conservation and horticulture and made adjustments accordingly.

Data Analysis

We created a compatibility index by averaging the four compatibility scores after reverting one reversed item. The mean compatibility score was 3.10 (*SD* = 0.65). We created a trialability index by averaging the three trialability scores after reverting one reversed item. The mean trialability score was 3.15 (*SD* = 0.89). We created a complexity index by averaging responses to the five semantic differential items after the two reversed pairs were reverted. The mean complexity score was 3.36 (*SD* = 0.76). The real limits of the compatibility, trialability, and complexity indexes was one to five, where the most favorable conditions for adoption were indicated by a five on perceived compatibility, trialability, complexity.

The greatest frequency of responses for the relative advantage question was provided by 51.2% of respondents (*f* = 84), who indicated they agreed current water conservation technologies are better than what they had used in the past. When asked how likely they were to the new water conservation technologies or practices they observed someone else using, the greatest number of respondents (46.3%; *f* = 37) indicated they were somewhat likely to do so.

We created a UFCTI score by summing the total of 16 items after those which were reverse coded were reverted and multiplied by 1.833. The mean UFCTI score was 77.87 (*SD* = 4.10), meaning the average grower in our study tended toward a seeking critical thinking preference. We created a KAI score by summing the total of 32 items. The mean KAI score was 109.01 (*SD* = 11.59), meaning the average grower in our study had an innovative problem-solving style.

We created an implementation score by summing the total *yes* responses to the eight water conservation technologies. Of the eight technologies, implementation score ranged from zero to seven, with the greatest number of respondents indicating they had tried either none (26.4%; *f* = 52), three (18.8%; *f* = 37), or one (16.2%; *f* = 32) of the water conservation technologies. The mean implementation score was 3.78 (*SD* = 3.20). Similarly, we created an adoption score by summing *yes* responses to the technologies which were still in use. Adoption score ranged from zero to six with the greatest frequency of responses indicated either none (27.4%; *f* = 54), one (26.4%; *f* = 52), or three (16.8%; *f* = 33) of the technologies they had implemented were still in use. The mean adoption score was 1.69 (*SD* = 1.53).

To examine how problem-solving style and critical thinking style influences perceived characteristics of water conservation technologies, we conducted linear regressions with KAI and UFCTI scores as the input variables and compatibility, trialability, and complexity as the outcome variables, respectively, through three independent analyses. Because relative advantage and observability were single Likert-type scale items, these variables were categorical. Therefore, we used two multinomial logistic regression analyses with KAI and UFCTI scores as the input variables and relative advantage and observability as the two separate outcome variables. Of the variables used in these analyses, we had the fewest (*n* = 129) for UFCTI score, and therefore the sample sizes for these analyses were 129.

We used a multiple linear regression analysis to determine if perceived compatibility, relative advantage, complexity, and trialability of water conservation technologies predicted implementation. The four characteristics of an innovation were the input variables and the implementation index was the outcome variable. The sample size for this analysis was 151 due to having complete trialability responses from 151 individuals. We used a separate linear regression analysis to determine if observability predicted implementation, due to the different sample size (*n* = 78) for this input variable. We used one more linear regression analysis to determine if implementation influences growers' adoption of water conservation technologies, using implementation as the input variable and adoption as the outcome variable.

Cronbach's alpha coefficients were estimated *post-hoc* for the appropriate (continuous) variables as: 0.798 (compatibility), 0.612 (trialability), 0.874 (complexity), and 0.789 (KAI). All of these exceeded .7, which is the generally accepted minimum for survey research, except for trialability. Variables with lower values should not be excluded if the instrument is well-designed (Schmitt, 1996). All analyses were conducted using SPSS (version 23.0; IBM Corp., Armonk, NY).

Results

Examine How Problem-Solving Style and Critical Thinking Style Relate to Perceived Characteristics of Water Conservation Technologies

Compatibility. The linear regression model was not significant ($p = 0.30$), indicating problem-solving style and critical thinking style do not predict growers' perceptions of compatibility (see Table 2).

Table 2

Compatibility Predicted by Problem Solving Style and Critical Thinking Style in an Evaluation of United States Nursery and Greenhouse Growers' Use of Water Conservation Practices

	R^2	β	p
Model	0.02		0.30
KAI (M = 109.01)		0.01	0.17
UFCTI (M = 77.87)		0.01	0.62

Note. Sample size for this analysis was 129. Mean values were: compatibility, 3.10; KAI, 109.01; UFCTI, 77.87

Trialability. The linear regression model was not significant ($p = 0.15$; see Table 3). However, when considered separately, KAI was significant, indicating problem-solving style does predict growers' perceptions of trialability ($p = 0.05$).

Table 3

Trialability Predicted by Problem Solving Style and Critical Thinking Style in an Evaluation of United States Nursery and Greenhouse Growers' Use of Water Conservation Practices

	R^2	β	p
Model	0.03		0.15
KAI*		0.01	0.05
UFCTI		-0.01	0.71

Note. * indicates significant at $p = .05$. Sample size for this analysis was 129. Mean values were: trialability, 3.15; KAI, 109.01; UFCTI, 77.87

Complexity. The linear regression model was not significant ($p = 0.22$), indicating problem-solving style and critical thinking style do not predict growers' perceptions of compatibility (see Table 4).

Table 4

Complexity Predicted by Problem Solving Style and Critical Thinking Style in an Evaluation of United States Nursery and Greenhouse Growers' Use of Water Conservation Practices

	R^2	β	p
Model	0.024		0.22
KAI		0.01	0.20
UFCTI		0.02	0.31

Note. Sample size for this analysis was 129. Mean values were: complexity, 3.36; KAI, 109.01; UFCTI, 77.87

Relative advantage. The logistic regression model was not significant (p = 0.80), indicating problem-solving style and critical thinking style do not predict growers' perceptions of relative advantage (see Table 5).

Table 5

Relative Advantage Predicted by Problem Solving Style and Critical Thinking Style in an Evaluation of United States Nursery and Greenhouse Growers' Use of Water Conservation Practices

	Log odds of changing from *Strongly disagree* to *disagree*		Log odds of changing from *Strongly disagree* to *neither agree or disagree*		Log odds of changing from *Strongly disagree* to *agree*		Log odds of changing from *Strongly disagree* to *strongly agree*		
	β	p	β	p	β	p	B	p	Model p
Model									0.80
KAI	4.27	0.86	-2.59	0.29	-2.10	0.39	-1.90	0.47	
UFCTI	-0.13	0.96	0.06	0.82	0.04	0.88	0.01	0.97	

Note. Strongly disagree was the reference. Sample size for this analysis was 129. Frequencies were: strongly disagree, 1 (.6%); disagree, 6 (3.7%); neither agree or disagree, 62 (37.8%); agree, 84 (51.2%); strongly agree, 11 (6.7%). Mean values were: KAI, 109.01; UFCTI, 77.87

Observability. The logistic regression model was not significant (p = 0.77), indicating problem-solving style and critical thinking style do not predict growers' perceptions of observability (see Table 6).

Table 6

Observability Predicted by Problem Solving Style and Critical Thinking Style in an Evaluation of United States Nursery and Greenhouse Growers' Use of Water Conservation Practices

	Log odds of changing from *I will not install the new technology* to *not very likely*		Log odds of changing from *I will not install the new technology* to *somewhat likely*		Log odds of changing from *I will not install the new technology* to *likely*		Log odds of changing from *I will not install the new technology* to *very likely*		
	β	*p*	*β*	*p*	*β*	*p*	*B*	*p*	Model *p*
Model									0.77
KAI	0.06	0.33	0.05	0.39	0.07	0.29	0.08	0.26	
UFCTI	0.13	0.39	0.01	0.93	0.04	0.78	0.01	0.97	

Note. I will not install the new technology was the reference. Sample size for this analysis was 129. Frequencies for observability were: I will not install the new technology, 2 (2.5%); not very likely, 19 (23.8%); somewhat likely, 37 (46.3%); likely, 16 (20.0%); very likely, 6 (7.5%). Mean values were: KAI, 109.01; UFCTI, 77.87

Determine If There is an Association Between Characteristics of Water Conservation Technologies and Their Implementation

The multiple linear regression model was statistically significant, with trialability and relative advantage predicting implementation (see Table 7).

Table 7

Implementation Predicted by Compatibility, Complexity, Trialability, and Relative Advantage, in an Evaluation of United States Nursery and Greenhouse Growers' Use of Water Conservation Practices

	R^2	*B*	*p*
Overall Model*	.100	-1.22	< .01
Compatibility		-0.01	0.98
Complexity		-0.06	0.39
Trialability*		0.47	0.05
Relative advantage*		0.47	0.01

Note. * indicates significant. Sample size for this analysis was 151. Mean values were: compatibility, 3.10; complexity, 3.36; trialability, 3.15; implementation, 3.78. Frequencies for relative advantage were: strongly disagree, 1 (.6%); disagree, 6 (3.7%); neither agree or disagree, 62 (37.8%); agree, 84 (51.2%); strongly agree, 11 (6.7%).

Linear regression revealed observability also predicted implementation (see Table 8).

Table 8

Implementation Predicted by Observability in an Evaluation of United States Nursery and Greenhouse Growers' Use of Water Conservation Practices

	R^2	B	p
Observability*	0.05	0.16	0.04

Note. * indicates significant. Sample size for this analysis was 78. Frequencies for observability were: I will not install the new technology, 2 (2.5%); not very likely, 19 (23.8%); somewhat likely, 37 (46.3%); likely, 16 (20.0%); very likely, 6 (7.5%). Mean value for implementation: 3.78

Determine If Implementation of Water Conservation Technologies Relates to Their Adoption

The linear regression model was statistically significant, indicating conservation implementation is a predictor of conservation technologies still in use (see Table 9).

Table 9

Adoption Predicted by Implementation in an Evaluation of United States Nursery and Greenhouse Growers' Use of Water Conservation Practices

	R^2	B	p
Implementation*	0.80	0.77	< 0.001

Note. * indicates significant. Sample size for this analysis was 197. Mean values were: implementation, 3.78; adoption, 1.69.

Conclusions and Implications

Through this study, we responded to the need to quantitatively examine adoption processes among a critical Extension audience, nursery and greenhouse growers, as identified by Lamm, Warner, Martin, et al. (2017) and Lamm, Warner, Taylor, et al. (2017). Critical thinking style did not appear to influence perceptions of characteristics of innovations in this context. However, problem-solving style did influence one characteristic, trialability. Growers who are more innovative in problem-solving style tended to perceive they had more opportunities to try water conservation techniques before implementing them. The beta value associated with this finding was very small, but the significance reveals a relationship warranting future discussion and evaluation.

Three of the five Diffusion of Innovation characteristics predicted implementation of water conservation technologies among growers. Trialability and relative advantage appear to be the most important of the five characteristics in this context. For every one-unit increase in trialability or relative advantage while holding other variables constant, implementation increases by about half a unit.

Neither compatibility nor complexity predicted implementation. It is possible these two variables did not have an effect because water conservation technologies have been available to the greenhouse and nursery industry for a considerable amount of time. Given time is critical to adoption (Rogers, 2003), it is possible that water conservation technologies are being adopted by the late majority at this point and no longer something growers would consider as being incompatible or overly complex. It is also possible our sample represented early adopters. Although compatibility did not predict implementation in this study, recent work has reported that perceived incompatibility of new water conservation technologies with both grower values and physical operations as potential barriers to adoption (Lamm, Warner, Taylor, et al., 2017).

The finding that trialability, observability, and relative advantage predicted implementation was not surprising. Yet, this application of the Diffusion of Innovations in an under-examined context provides valuable theory-based guidance Extension can use to foster adoption among nursery and greenhouse growers. Growers need to have opportunities to both observe and try out new technologies before using them. These are educational strategies Extension commonly employs through field days, trade shows, and other types of demonstrations. The findings highlight the importance of integrating and continuing the use of these methods. Growers are also in the position of needing to make the best choice for what are most often small businesses; hence, innovations need to be easy to use and have distinct advantages over other options. We were not surprised that implementation predicted adoption and consider this study context as a possible diffusion success story.

A need exists to determine how Extension professionals can support nursery and greenhouse growers' adoption processes (Caplan et al., 2014). Through the lens of the theoretical framework presented in this research, we offer several recommendations. Because growers with more innovative problem-solving styles perceived greater levels of trialability, there is an opportunity for Extension professionals to target those growers with a more adaptive problem-solving style and provide them with opportunities to try different water conservation technologies. Following Lamm et al. (2012), Extension professionals might consider pairing growers with different problem-solving styles together when delivering programs to foster their adoption of water conservation technologies. Extension professionals should provide nursery and greenhouse growers with opportunities to see some of the available water conservation technologies in use. Finally, it is important that Extension professionals help growers recognize how specific water conservation technologies may be better than what they currently use.

A new model illustrating how problem-solving style influenced perceived characteristics of water conservation technologies, which in turn influenced implementation, is presented in Figure 2.

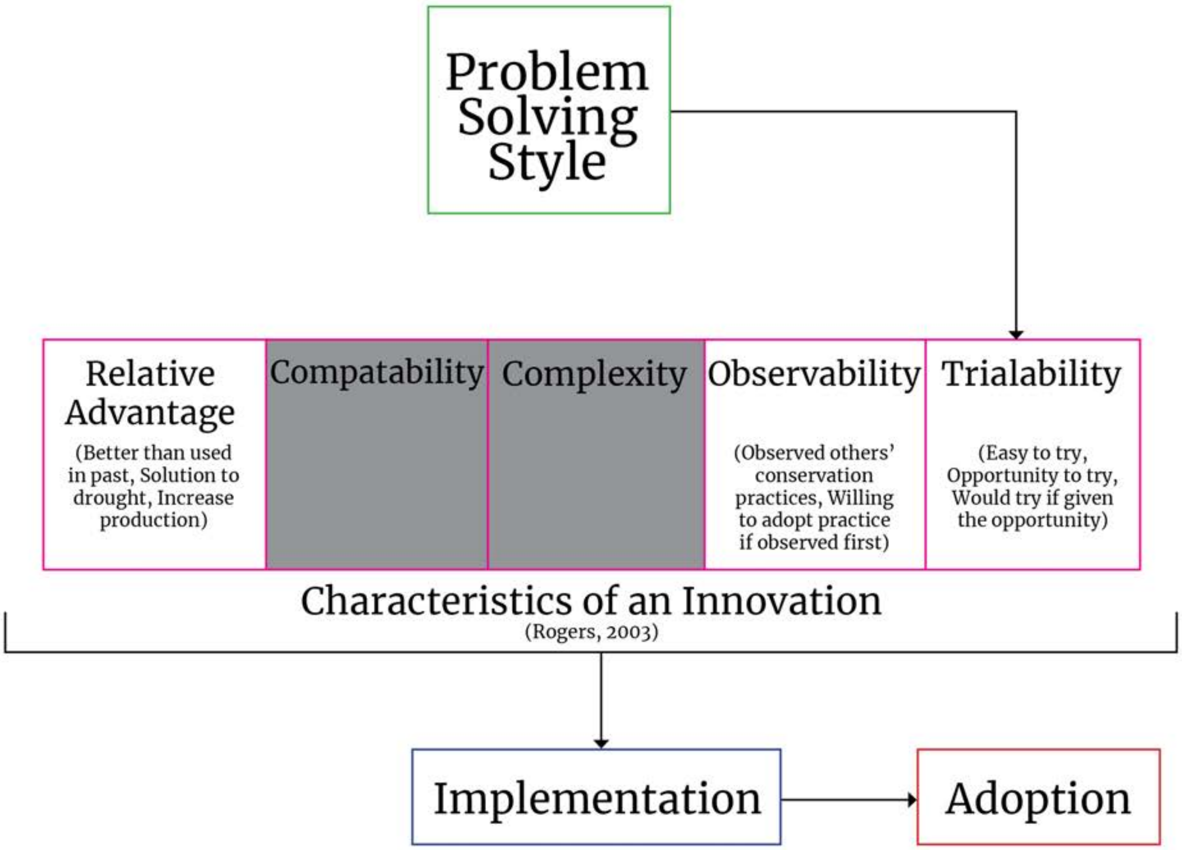

Figure 2. Preliminary model integrating problem-solving style, characteristics of innovations, implementation, and greenhouse and nursery growers' adoption of water conservation technologies.

Because we found problem-solving styles predicted perceived trialability, we suggest further examination of this relationship. Notably, the growers who participated in our study tended toward a more innovative problem-solving style, as demonstrated by a mean KAI score of 109.01. We do not know if nursery and greenhouse growers are more innovative by nature, or if more innovative individuals opted to complete our survey. The average responses we received indicated respondents perceived the characteristics of water conservation innovations to be somewhat, although not strongly, favorable. A replication of this study using a national random sample should be conducted to determine whether our findings could be generalized to the target population.

While outside the scope of this study, there are further measures the KAI can provide to this research. In addition to the overall score, the KAI is comprised of three subcomponents: Sufficiency of Originality, Efficiency, and Rule/Group Conformity. Sufficiency of originality refers to the number and practicality of potential solutions, with adaptors generating fewer and more realistic solutions (Bagozzi & Foxall, 1995). Efficiency is the level of detail preferred, with innovators preferring more 'big-picture' solutions. Rule/group conformity refers to the preferred level of structure, with adaptors preferring to conform to social norms and established rules. Future research should examine the KAI's individual components of sufficiency of originality efficiency, and rule/group conformity and how they influence perceived characteristics of innovations.

Previously, critical-thinking style has been shown to contribute to decision-making in an agricultural education context. Therefore, we were somewhat surprised to learn that it did not predict perceptions of water-conservation innovations among nursery and greenhouse growers. Given engagers work collaboratively with others when they seek to engage in critical thinking, we expected observability and trialability to be predicted by this critical thinking style. Conversely, seekers look for information that conflicts with their beliefs and like to challenge innovation through intense information acquisition. Therefore, we expected this to be predictive of perceived relative advantage of water conservation technologies and drive perceptions of all five characteristics. Perhaps information is not currently being presented in a way that appeals to either style and therefore the consumption is not diversifying response. A future study could be conducted using a quasi-experimental design to examine the impact of critical thinking style on perceptions of the diffusion characteristics when a targeted educational communication effort is put into place that focuses on engagement versus seeking information critical thinking style.

This study has provided new insight into the adoption process of nursery and greenhouse growers, an audience that is extremely important to Extension professionals and at the same time under-researched. While the findings are not generalizable beyond individuals who participated in this study, they have begun to address an important gap in what is known about this audience so Extension can better serve them. Extension professionals who seek to integrate Rogers' (2003) characteristics of innovations should focus on developing accurate measures of these characteristics. We suggest there is an opportunity to improve upon our measures in future studies and possibly develop a consistent measure of perceptions of diffusion characteristics that could be used across the agricultural education discipline.

We suggest future research examine the UFCTI's individual construct scores, engagement and seeking information, separately from the overall UFCTI style score to ensure no relationships were overlooked. Our instrument allowed respondents to define observability on their own terms as we did not specify whether they should indicate direct observation from field days only, or also include reading about technologies in professional journals, magazines and the like. Future research may be used to explore this variable on a more granular level. Our findings revealed a possible Diffusion of Innovations success story with water conservation technologies being accepted and adopted by the majority of nursery and greenhouse growers in our study. We suggest additional research should be conducted to examine newer types of innovation with this audience, such as water treatment technologies. It would also be interesting to compare the greenhouse and nursery industry with fruit and vegetable producers that utilize irrigation and row crop producers utilizing irrigation. Finally, there are numerous grower characteristics we did not include that could be important to understanding adoption of water conservation technologies in future studies. These include detailed profiles of operation size and type, life-stages, succession plans, as well as other demographic characteristics.

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