An Examination of Clickers in an Informal Educational Setting: Quantitative Improvements in Knowledge Gain for North Carolina Cooperative Extension Pesticide Applicator Training

By

Gregory R. Denlea

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Dr. Catherine E. LePrevost, Chair
Linda Taylor

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Abstract

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In 2012, the Extension Toxicology program at North Carolina State University (NCSU) received an award for pilot funds from the University of Kentucky's Southeast Center for Agricultural Health and Injury Prevention to examine the effectiveness of audience response systems (ARS, "clickers") in enhancing pesticide applicator safety and health training programs. Data was collected on pesticide applicator audiences' learning and receptiveness to the technology. The pilot project assessed the impact of ARS on pesticide applicators' learning and the potential for statewide expansion of ARS implementation in pesticide applicator programs. This paper contains the quantitative analyses of pre-intervention (without clickers) and post-intervention (with clickers) knowledge gains for pesticide applicators located in the 5 North Carolina (NC) Cooperative Extension Districts who participated in this pilot project. A questionnaire (see Appendix 1) was administered both before and after pesticide applicator required training to assess content knowledge, with each pesticide applicator serving as his/her own control. The quantitative results show that more pesticide applicators gave correct answers to the multiple choice questions after the sessions conducted using clickers (post-intervention) than provided correct answers after sessions without clickers (pre-intervention). Data collected for this pilot also suggests that the use of clickers has a positive impact on learning outcomes regardless of the education level, age, or experience of the pesticide applicator. Some implications are identified and recommendations are suggested regarding the on-going use of clicker technology for pesticide applicator training sessions.

Biography

Gregory R. Denlea is a candidate for the Master of Environmental Assessment Degree at North Carolina State University. Gregory received dual BA/BS degrees from Washington State University, with honors, and was recognized as the outstanding senior of the year in the department of environmental science. He earned an MBA from Thunderbird in international marketing. Gregory's private sector experience includes management roles with Amazon.com, Sunkist, Universal Studios, Matson Navigation, Collins & Aikman, Washington Mutual, Wachovia, and Bank of America. He has been with Wells Fargo's Home Mortgage Marketing management team since 2009. Gregory begins his doctorate in education this fall.

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Introduction

Audience response systems, known commonly as “clickers”, are interactive software systems that use response cards (see Figure I) to allow audiences to send real-time responses to questions displayed in a Microsoft PowerPoint presentation (Quinn, 2007). Clickers are also referred to in the literature as electronic response systems (ERS), audience response systems (ARS) [b], audience response devices (ARD), interactive classroom response technologies, student response systems, personal response systems (PRS), classroom performance systems, classroom communication systems (CCS), mobile response systems, and digital response systems.

Fig I. The “clicker” or response card component in an Audience Response System

The spread of ARS in the United States extends to almost all of the universities and over 3,000 schools at the primary and secondary level (Boscardin & Penuel, 2012). North Carolina State University (NCSU) offers ARS systems to both instructors and students (see ResponseWare at http://oit.ncsu.edu/clickers/responseware). NCSU uses a system built by Turning Technologies located in Youngtown, Ohio (http://www.turningtechnologies.com). ARS systems receive the audience responses from clickers (or smart phones) and display them in real-time via a Microsoft

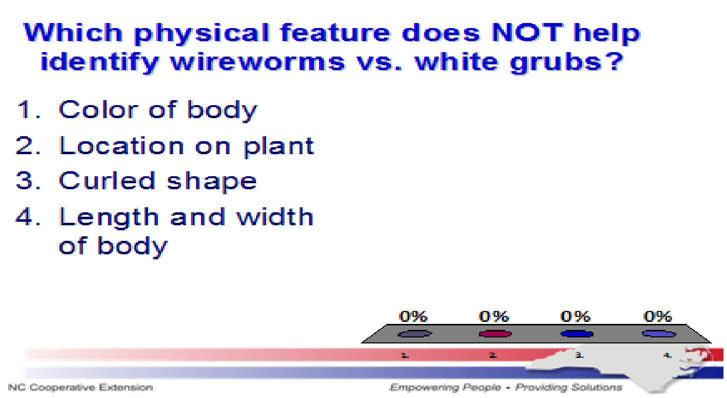

Fig II. Microsoft PowerPoint displaying clicker responses

PowerPoint presentation. Figure II displays how MS PowerPoint might display responses from an audience for a “yes/no” question.

ARS systems have additional features like emoticons and countdown timers. The presenter is able to see the number of audience responses to a question via a toolbar. Audience members are

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[b] Hereinafter clickers will be referred to in this project as ARS.

allowed to remain anonymous when responding. Potentially the use of ARS systems may facilitate discussion, reinforce knowledge, and enhance learning (Boscardin & Penuel, 2012; Quinn, 2007; Shapiro & Gordon, 2012). Numerous no-cost alternatives to ARS systems exist via providers like Polldaddy (https://polldaddy.com) and Obsurvey (http://obsurvey.com) which enable the creation of simple polling sites once you have registered for a free account (Byrne, 2012).

This study focuses on measuring changes in learning outcomes as a result of the use of ARS during pesticide applicator training conducted by the NC Cooperative Extension. Dr. Catherine LePrevost, Dr. Greg Cope, and Ms. Julia Storm were awarded a pilot project grant to assess the impact of ARS on pesticide applicators' learning and the potential for statewide expansion of ARS implementation in pesticide applicator programs (Kentucky, 2013). In North Carolina, Cooperative Extension professionals from five districts serve 100 counties. The approximately 35,000 pesticide applicators in North Carolina must attend a recertification training session every three years, which is provided by county Cooperative Extension pesticide education coordinators.

A survey of NC Cooperative Extension pesticide education coordinators showed that 83% were in favor of implementing ARS. To prepare a subset of extension educators to implement ARS, NC State University hosted a training session demonstrating how to integrate ARS with pesticide educational materials. Educators adapted their existing training materials for use with ARS and practiced using ARS in a mini-lesson to peers. County pesticide coordinators conducted training in 15 NC counties after receiving training in the use of ARS software. Additional data were collected on pesticide applicator learning for training sessions in 5 counties[c] both pre-intervention (i.e. training without ARS) and post-intervention (i.e. training conducted with ARS). A questionnaire (see Appendix 1) was administered both before and after training sessions to assess content knowledge gains before and after the implementation of ARS in pesticide training courses.

Quantitative data collected from the pre-/post-training content knowledge assessments were analyzed in order to assess impacts on learning outcomes as a result of the use of ARS in regularly scheduled pesticide applicator continuing education classes. This project will investigate the change in pre- and post-intervention content knowledge assessments. Demographic variables collected in this study will enable the reporting of differential results for additional dimensions such as age, level of education, and number of years licensed.

Literature Review

There is a general consensus in the literature that ARS has a positive impact on student learning (Conoley, Croom, Moore, & Flowers, 2007; Hecht, Adams, Cunningham, Lane, & Howell, 2012; Keough, 2012; Lantz, 2010; Lymn & Mostyn, 2010; Oigara & Keengwe, 2011; Shapiro & Gordon, 2012; L. A. Smith, Shon, & Santiago, 2011; Sternberger, 2011). Some

[c] Names of counties have been replaced with pseudonyms to maintain the confidentiality of educators.

studies have further identified active learning as one of the benefits from ARS (Kay & LeSage, 2009; Tregonning, Doherty, Hornbuckle, & Dickinson, 2012). Instructor effectiveness also plays a role in student learning. ARS allow instructors to find out what students did not understand from their lecture so that instructors can adjust their methods in subsequent classes (Carnaghan, Edmonds, Lechner, & Olds, 2011). Larger class sizes may adversely impact student learning due to lower student engagement. However, student engagement may be stimulated by ARS and potentially mitigate the impacts on knowledge gain due to larger class sizes (Chaudhry, 2011; FitzPatrick, Finn, & Campisi, 2011). ARS may support the synthesis of advanced concepts and skill development for advanced reasoning (DeBourgh, 2008). In a computer programming class ARS allowed students to learn from the mistakes of their peers (Hauswirth & Adamoli, 2013). ARS has been put forth as a tool that may enable scientist-educators to adequately design, implement, measure, model and continually assess the learning outcomes from their classes (Landrum, 2013; Rimland, 2013; Stewart & Stewart, 2013). The content questions used in ARS may be beneficial for teaching metacognition and enhancing critical thinking skills, mastery of key concepts, and peer learning in distance learning classes (Mareno, Bremner, & Emerson, 2010). ARS is highly flexible tool that is adaptable to a wide range of learning styles (Moss & Crowley, 2011). Although some studies have shown only moderate learning gains from ARS the technology enhances learning for weaker and disadvantaged students (Carnaghan et al., 2011; Williamson Sprague & Dahl, 2009).

Abundant studies exist documenting how ARS was used to increase knowledge gain in formal learning environments. Formal learning environments are defined by the organized, systematic, and integral functionality between teachers, students, and course content (Schwier, 2012). Nicol and Boyle (2003) cite learning gains from ARS when the technology supports “teaching and learning principles centered on active engagement and dialog” p. 472). Anderson, et al. found that ARS supports more effective learning than alternative teaching methods (Anderson, Healy, Kole, & Bourne, 2013). ARS is seen as a tool that can impact student learning when integrated into a pedagogic approach (Beatty, Leonard, Gerace, & Dufresne, 2006). Blasco-Arcas, et al, 2013, show that ARS promotes social interaction among teachers and students leading to sharing of ideas and ultimately a better understanding of the material. More importantly, students believe that ARS enhanced their learning because their individual ARS responses are clearly taken into account by the instructor and peers (Blasco-Arcas, Buil, Hernández-Ortega, & Sese, 2013).

ARS technology allows participants to perform self-monitoring and self-regulation during their knowledge acquisition process. In that ARS stimulates metacognition in students it can indirectly influence the learning process (Brady, Seli, & Rosenthal, 2013a). The use of ARS increases interaction between teachers and students, and ARS further acts to enable a student’s metacognitive behavior. The ARS questions are generally designed to reinforce the main concepts of the lesson and may prevent a student from thinking over the “wrong” information (Blood & Gulchak, 2012). Blood and Gulchak, 2012, postulate that ARS may potentially be a tool for students with attention difficulties since ARS help stimulate both student engagement and learning. ARS can influence metacognition depending upon the degree to which the learning environment is student-centric (Brady, Seli, & Rosenthal, 2013b).

Some studies contend that the research does not firmly establish knowledge gain as a benefit of ARS (Boscardin & Penuel, 2012; Heaslip, Donovan, & Cullen, 2013). Boscardin and Penuel (2012) reviewed forty-two papers, written prior to the year 2010, which explicitly evaluated the effects of ARS on learning; 12 of the papers examined the effect of ARS on knowledge gain. Boscardin and Penuel's findings were that there is a positive perception of ARS but the impact on knowledge gain is not consistent (Boscardin & Penuel, 2012). They believe that future studies on the effect of ARS on knowledge gain need to provide additional details on the implementation of ARS in the curriculum, validity information for measures used, and clear hypotheses of the expected outcome. Studies have not found that ARS benefits student's longer term knowledge retention (Karaman, 2011; Liu, Gettig, & Fjortoft, 2010; Rush et al., 2013). One study of ARS effectiveness in knowledge gain found that non-randomized designs produced more positive results than higher quality randomized studies (Nelson, Hartling, Campbell, & Oswald, 2012).

The effectiveness of ARS may be impacted by the way the instructor uses the technology. For instance if an instructor uses ARS for formative assessment, pop quizzes, and taking attendance the students may form some resentment against ARS (Dallaire, 2011). Questions used to assess the impact of ARS may need to be validated in order to adequately measure knowledge gains (Doucet, Vrins, & Harvey, 2009). Learning quality is also determined by the appropriateness of the instructors' question design, presentation, classroom control and technical preparation (Efstathiou & Bailey, 2012; Jensen, Ostergaard, & Faxholt, 2011; Karaman, 2011; Klein & Kientz, 2013; Kolikant, Drane, & Calkins, 2010).

There is relatively sparse quantitative information available on the knowledge gain due to the use of ARS in informal learning environments Informal learning environments are characterized as unorganized, unsystematic, and serendipitous (Schwier, 2012). ARS was used for a lecture during a statewide faculty meeting on University of North Carolina-affiliated family medicine residency programs to enhance overall learning. The audience at the faculty meeting felt that ARS "allowed them to learn more than the traditional lecture formats" (Latessa & Mouw, 2005, p.13). The University of Minnesota Extension Crops Systems successfully used ARS to collect data for a needs assessment on crop production, agricultural drainage, and water quality (Carlson, 2014). At an extension conference in Tennessee regarding the use of switch grass for forage and biofuel production researchers noted that the real time demographic information collected by ARS would allow the Extension professional to better align the appropriate information with the participants (de Koff, 2013). A multi-state study of a health development message with rural mothers used ARS in focus groups and plans to release future reports on the quantitative data (Ginter, Maring, Paleg, & Valluri, 2013).

After the September 11, 2001, disaster the University at Albany Public Center for Health Awareness (UA-CPHP) used ARS for 15 technical seminars and community presentations. UA-CHCP reported that for Medical Reserve Corp training the trainees found ARS to be beneficial to the training (Waltz et al., 2010). ARS enables instructors to gauge the level of understanding, adjust the presentation if needed, and reduce the time needed to evaluate the effectiveness of the training (Hashim, 2013; Waltz et al., 2010). Focus groups in Spanish of low-literacy, low-English speaking, and socially vulnerable immigrant dairy workers in Wisconsin found ARS easy and comfortable to use (Keifer, Reyes, Liebman, & Juarez-Carrillo, 2014). Extension organizations have adopted ARS to assist extension professionals in analyzing questionnaire data, which frees their time to focus on interpreting the results (McClure, Fuhrman, & Morgan, 2012). ARS enables extension outreach via remote polling with farming webinars and real-time interaction for distance learning (Sciarappa & Quinn, 2014).

Some of the research questions this project included; (1) Was there an increased knowledge gain for pesticide applicators who participated in trainings in which ARS was implemented? (2) Was there a difference in knowledge gains for the training locations, and what does this mean? (3) Was there a difference in knowledge gain between questions on the questionnaire? ; (4) Do the number of years of licensing affect learning outcomes? (5) What impact does the level of education completed have on learning outcomes? (6) Does the age of the participant affect learning outcomes when using ARS technology?

Research Methodology

Population and Sample

Fifteen pesticide educators, three from each of the five districts (Figure III) chosen for this project were randomly selected to participate in the pilot program. The educators adapted their training materials for the use of ARS or used project-developed ARS-ready presentations.

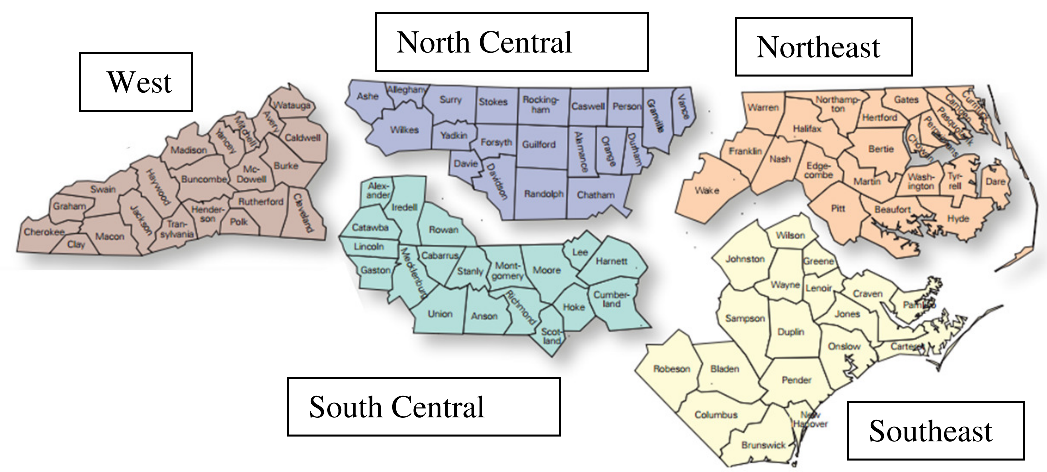


Fig III. Map of all 100 North Carolina counties and five North Carolina Cooperative Extension Service districts in which pesticide educators provide continuing education for pesticide applicators.

Then the ARS were implemented during regularly scheduled pesticide applicator continuing education (i.e. informal training sessions). The pesticide applicator continuing education training sessions lasted for 2 hours in total time; one of the hours of the training session was conducted by a representative of the NC Department of Agriculture and Consumer Services and the other was conducted by the county Cooperative Extension pesticide education coordinator. NC

Cooperative Extension pesticide educators conducted post-intervention (with ARS) interactive training using clicker questions during their presentation.

During the post-intervention training sessions, the pesticide educators used the peer instruction technique for each question (M. K. Smith, Annis, Kaplan, & Drummond, 2012). For each ARS question, the attendees would see the question projected onto the screen, and the educator would read the question aloud. Answers were prompted from the attendees for both pre and post-intervention sessions. Attendees were able to respond using their response card and were able to see the responses of all their peers. From the original 15 pesticide education coordinators selected for the ARS pilot, 5 pesticide education coordinators participated in a more rigorous evaluation process to assess improved learning outcomes for their pesticide applicator audiences. Ten content questions were included on printed questionnaires administered to the attendees both at the beginning and the end of the pesticide applicator training sessions. One of the questions is shown in Figure IV (the text for all questionnaire questions is in Appendix I).

Which of the following best describes pesticides?

a) Only effective tool to manage pests
b) Always control pests as planned
c) <u>Only one of several tools in an effective treatment plan</u>
d) Always replace biological control methods

Fig IV. Example ARS question about the general use of pesticides. The correct answer is underlined.

Questionnaire responses were anonymous since participants were instructed to use the last 4 digits of their phone number as the identification code for their written questionnaires.

The experimental design used in the pilot enabled the comparison of quantitative data for the same educators before and after the intervention of ARS technology. Content knowledge questionnaire sheets were distributed at the beginning and end of the training, whether or not ARS technology was used for the session. Table I shows the number of respondents to the questionnaire for each of the training sessions conducted by the subset of 5 NC Cooperative

	Pre-intervention (without clickers)		**Post-intervention (with clickers)**	
County	**# of Pre questionnaire responders**	**# of Post questionnaire Responders**	**# of Pre questionnaire responders**	**# of Post Questionnaire responders**
Carroll	12	12	31	31
Fulton	10	9	25	25
Howard	5	6	18	18
Richland	27	27	58	58
Upton	32	32	10	10

Tab I. Pre/post intervention respondents for the 5 NC Cooperative Extensions in this study

Extension pesticide educators. Quantitative data was collected from the questionnaires during 5 pre-intervention sessions (i.e. no ARS technology as used). Post-intervention questionnaire data was collected from 7 sessions (2 sessions were conducted at Carroll and Richland) in which ARS technology was used during the training. The comparison of pre-ARS intervention and post-ARS intervention knowledge gain for this project was enabled by this experimental design feature.

Participants were also asked demographic questions. The demographic questions were included so that knowledge gains could be evaluated among different demographic groups. Responses to the demographic questions have been summarized in Table II for both the pre-intervention training and post-intervention training sessions (the text of all demographic

Category	**Subcategory**	**Pre Intervention Result (%)**	**Post Intervention Result (%)**
Sex	Male	97	95
	Female	1	4
	Not answered	2	1
Age	Under 40	14	23
	40 and older	86	77
Level of education	Some school	6	2
	High school	44	37
	Some college/Associate’s degree	35	38
	Bachelor’s degree	10	10
	Graduate/Professional degree	2	9
	Not answered	3	4
Years Licensed	Under 20	46	56
	20 and over	54	44
Ethnicity	White/European American	84	74
	African American	2	5
	Native American	14	17.6
	Pacific Islander	0	0.7
	Other	0	0.7
	Not answered	0	2

Tab II. Pesticide licensee’s demographic information for all pre and post-intervention sessions used in this project.

questions is in Appendix II). Sex was not a demographic variable that could be used in this project as participants in pesticide applicator training classes were overwhelmingly male. Ethnic diversity was limited; only two ethnic groups were well-represented.

Procedure for Collecting Questionnaire Responses

Data Analysis

Results from the questionnaires, for both the pre- and post-intervention training sessions, were keyed into a Microsoft Excel (Microsoft Excel®, Microsoft Corp, Redmond, WA). Questions were indentified as being either pre-training, Q-I (question initial), or post-training, Q-F (question-final). The attendees' 4-digit phone numbers were used as an identification key to keep together their responses for both the pre- and post-training questionnaires. In order for the data from any one question from an attendee to be included for this project, the attendee had to answer both Q-I and Q-F. If both Q-I and Q-F were not answered then the data point was removed for that attendee for that question (M. K. Smith et al., 2012).

Statistical Analyses

Multiple statistical analyses were conducted for this project. Analyses included normalized change formula and a logistic regression model (Smith et al., 2012), as well as test for correlation, a one-way analysis of variance (ANOVA), an analysis of summary statistics, and a McNemar test.

The change in an attendee's learning between answering the pre- and post-training assessments was measured for each attendee using the Hake normalized change <c> formula. Normalized change is a rough measure of the average effectiveness of a course in promoting learning (Hake, 1998). Hake used his formula to measure what he termed interactive-engagement (IE) methods of teaching physics versus traditional practices. Hake found that the use of IE methods can increase teaching effectiveness (Hake, 1998). The normalized change can be used to compare how much the attendees scores changed versus the maximum possible change for that individual (M. K. Smith et al., 2012). The Hake normalized change formula uses two equations; (1) one if the attendee's mean Q-F score was higher than their mean Q-I score and (2) another if the attendee's mean Q-I score is higher than the mean Q-F as follows:

Normalized change <c> formula when Q-F score is higher than the Q-I score:

$$(1) \quad \langle c \rangle = 100[(\text{mean Q-F} - \text{mean Q-I}) / (100 - \text{mean Q-I})]$$

Normalized change <c> formula when Q-I score is higher than the Q-F score:

$$(2) \quad \langle c \rangle = 100[(\text{mean Q-F} - \text{mean Q-I}) / (\text{mean Q-I})]$$

When the Q-I and the Q-F score equaled either 100 or 0 the normalized change was not calculated since it would otherwise have been recorded as a 0 (M. K. Smith et al., 2012). If the Q-I score was higher than the Q-F score (formula number 2 above) then the normalized change formula would result in a negative number. The normalized gain for all questions answered by the attendees for the pre-ARS intervention and the post-ARS intervention pesticide training sessions were analyzed by the following analyses.

A logistic regression model was used to determine whether the demographic variables impacted the knowledge gain results for the attendees. Logistic models are desirable when the response variable has two distinct categories (i.e. 1= learning increase and 0 = no learning increase). The score results from the attendees questionnaires' fall into four categories as follows; (1) increase score after 1 hour training session (increase), (2) no change to score before or after training session (no change), (3) decrease in score after training session (decrease), and (4) perfect score both before and after the training session (ceiling). These four categories were collapsed into two categories for the logistic regression model; attendees who increased their learning after the training (increase) and attendees who did not increase their learning after the training (decrease and no change combined) (M. K. Smith et al., 2012). The ceiling category was excluded from this analysis. The resulting two categories above were coded for the logistic model as 1 for increase learning and 0 for no increase to learning. Some of the demographic variables listed in Table II were used as factors in the model. The logistical model was developed using the SAS (SAS Institute Inc., Cary, NC) code listed below and the results are capture in Appendix VIII:

```
proc logistic data=<dataset name> descending;
TITLE 'Post intervention results by variables';
class age_band race_band educ_band;
model subs= age_band race_band educ_band;
run; quit;
```

Number of years with a pesticide license, age, and level of education were categorized as ordinal variables since these categories could be order from low to high. Gender and ethnicity were not used in this analyses as there was not a sufficiently diverse representation for these demographic variables.

To analyze the linear distribution of the independent (demographic) variables the SAS PROC CORR model was used. The correlation model is used primarily to determine if there is a linear relationship between two variables. The PROC CORR model was developed using the SAS code listed below I:

```
proc corr data=<dataset name> nosimple;
var age_num lic_num educ_num subs;
run;;
```

PROC CORR was used to investigate age, years licensed, and level of education independently of one another.

Summary statistics were analyzed including means by location, by question, and for some of the demographic variables. A mean score analysis was performed in order to understand and begin to define measures of success for ARS. The mean score of each participant was calculated for the number of questions they responded to correctly over the number of questions they answered where the mean score = (score / total answered)*100. If a question was not answered it was removed from this mean score since the total answered would be reduced by that question. Consequently if a participant only responded to a single question, and they got that question correct, then their mean score would be 100%. The SAS formula used to provide the mean scores is:

```
proc means data=<dataset name> min max median ;
var mean_score_qi mean_score_qad;
by loc; run;
```

Mean scores were reviewed for both pre- and post-ARS intervention training sessions by location, level of education, age, and number of years licensed.

One-way analysis of variance, or ANOVA, was performed to investigate the categorical demographic (independent) variables against the dependent variable, that is, knowledge gain. ANOVA is useful when attempting to test for differences in the means of the dependent variable broken down by the levels of the independent variable. Each of the independent (demographic) variables had multiple levels. Location was also tested as an independent variable using ANOVA. The SAS code used and the results obtained for ANOVA are in Appendix V.

A McNemar analysis was used to determine whether or not the training sessions made a difference in the number of correct answers obtained on the post-training questionnaire. A McNemar analysis is used to determine whether there is a significant difference in the proportion of questions answered correctly for the pre- and post-training questionnaire responses. Figure V depicts the configuration of the McNemar test for the two outcomes for the same groups. A McNemar analysis requires two variables each with two categories. The two variables are the pre-training and post-training test questions (on the questionnaires) and the two categories are correct or incorrect responses to the question. The McNemar analysis was initially prepared for

Fig V. Configuration of the McNemar analysis for both pre and post training questionnaire responses and for both pre and post intervention (ARS).

		Pre-intervention (No ARS)	
		Post-training	
		Correct	Incorrect
Pre-training	Correct	a	b
	Incorrect	c	d

		Post-intervention (ARS)	
		Post-training	
		Correct	Incorrect
Pre-training	Correct	a	b
	Incorrect	c	d

all participants in the pre- and post-ARS intervention groups for each individual question on the questionnaire. McNemar tests were conducted on each question and for both the pre-intervention and the post-intervention training sessions. The SAS code used for the McNemar test and an example of the results obtained is show in Appendix VII.

Institutional Review Board Statement

Approval to evaluate licensed pesticide applicators' responses to the ARS pilot was obtained from the NC State University Institutional Review Board for the Protection of Human Subjects in Research.

Results

1. **The attendees for both the pre- and post-ARS intervention classes answered more questions correctly after the 1-hour presentation (Q-F), Table IV, than prior to the presentation (Q-I), Table III**. Normalized change scores were found to be higher for the post intervention classes than the normalized change for the pre intervention classes. The attendees for both the pre- and post-ARS intervention classes answered more questions correctly after the 1-hour presentation (Q-F), Table IV, than prior to the presentation (Q-I), Table III. Normalized change scores were found to be higher for the post-ARS intervention classes, 28.2%, than the normalized change for the pre-intervention classes, 25.7% .

Variable	**N**	**Mean(%)**	**STD(%)**	**SEM(%)**
Q-I	84	69.9	20.04	9.16
Q-F	84	75.5	20.04	9.16
Raw Difference	84	5.6	15.37	1.71
Normalized Change Score <c>	78	25.7	41.96	4.751

Tab III. Summary statistics for performance variables for all pre-ARS intervention pesticide licensees.

Variable	**N**	**Mean(%)**	**STD(%)**	**SEM(%)**
Q-I	140	64.9	23.78	2.011
Q-F	140	72.5	25.57	2.161
Raw Difference	140	7.6	16.8	1.419
Normalized Change Score <c>	128	28.2	44.84	3.963

Tab IV. Summary statistics for performance variables for all post intervention pesticide licensees.

2. **Scores trended upwards after the intervention of ARS technology in the training**

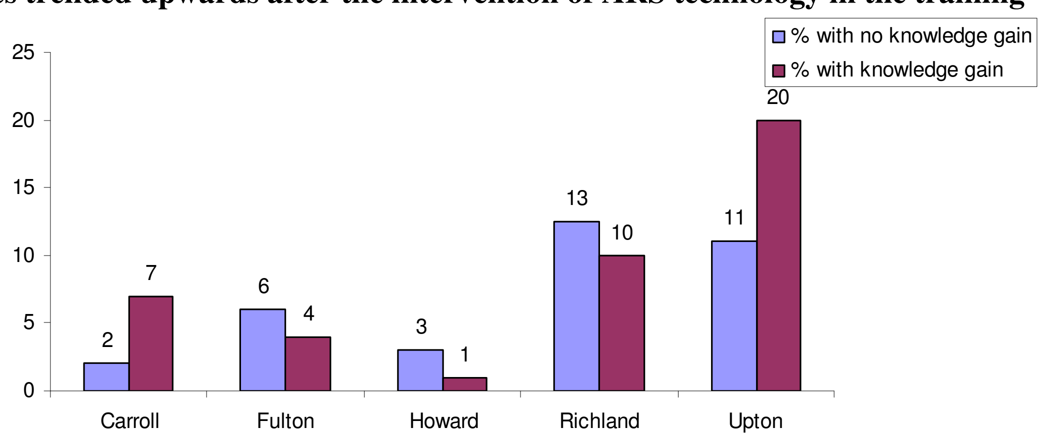


Fig VI. Distribution of the percent knowledge gain versus no knowledge gain for pre-intervention (no ARS) training sessions by location.
Only the Carroll and Upton locations had a higher percentage of participants with knowledge gains.

sessions. There were upward trends in scores for post intervention sessions at the various locations used for the pilot with the exception of Fulton. Ceiling scores are omitted from the normalized change results since their normalized change score would be equal to 0. Since the ceiling scores were not used the distribution of the attendee's normalized change

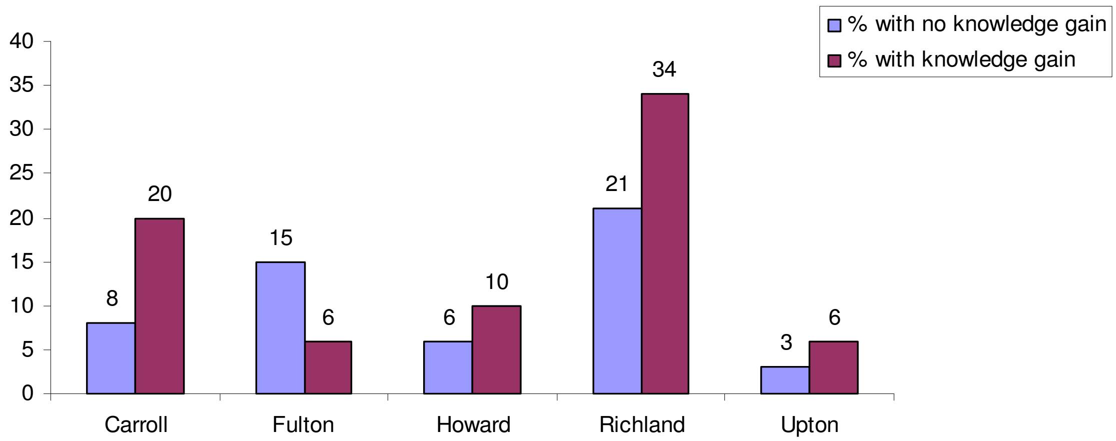


Fig VII. Distribution of the percent knowledge gain versus no knowledge gain for post-intervention (ARS) training sessions by location**.**
All locations had a higher percentage of participants with knowledge gains with the exception of Fulton

scores ranged from 10% to 90% correct. For the pre-ARS intervention training, the scores trend upward for 2 out of the 5 locations, namely Carroll and Upton (Figure VI). The scores trended upwards after the intervention of ARS technology in the training sessions. Figure VII shows upward trends in scores for post-intervention sessions at the various locations used for the pilot with the exception of Fulton.

Normalized change was further investigated by location in order to understand the impact of the downward post-ARS intervention trend in Fulton on the overall pre- and post-ARS intervention analyses. Table V displays the pre-intervention training sessions normalized

Normalized Change Score <c> by Location	**N**	**Mean(%)**	**STD(%)**	**SEM(%)**
Fulton	10	18.7	38.50	12.175
Upton	32	30.7	35.35	6.249
Carroll	10	41.2	42.65	13.487
Richland	22	16.5	49.51	10.555
Howard	4	15.8	56.83	28.415
All locations - excluding Fulton	68	26.7	42.61	5.167

Tab V. Pre-intervention normalized change by location and normalized change results after Fulton is removed.

change scores and the overall score corresponding to an increase of 4%. Carroll and Upton county locations were the only two pre-ARS intervention training classes that demonstrated overall increased learning. Table VI shows the post-ARS intervention normalized change

Normalized Change Score <c> by Location	N	Mean(%)	STD(%)	SEM(%)
Fulton	21	7.7	35.35	7.714
Upton	9	46.2	45.28	15.093
Carroll	27	39.3	36.92	7.105
Richland	55	26.8	46.84	6.315
Howard	16	30.6	54.59	13.647
All locations - excluding Fulton	107	32.2	45.54	4.403

Tab VI. Post intervention normalized change by location and normalized change results after Fulton is removed.

calculation at 32.2% when Fulton is removed. The pre-intervention normalized change calculation for all locations, excluding Fulton, increases by 1% (from 25.7 in Table III to 26.7 in Table V).

Fulton was the only location to experience a decrease in knowledge gains overall using ARS. An investigation of the detailed data by participant showed that eight Fulton participants (i.e. students) had pre-training questionnaire scores that were higher than the post-training questionnaire scores. In order to understand the negative learning gains for the eight Fulton students attending the post-ARS intervention training, the data was analyzed at both the student level and the individual question-response level for both the pre- and post-training questionnaire responses. Appendix X shows the detail responses for the eight students in the Fulton post-intervention training for both the pre and post intervention questionnaires. Question-level analysis may serve to uncover issues and thus enable increased knowledge gains for future pesticide training classes. Question level analysis may also help detect issues with the teaching approach used. The eight students with negative learning gains all responded to question #1 on the questionnaire correctly prior to the start of the training. After the training session only 75% of the students got question #1 correct. A downward trend in score was noted for all questions except for question #7 for these eight students. Question #3 was answered incorrectly by all eight students after the training was conducted.

3. **Seven out of ten questions used for the training sessions exhibited learning gains for post-intervention training**. Three out of the seven questions had learning gains greater than 9%. Discussion questions used for this project were analyzed individually to identify learning gains by question. Table VII shows the percentage of correct and incorrect responses by question for pre- and post-training questionnaires and for both pre- and post-ARS intervention training sessions. A score of 0 in the table indicates an incorrect response to the question and a score of 1 indicates a correct response. A 0 for both Q-I and Q-F indicates that the question was answered incorrectly both before and after the discussion. The rows

highlighted in bold below represent attendees who initially answered the question incorrectly (score of 0) and then subsequent to the training answered the question correctly (score of 1) (i.e. a learning gain). Table IX shows that 7 of the questions (1, 3, 4, 6, 8, 9, and 10) had a greater percentage of post-ARS intervention attendees with learning gains than pre-ARS intervention. However a greater percentage of attendees of the pre-intervention sessions exhibited learning gains for 2 of the questions (2 and 7). Question number 5 indicated nearly the same percentage of learning gain for both pre- and post-ARS intervention attendees. The rows with a Q-I=1 and a Q-F=0 represent a decrease in learning when input into the

Question #	Q-I	Q-F	Pre-ARS Percent	Post-ARS Percent	Question #	Q-I	Q-F	Pre-ARS Percent	Post-ARS Percent
1	0	0	13.79	15.49	6	0	0	4.60	9.15
	0	**1**	**6.90**	**9.86**		**0**	**1**	**5.75**	**9.15**
	1	0	12.64	9.86		1	0	2.30	2.11
	1	1	66.67	64.79		1	1	87.36	79.58
2	0	0	18.39	23.24	7	0	0	18.39	18.31
	0	**1**	**20.69**	**14.79**		**0**	**1**	**9.20**	**8.45**
	1	0	5.75	11.27		1	0	3.45	4.23
	1	1	55.17	50.70		1	1	68.97	69.01
3	0	0	41.38	40.14	8	0	0	31.03	25.35
	0	**1**	**21.84**	**31.69**		**0**	**1**	**18.39**	**21.13**
	1	0	9.20	4.93		1	0	10.34	15.49
	1	1	27.59	23.24		1	1	40.23	38.03
4	0	0	12.64	11.97	9	0	0	3.45	4.23
	0	**1**	**33.33**	**35.92**		**0**	**1**	**1.15**	**9.86**
	1	0	5.75	6.34		1	0	8.05	8.45
	1	1	48.28	45.77		1	1	87.36	77.46
5	0	0	36.78	42.25	10	0	0	14.94	18.31
	0	**1**	**14.94**	**14.79**		**0**	**1**	**6.90**	**19.72**
	1	0	9.20	7.75		1	0	13.79	7.75
	1	1	39.08	35.21		1	1	64.37	54.23

Tab VII. Correct and incorrect responses to all questions for pre and post-ARS attendees. A Q-I of 0 and a Q-F of 1 for a question represents a learning gain for that question. Learning gains are shown in bold.

normalized change formula; this was observed for questions 2, 5, and 7. The largest increases in percentage of attendees with learning gains on the post-intervention questionnaire were for questions 3, 9, and 10. Question 3 showed a 10% improvement among post-ARS intervention attendees over pre-ARS intervention attendees, while questions 9 and 10 showed gains of 8.7% and 12.8%, respectively.

4. **A comparison of all education groups revealed that the high school education group was able to improve their scores when using ARS**. Generally, the average participant in this study was a white male over 40 years of age. One demographic variable of interest was the level of education. Seventy-five percent of the participants identified themselves as having a high school education or some college/associates degree. A statistical comparison (PROC CORRELATION) of all education bands revealed that there was not a correlation between the level of education and knowledge gain. Table VIII depicts the pre- and post-

	Pre-intervention p value	Post-intervention p value
Education	0.7998	0.2523
Years Licensed	0.5552	0.2523
Age	0.9596	0.5453

Tab VIII. Test of correlation using SAS PROC CORR to test for a linear relationship between years licensed and age variables and knowledge gain.

ARS intervention results from a test for correlation (SAS PROC CORR) for education level, years licensed, and age. There is no significant correlation with knowledge gain found between any of these demographic variables.

Post-ARS intervention participants were classified into four groups in order to compare performance results for the education variable. Each participant was classified as either increasing their overall score (increase), showing no overall change (no change), decreasing their overall score (decrease) or having a perfect score (ceiling). Figure VIII compares participants in post intervention training sessions by their education bands. The number of participants with bachelors' degrees and graduate degrees was very small so those groups were combined for this comparison into the post high school column in Figure VIII. The greatest percentage of participants in both education groupings had increased scores.

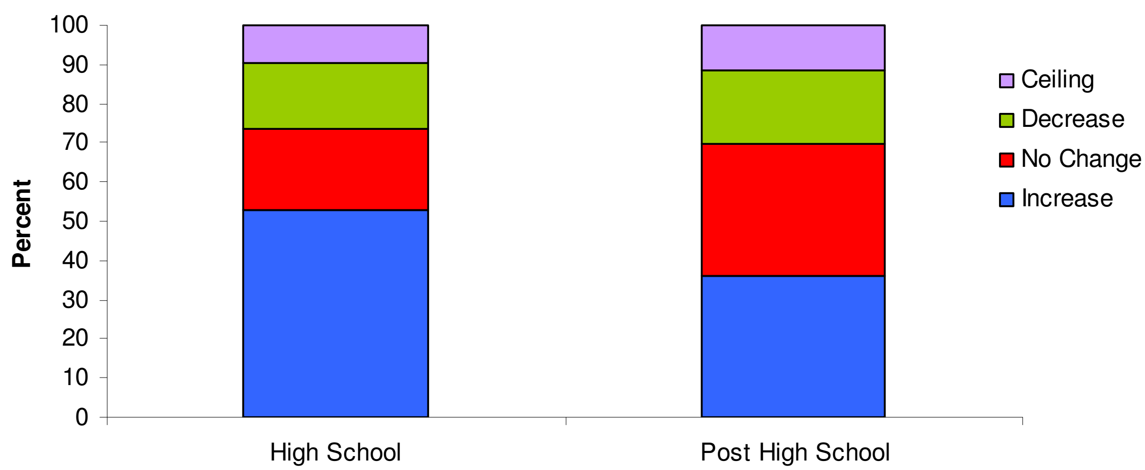


Fig VIII. Post-intervention performance on ARS questions by participants grouped by their education level.

In Figure VIII a greater percentage of participants with increased scores was observed among the high school group, with 52%, than the post high school group, with 35% .

Demographic variables mean scores were also reviewed in order to determine if the age of the participants played a role in the change in mean scores. Figure IX depicts the post-ARS intervention mean scores by level of education, and Figure X shows the pre-intervention

Fig IX. Post intervention mean scores by level of education.

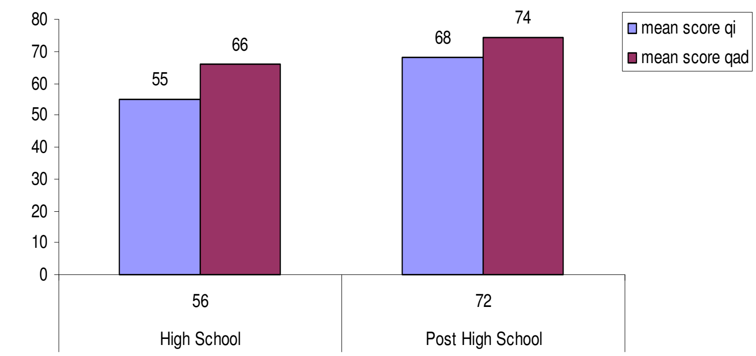
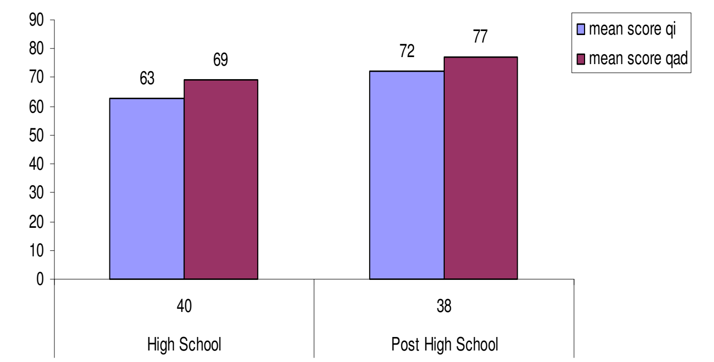


Fig X. Pre-intervention mean scores by level of education.



mean scores. There is an 11% change in the post-ARS intervention mean scores for the high school education level which is bigger than the change in the post high school group.

5. **For post-intervention training scores are improved for both the less than 20 and over 20 years licensed groups (Figure XI).** For post-intervention

Fig XI. Post intervention mean scores by number of years licensed.

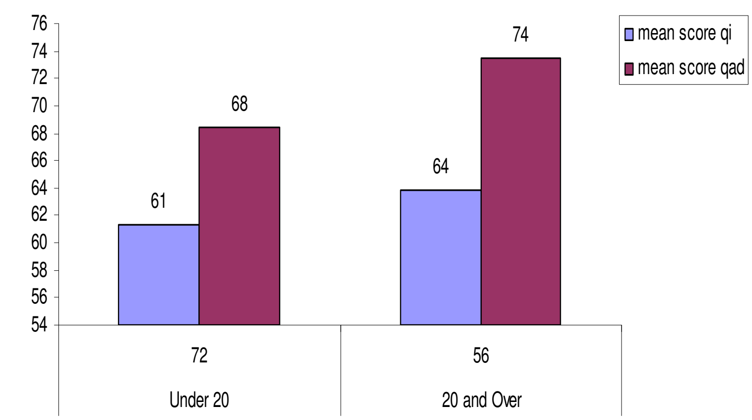
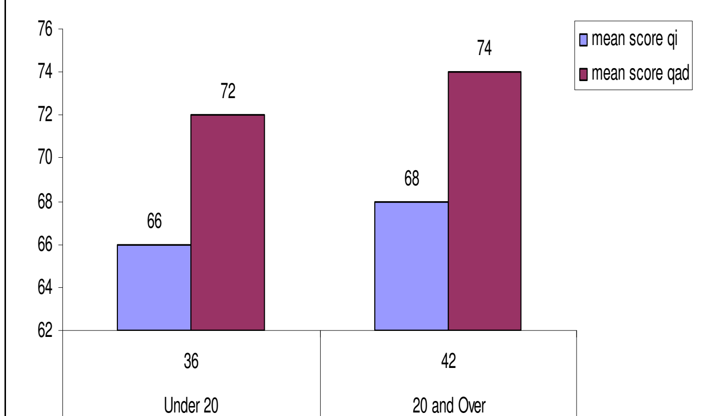


Fig XII. Pre-intervention mean scores by number of years licensed.



training scores are improved for both the less than 20 and over 20 years licensed groups (Figure XI).

6. **The use of ARS showed learning gains for pesticide licensees in the over 40 years of age group**. The comparison of mean scores by age for post and pre intervention, Figures XIII and XIV respectively, shows that increases in post-intervention means were more favorable than

Fig XIII. Post-intervention mean scores by age.

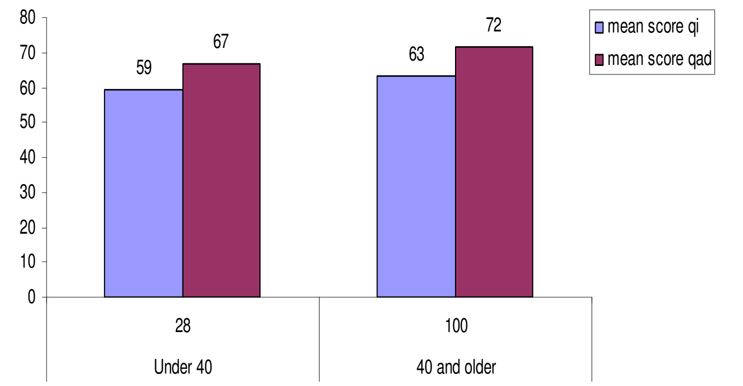
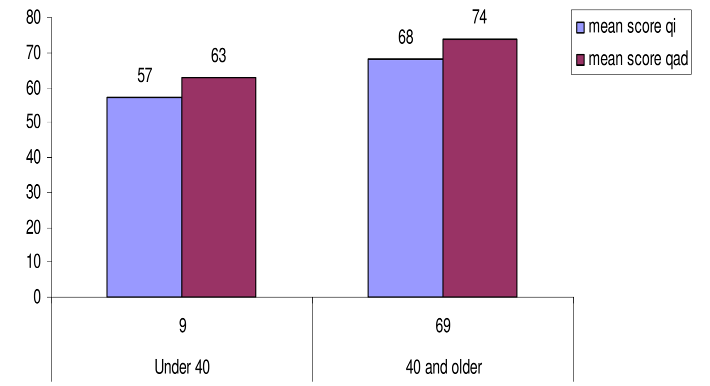


Fig XIV. Pre-intervention mean scores by age.



pre- intervention means for all age groups.

7. **A logistic regression model did not show a significant relationship between any demographic variable and the use of ARS.** A logistic regression analysis was performed incorporating multiple demographic variables into a single model. Fisher's extract tests revealed no significant differences for the participants when combining the age, level of education, and number of year's licensed demographic variables. The logistic regression analysis controls for the comparison of each variable to the overall learning improvements observed with the use of ARS. Running each variable independently and in combinations did not produce significant relationships between any demographic (independent) variable and knowledge gain (dependent variable) for either the pre- or post-ARS intervention training sessions.

8. **ANOVA tests showed that the location variable had a statistically significant relationship for post intervention training.** The demographic variables did not show any significant relationships under the ANOVA tests**.** ANOVA results for the demographic variables were consistent with the findings from logistic regression and correlation analyses (i.e. the demographic variables were not found to be significant). Table IX shows the p-values for pre and post

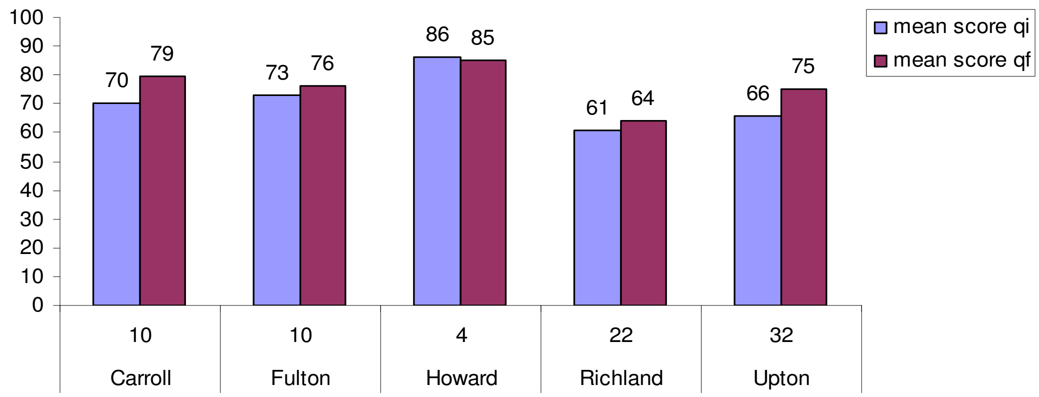
Tab IX. ANOVA results (p-value) for pre and post intervention training.

		Pre-intervention P-value	**Post-intervention P-value**
ANOVA			
	Education Level	0.7980	0.2394
	Location	0.1435	**0.0390**
	Years of Age	0.9564	0.2394
	Number of years licensed	0.5622	0.1607

intervention ANOVA results by demographic variable and for location.

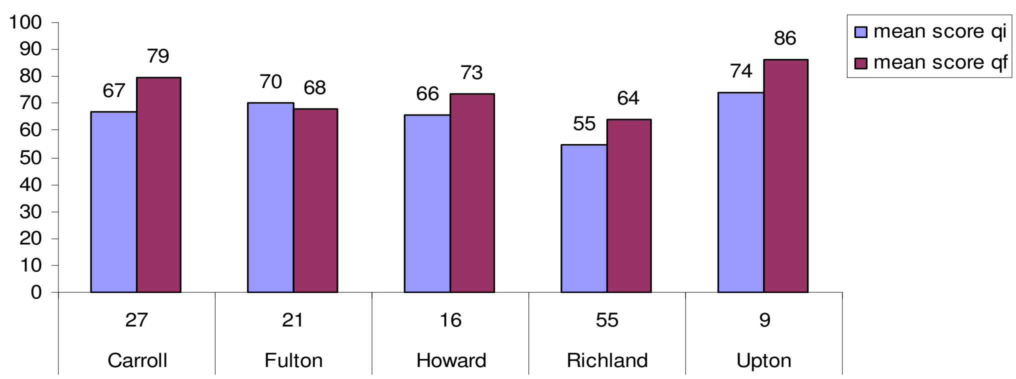
9. **Mean score analysis showed that the increases for Upton and Carroll were more favorable both with and without ARS.** The mean scores were analyzed in order to by

Fig XV. Pre-intervention mean scores by location. The population size for all demographic variables is the number displayed on the x-axis.
The mean score Q-I signifies the initial questionnaire that was filled out by the participants prior to the training session and the mean score Q-F represents the questionnaire filled out after the training session



investigate teaching effectiveness location and for other demographic variables. Figure XV and Figure XVI are the mean scores by location for pre intervention and post-intervention training sessions respectively. Consistent with the analyses of the normalized change scores the mean score for Fulton decreased while all other locations show increased mean scores. The Upton scores are higher than any other location, but there were only 9 participants for the Upton session so this finding should be interpreted with caution. Richland and Carroll each had two post-intervention training sessions which have been grouped together for this analysis. Upton and Carroll attendees demonstrated the largest changes in post intervention mean scores, both

Fig XVI. Post-intervention mean scores by location. The population size for all demographic variables is the number displayed on the x-axis



groups showing an increase of 12 percent. The pre-intervention increase in mean scores for both Carroll and Upton (see Figure XV) are also the highest of all locations at 9%.

10. **The McNemar analysis identified four questions that had knowledge gains post ARS.** In order to analyze the categorical pre- and post-training questionnaire data, a McNemar analysis was performed. McNemar results by question for pre and post-ARS intervention training sessions are shown in Table X and XI respectively. Tables X and XI show the question on the questionnaire alongside the PowerPoint ARS question used in the training session. The percent incorrect is listed for both pre- and post-training questionnaire responses. The change in the percent incorrect between the pre- and post-questionnaires is shown as a difference and this difference is positive if fewer participants answered incorrectly at the end of the training session.

The McNemar analysis was performed on the pre-intervention training session results. Table X shows the question on the questionnaire alongside the PowerPoint question used in the pre-intervention training session (no ARS).

Tab X. Pre-intervention McNemar Results by question showing both the Questionnaire question and the PowerPoint (ARS) question. Questions shown in bold and highlighted are significant for the McNemar test.

		Pre-Intervention			
Question on Questionnaire	**Question on PowerPoint Slide**	**% Incorrect Pre**	**% Incorrect Post**	**Difference (positive is improvement)**	**McNemar P>S**
1. Which of the following best describes pesticides?	Which of these causes the most pest control failures?	20	25	-5	0.3173
2. Which of the following statements about pest identification is most accurate?	**Which physical feature does NOT help identify wireworms vs. white grubs?**	**41**	**27**	**14**	**0.0116 (S=6.4)**
3. You have decided to apply a pesticide that happens to kill a bio-control organism. Which of the following would be a likely result?	What pressure is most desirable for an insecticide application?	69	57	12	0.0606
4. You are considering applying an insecticide. What life stage will be most susceptible?	**If you are applying an insecticide, what life stage will be most susceptible?**	**49**	**17**	**32**	**<0.0001 (S=18.9)**
5. Which of the following statements about reaching the target pest is most accurate?	Which is the most important factor to you when choosing a pesticide?	57	49	8	0.1573
6. You are planning to apply a pesticide using a boom sprayer. Which forecast represents the best day to minimize drift?	Which weather condition is least favorable for pesticide application?	9	5	4	0.1797
7. What condition is most problematic when storing a granular pesticide?	What's wrong with the storage in the previous picture?	28	22	6	0.0956
8. Which would decrease the likelihood of pesticide resistance?	Which can cause pesticide resistance?	52	48	4	0.5127
9. Which of the following statements about determining the pesticide dosage (application rate) is most accurate?	How often do you calibrate?	3	9	-6	0.0588
10. Which of the following is a way to avoid failure of a pesticide to control a pest?	Which of the following is a way to avoid failure of a pesticide?	21	28	-7	0.1336

For the pre-ARS intervention training sessions, only questions #2 and #4 were statistically significant for the McNemar analysis. Questions #1, #9, and #10 all showed a decrease in correct responses after the training sessions. Although not all significant, seven out of the ten questions showed an improvement in the percent of correct responses after the training sessions. Some of the improvements noted for the pre-intervention training exceed the improvements noted for the post-intervention training sessions. For example question #2 has a 14% improvement for the pre-intervention training while the same question only has a 2% improvement for the training sessions using ARS.

In Table XI (post-ARS intervention) question #3 shows that there was an improvement of 28% in that 28% fewer respondents answered incorrectly after the training session. Question #3 as well has the highest percent of incorrect responses (78%) prior to the start of the training, indicating that the knowledge level for question #3 was low at the beginning of the training session.

Tab XI. Post intervention McNemar results by question showing both the questionnaire question and the PowerPoint (ARS) question. Questions shown in bold and highlighted were significant for the McNemar test.

		Post Intervention			
Question on Questionnaire	**Question on PowerPoint Slide**	**% Incorrect Pre**	**% Incorrect Post**	**Difference (positive is improvement)**	**McNemar Pr>S**
1. Which of the following best describes pesticides?	Which of these causes the most pest control failures?	25	27	-2	0.6949
2. Which of the following statements about pest identification is most accurate?	Which physical feature does NOT help identify wireworms vs. white grubs?	39	37	2	0.8575
3. You have decided to apply a pesticide that happens to kill a bio-control organism. Which of the following would be a likely result?	**What pressure is most desirable for an insecticide application?**	**78**	**50**	**28**	**<0.0001 (S=29.4)**
4. You are considering applying an insecticide. What life stage will be most susceptible?	**If you are applying an insecticide, what life stage will be most susceptible?**	**50**	**21**	**29**	**<0.0001 (S=24.9)**
5. Which of the following statements about reaching the target pest is most accurate?	Which is the most important factor to you when choosing a pesticide?	60	58	2	0.5316
6. You are planning to apply a pesticide using a boom sprayer. Which forecast represents the best day to minimize drift?	**Which weather condition is least favorable for pesticide application?**	**18**	**12**	**6**	**0.0522 (S=3.8)**
7. What condition is most problematic when storing a granular pesticide?	What's wrong with the storage in the previous picture?	28	25	3	0.285
8. Which would decrease the likelihood of pesticide resistance?	Which can cause pesticide resistance?	51	48	3	0.5271
9. Which of the following statements about determining the pesticide dosage (application rate) is most accurate?	How often do you calibrate?	16	14	2	0.6547
10. Which of the following is a way to avoid failure of a pesticide to control a pest?	**Which of the following is a way to avoid failure of a pesticide?**	**40**	**28**	**12**	**0.0112 (S=6.4)**

After the ARS intervention ,questions #3, #4, #6, and #10 were the only questions wherein the McNemar analysis statistically demonstrates knowledge gain. However, 9 out of the 10 questions also show improvements based upon the lower percent of incorrect responses at the end of the training session.

For question #4, the ARS question and the question on the questionnaire are identical whereas for question #3 they are not. Question #6 and #10 are the next largest improvements at 6% and 12%, respectively. Question #1 showed a decrease in correct responses after the training. The McNemar analysis did not yield any other statistically significant results when the questions were individually analyzed for isolated demographic variables (see Appendix IX), which is consistent with the findings for the demographic variables from the logistic regression and ANOVA analyses.

Controlling Errors

Errors in data assessment occur when the proper handling and quality review of data is not maintained. Errors may occur during the data entry step when attempting to analyzing data. In order to prevent this type of error data was reviewed at multiple times during the gathering, preparation, and analysis. The person handing out the questionnaires at the recertification training sessions controlled for distributing the pre and post-questionnaire at the beginning and end of the training respectively and ensured that all participants responded to both the pre and post questionnaire. The questionnaires were then sorted by type and maintained by the project manager under the guidelines prescribed by the Institutional Review Board and NC State University. Data entry into a spreadsheet was verified by a person separate from the one performing data entry. Validation, or itemized QC assessment, is important to assess QC data. All documents and raw data must be available for recalculation of results. For this project the validation of the spreadsheet data was done by selecting random questionnaires and then reconciling them with the data in the spreadsheet. When data anomalies were discovered further reconciling of the data entered into the spreadsheet was performed by comparing the spreadsheet to the source questionnaires.

Aside from errors during data entry the data that was captured may be subject to measurable and non-measurable errors. Errors may occur from unanswered questions, misunderstood questions (cultural interpretations of test), multiple responses provided for a single question, and misunderstood reason for the test (Nichols, 2013). When entering data into the Microsoft Excel spreadsheet the unanswered questions were left blank. Questions that contained multiple answers were left blank on the spreadsheet as well. Measurable errors were managed by Quality Assurance/Quality Control (QA/QC) procedures. Non measurable errors may be controlled with quality assurance specifications, adherence to standard operation procedures (SOPs), documentation, training, and experience (Nichols, 2013). For this project the p-value was used in order to determine whether or not the independent variables were significant. The level of significance of the p-value for the models used in this project was <0.05. This study was bounded by the five counties selected for investigating knowledge gain. Decision units were proposed and reviewed by a statistician. Some of the inputs to the decision were constrained by the scarcity of diversity in the test and control populations.

Discussion

The following research questions were posed by this project; (1) Was there a knowledge gain from the user of ARS for the pesticide training? (2) Was there a difference in knowledge gains for the training locations and what does this mean? (3) Was there a difference in knowledge gain between questions on the questionnaire? (4) Do the number of years of licensing effect learning outcomes? (5) What impact does the level of education completed have on learning outcomes? (6) Does the age of the participant affect learning outcomes when using ARS technology? In the following section the results for each question are briefly discussed.

Was there a knowledge gain from the user of ARS for the pesticide training?

This project identified a Hake normalized gain of 28.2% for pesticide training classes in the pilot using ARS. Smith, et al, 2012, conducted a similar pilot for pesticide applicator training of blueberry growers in Maine and they calculated a normalized change for clicker question responses before and after peer review discussions. The normalized change results from Smith, et al, 2012, were 35.4% which, though higher than the results for this study, are nonetheless consistent. Smith, et al's, informal education setting consisted of a three hour training session where the pesticide training used in this pilot was only one hour in duration. Smith only posed 6 clicker questions for their study while this pilot contained 10 questions. Also Smith, et al, encouraged peer review time where each grower talked with the other growers prior to making their final clicker selection (Q-F). In this study the clicker discussion (Q-F) question responses were collected for each individual on a paper questionnaire which did not allow for subsequent peer review prior to the submission of responses (since the questionnaire was not provided until the end of the presentation). Finally Smith, et al, used clicker questions that were the primary focus of the training session while for the North Carolina study the ten clicker questions were embedded inside a sixty-plus page PowerPoint presentation used for the pesticide applicator training recertification.

The results for the post-ARS intervention training session conducted in Fulton County differed from other sites. Eight of the participants at Fulton had post-training results which were inconsistent with the rest of the test population. When Fulton was removed from the post-ARS intervention data, the normalized gain for this project was 32.2%. The change in mean scores for the training classes with ARS was 8% (mean score Q-I=64% and mean score Q-F=72%). When Fulton was removed the change in mean scores for the training classes with ARS was 10%. Smith, et al, 2012 reported a 17% gain between the initial and post-training scores. In their paper Smith, et al, cited published reports of other science classes' pre and post training mean scores showing a range of 10% to 27%.

Was there a difference in knowledge gains for the training locations and what does this mean?

It is interesting to note that 2 locations Upton and Carroll exhibited learning gains without the use of ARS (pre-intervention). This demonstrates that a one-hour pesticide licensing certification training can support learning gains for participants. Because the gains for both these counties were markedly higher than the remaining locations, it would suggest that pedagogy and teaching practice were not consistent across all of the locations.

Upton and Carroll Counties each showed a 12% gain from pre to post training means scores while Howard and Richland showed 7% and 9% for post intervention classes. As was reported in this paper Fulton showed a decline in mean scores from pre to post training of 2%. The two students who had 100% correct on the pre-training test subsequently scored worse on the post-training test. These downward trending results may be indicative of issues with either the teaching approach or the wording used for the ARS questions on the PowerPoint slides, or both. The ANOVA results for post intervention training were significant for location but this may be attributed to the issues with the Fulton data rather than to any significant differences between other locations in this study.

There are enough variations between training sites that it would be difficult to isolate exactly what is causing the difference in mean scores. However, one variable that should be considered is the teaching approaches used for each location. The educators in locations with larger knowledge gains may have a better teaching approach for the material being covered. For future ARS training sessions the approach used by the instructors in Upton and Carroll should be further developed and adopted. One of the benefits of ARS is that the data for each class can be collected and analyzed and thus evaluations for all training sessions can be generated. The learning gains achieved without the use of ARS in the training classes should be understood and any successful teaching methods should be adapted for use in the ARS training sessions. The pre-intervention increase in mean scores for both Carroll and Upton (see Figure IX) are also the highest of all locations at 9%, which suggests again that the teaching approach was consistent across those 2 locations and possibly better than the approaches used for the remaining locations.

Was there a difference in knowledge gain between questions on the questionnaire?

When applying the McNemar test to all questions question #3, #4, #6, and #10 were significant for rejecting the null hypothesis (i.e. that the training had no impact on knowledge gain). These questions should be further analyzed in order to understand why learning occurred in the training sessions using ARS. Questions #2, #5, #7, #8, and #9 showed improvements that were not statistically significant per the McNemar Test. Even though these improvements were not found to be statistically significant in the McNemar analysis the approach used for these questions in the training merits further examination. Recognition of the success factors for those questions may be applied to remaining questions in order to enhance learning gains for all questions in future training sessions. The reason that some questions did not experience a learning increase proportional to the most successful questions should be investigated further with resultant consideration towards their inclusion or exclusion from future studies.

Many of the questions were not posed the same way on the questionnaire as they were displayed as clicker questions in the PowerPoint presentation. Analysis of the questions on the questionnaire alongside the clicker questions in the PowerPoint deck revealed that question #4 was worded verbatim on the slide and the questionnaire. However questions #3, and all other questions for that matter, were not identical on the presentation and the questionnaire. There were a lower percentage of incorrect responses for all of the questions, post intervention, save for question #1. Though this decrease is small the reasons that participants continued to answer question #1 incorrectly after the training session should be evaluated further. The wording used for the PowerPoint slide (ARS) is different from the wording used on the questionnaire for question #1. A question-level analysis may help to determine whether the script for some of the questions needs to be revised either on the PowerPoint deck or on the questionnaire. Possibly the wording on the clicker slides and/or the questionnaire could be modified to capture knowledge gain. The PowerPoint deck that is used for the ARS training could also be rearranged, shortened, and otherwise modified to further benefit learning gains.

One question that this project did not attempt to address but which may merit examination in subsequent studies is the learning gain from clickers based upon the placement of the question in a presentation. Questions which are asked at the end of a lecture may be recollected more readily by attendees using ARS in informal education settings as the question was most recently discussed. Overall learning gains may be negatively impacted by the duration of the presentation. A presentation with a longer duration may actually serve to decrease the benefits derived from ARS in an informal education setting. Future studies could be conducted to better define the optimal length for informal education presentations which serve to maximize the learning gains from ARS.

Do the number of years of licensing effect learning outcomes?

The number of years of licensing experience was not significant in the logistic model which signifies that you cannot reject the null hypothesis for years of licensing experience. Differences in number of years licensed did not significantly affect knowledge gains from ARS. However ARS showed learning gains for pesticide licensees in the over 40 years of age group which may indicate that ARS does not discriminate for older age groups.

What impact does the level of education completed have on learning outcomes?

As with the number of years licensed, the level of education, another demographic variable, does not significantly affect knowledge gains from ARS. ARS has been shown to support student's metacognition. Consistent with Smith, et al, 2012, this project showed that the high school group had a lower ceiling (representing participants who scored 100% on the questionnaire both before and after the training) than the post high-school group. As asserted by Smith, et al, 2012, the high school group had the most opportunity to learn from the training.

Does the age of the participant affect learning outcomes when using ARS technology?

Given the older age distribution of pesticide applicators, this study explored whether older people are less comfortable with ARS technology. This project was unable to detect any differences in scores based upon the age of the participant. Age, consistent with the other demographic variables tested for this project, did not affect knowledge gains from ARS. This finding regarding the age of the participant was also consistent with the results reported by Smith, et al, 2012. This may indicate that the demographic factors do not impede the benefits derived from ARS (M. K. Smith et al., 2012). Lack of significance for this project is not conclusive as there may not have been sufficient variation among participants in this study for the demographic variables that were studied.

Conclusion

There are few studies that have quantified the knowledge gain for ARS in an informal education setting. Some studies cite the scarcity of sound quantifiable research on knowledge gains from the use of ARS in formal education settings. Logically, the same comment may be made regarding the scarcity of research for knowledge gain in informal education settings. Additionally researchers claim that the knowledge gains identified in the literature for ARS are mostly from research projects that did not use a randomized design of experiment. And some researchers cite that the knowledge gains from ARS are small in magnitude. This project may be seen as one of the initial attempts to quantify knowledge gains from ARS in an informal education setting. Knowledge gains were identified for groups using ARS (test groups) in this project that were higher in magnitude than the knowledge gains for the groups (control groups) that did not use ARS.

The learning gains from the informal education training sessions conducted by the NC Cooperative Extension for pesticide recertification serve to improve safety and ultimately save lives. So the question of whether or not ARS should be used is not disputable considering that any increase in knowledge, no matter how small, is valuable to public safety. Another consideration for the use of ARS for future training sessions is that ARS does not seem to discriminate for any demographic variable. ARS may possibly favor disadvantaged students (e.g. students who do not speak English) (Keifer et al., 2014). Furthermore ARS is a useful technology for gathering data from training sessions. Such data once gathered may be analyzed by the Extension professional in order to refine the message they are attempting to deliver. Considerable time is required to capture of data from questionnaires and clean the data for further analyses. ARS, when used for data capture, would free up the time of the extension professional so that they can spend more time analyzing and less time recording training data.

This data suggests that, once deployed to all extension professionals, ARS may improve applicator learning and aid in identification of inconsistencies in the delivery method used by the extension professionals for the recertification training classes. ARS promotes program evaluations which may be conducted proactively, by assessing knowledge gain for pesticide applicators who have attended the training, rather than reactively, by counting accidents and injuries. Using ARS would be one way to ensure that all pesticide recertification training sessions are evaluated in a proactive manner. Proactive management of pesticide recertification training may serve to increase pesticide applicator knowledge and consequently help to reduce the number of pesticide spills, injuries, and deaths in North Carolina.

Recommendations

Below is a summation of suggested recommendations for subsequent ARS efforts:

1) Consider using a smart phone application to supplant need for clickers where internet access is present. There are numerous free to use mobile-phone based systems available (Dunn,

Richardson, Oprescu, & McDonald, 2013; Jain & Farley, 2012; Lee et al., 2013; Salmon & Stahl, 2005; Sun, 2014):
   a) Most people seem to have smart phones.
   b) Clickers are expensive and the coordination of ensuring that there are enough operative clickers for the variable numbers of attendees is difficult.
   c) Clickers are easily damaged when being stored, transported, and used.
   d) First-time clicker distribution and training may pose a learning curve which imposes additional time demands on the short duration (one-hour) for the NC Cooperative extension recertification training.

2) Decrease the length of the PowerPoint deck used for the recertification training:
   a) Sixty-plus slides is too many to cover during a one-hour training session as is results in covering one slide per minute (death-by-PowerPoint).
   b) Adapt the PowerPoint content for each region so that eastern regions can focus on eastern crops and associated pesticide issues. The current PowerPoint deck used for Upton County does not focus on that region's pests and crops.
   c) Consider putting extra slides into an appendix section of the presentation.
   d) One study has shown that the optimal number of clicker questions to include in a presentation is five to seven (Williamson Sprague & Dahl, 2009).

3) Allow more time for discussion on each clicker question posed:
   a) Ensure that time is provided during the presentation for peer discussions when needed so that learning gains are maximized for each clicker question.
   b) Ensure that all peers are involved in the discussion as critical thinking may not occur until one speaks or writes (clicking) their thoughts. When using ARS the instructor can monitor the responses prior to moving on to the next slide.
   c) Consider reviewing the questions with the lowest clicker scores at the end of the presentation.

4) Incorporate software that allows for pre and post scoring of clicker questions:
   a) Clicker question responses can be captured and scored for both pre and post peer discussion
   b) Software calculations (scoring) may be use to establish normalized gain expectations for knowledge gain and to record the effectiveness of the instructors and/or the clicker questions
   c) Software calculations will be useful metrics for determining the effectiveness of individual training sessions or training materials.
   d) A recent article in the Journal of Extension found that Turning Point software was not designed for this purpose (Carlson, 2014).

5) Consider putting the ARS software into the internet (Hwang, Lacroix, & Usova, 2012; Kühbeck, Engelhardt, & Sarikas, 2014; Rush et al., 2013; Shon & Smith, 2011):
   a) Instructors experience challenges when attempting to load PowerPoint/ARS technology onto their laptop which may prevent them from incorporating ARS readily into their presentation
   b) ARS software in the cloud may be accessed from any computer via an internet link

   c) NC State already offers ARS software on the internet (see ResponseWare at http://oit.ncsu.edu/clickers/responseware)

6) Continue to refine clicker questions for inclusion in training decks:
   a) Certain questions did not experience learning gains for post intervention training sessions. Possibly these questions should be re-written or removed
   b) Certain questions showed higher learning gains than others. Continue to study reasons for differential learning gains and incorporate methods used for questions that show the maximum learning gains
   c) Continue to study whether or not the location of the question in the deck makes a difference in the level of learning gain
   d) Continue to define the acceptable range of learning gains for a single question. Such ranges could be used to determine the effectiveness of the instructor/presentation once they have been established

7) Continue to investigate the impact on learning gains due to demographic variables:
   a) One would expect that ARS technology would be more easily embraced by the younger generations but there were learning gains for NC Cooperative Extension pesticide recertification training where the audience was predominantly over 40 years old.
   b) ARS technology may provide learning gains for multiple ethnic groups but further study is needed in order to understand whether there are different cultural interpretations of the clicker questions and answers being used.
   c) Possibly different training courses could be conducted for those with fewer years of pesticide licensing (e.g. beginning, intermediate, and advanced courses).

8) Continue to define measurements of success for learning gains
   a) Success measures may be used to establish parameters for the effectiveness of an instructor
   b) Success measures may be used to establish parameters for the effectiveness of a PowerPoint presentation
   c) Success measures may be used to establish parameters for the effectiveness of the ARS technology (clicker devices, software, and delivery method).

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Appendices

App I. Text of all Content Questions and Answers (correct answers are underlined)

1. Which of the following best describes pesticides? a) Only effective tool to manage pests b) Always control pests as planned c) Only one of several tools in an effective treatment plan d) Always replace biological control methods	6. You are planning to apply a pesticide using a boom sprayer. Which forecast represents the best day to minimize drift? a) High temperature: 90 degrees F, Wind: 5 mph SSW b) High temperature: 90 degrees F, Wind: 15 mph SSW c) High temperature: 75 degrees F, Wind : 5 mph SSW d) High temperature: 75 degrees F, Wind: 15 mph SSW
2. Which of the following statements about pest identification is most accurate? a) Slight differences in damage caused by pests can be seen from a distance. b) Slight differences among pest species may lead to incorrect identification. c) Slight differences in physical features of different pests can be noticed with an unaided eye. d) The same management methods are used when different pests are identified.	7. What condition is most problematic when storing a granular pesticide? a) Low temperature b) Excess light c) High moisture d) Low wind
3. You have decided to apply a pesticide that happens to kill a bio-control organism. Which of the following would be a likely result? a) Pest resistance b) Pest susceptibility c) Pest resurgence d) Pest identification	8. Which would decrease the likelihood of pesticide resistance? a) Increasing label dosages b) Using pesticides from the same class of chemicals c) Applying the pesticide over a wide area d) Using pesticides with multiple sites of action in an organism
4. You are considering applying an insecticide. What life stage will be most susceptible? a) Adult b) Mature c) Seedling d) Larvae	9. Which of the following statements about determining the pesticide dosage (application rate) is most accurate? **a)** The goal of calibration is to measure and adjust equipment output to evenly apply the label dosage**.** b) The application rate for a single pesticide is the same for different commodities. c) There is no need to calibrate a backpack sprayer that has already been calibrated by someone else earlier in the day. d) Increasing the label dosages is a legal way to reduce the need for retreatment.
5. Which of the following statements about reaching the target pest is most accurate? a) Watering through rain or irrigation should be avoided when treating for root damaging pests. b) Insecticides should coat fruit during development when treating insects that are likely to bore into fruit. c) Granular applications should be used when treating for pests found under leaves and bark. d) Lower pressure settings (below 30 psi) should be used to apply insecticides that penetrate the canopy.	10. Which of the following is a way to avoid failure of a pesticide to control a pest? a) Applying pesticides in lower dose than found on the label b) Applying pesticides that have been stored in high temperatures c) Applying persistent pesticides d) Applying pesticides during a life cycle stage when pests are susceptible

App II. Text of all Demographic Questions.

1. Please indicate your age in years. _______________

2. Please indicate your gender.

    _________ Male

    _________ Female

3. Please indicate your race/ethnicity.

    _________ White/European American

    _________ African American

    _________ Latino/Hispanic

    _________ Native American

    _________ Asian

    _________ Pacific Islander

    _________ Other: _____________

4. Please indicate your country of origin. ________________________

5. Please indicate the number of years that you have been a licensed pesticide applicator. _____

6. Please indicate your highest level of education completed.

    _________ Some school

    _________ High school

    _________ Some college/Associate’s degree

    _________ Bachelor’s degree (4 years)

    _________ Graduate/Professional degree (more than 2 years after Bachelor’s degree)

App III. Questionnaire questions compared to Clicker Questions (questions 1-5).
Percent incorrect is shown in the columns on the right for the pre and post training questionnaires and for both the pre and post intervention training sessions. The difference column on the right is the difference between the pre and post training questionnaire. Correct answer is underlined.

Question on Questionnaire	Clicker Question on PowerPoint Slide	% Incorrect Pre	% Incorrect Post	Difference (positive is improvement)
1. Which of the following best describes pesticides? a) Only effective tool to manage pests b) Always control pests as planned c) Only one of several tools in an effective treatment plan d) Always replace biological control methods	**Which of these causes the most pest control failures?** 1. Improper pest identification 2. Improper choice of pesticide 3. Improper timing of application 4. Pesticide does not reach target pest(s) 5. Unfavorable environmental conditions 6. Pesticide has broken down 7. Pest resistance 8. Incorrect pesticide dosage	Post Intervention		
		25	27	-2
		Pre-Intervention		
		20	25	-5
2. Which of the following statements about pest identification is most accurate? a) Slight differences in damage caused by pests can be seen from a distance. b) Slight differences among pest species may lead to incorrect identification. c) Slight differences in physical features of different pests can be noticed with an unaided eye. d) The same management methods are used when different pests are identified.	**Which physical feature does NOT help identify wireworms vs. white grubs?** 1. Color of body 2. Location on plant 3. Curled shape 4. Length and width of body	Post Intervention		
		39	37	2
		Pre-Intervention		
		41	27	14
3. You have decided to apply a pesticide that happens to kill a bio-control organism. Which of the following would be a likely result? a) Pest resistance b) Pest susceptibility c) Pest resurgence d) Pest identification	**What pressure is most desirable for an insecticide application?** 1. 10 psi 2. 30 psi 3. 70 psi 4. 120 psi	Post Intervention		
		78	50	28
		Pre-Intervention		
		69	57	12
4. You are considering applying an insecticide. What life stage will be most susceptible? a) Adult b) Mature c) Seedling d) Larvae	**If you are applying an insecticide, what life stage will be most susceptible?** 1. Adult 2. Seedling 3. Larvae 4. Any stage as long as pest is listed on label	Post Intervention		
		50	21	29
		Pre-Intervention		
		49	17	32
5. Which of the following statements about reaching the target pest is most accurate? a) Watering through rain or irrigation should be avoided when treating for root damaging pests. b) Insecticides should coat fruit during development when treating insects that are likely to bore into fruit. c) Granular applications should be used when treating for pests found under leaves and bark. d) Lower pressure settings (below 30 psi) should be used to apply insecticides that penetrate the canopy.	**Which is the most important factor to you when choosing a pesticide?** 1.Price 2. Mode of action 3. Recommendation 4. Active ingredient 5. Brand 6. Design of label 7. Something else	Post Intervention		
		60	58	2
		Pre-Intervention		
		57	49	8

App IV. Questionnaire questions compared to Clicker Questions (questions 6-10).
Percent incorrect is shown in the columns on the right for the pre and post training questionnaires and for both the pre and post intervention training sessions. The difference column on the right is the difference between the pre and post training questionnaire. Correct answer is underlined.

Question on Questionnaire	Clicker Question on PowerPoint Slide	% Incorrect Pre	% Incorrect Post	Difference (positive is improvement)
6. You are planning to apply a pesticide using a boom sprayer. Which forecast represents the best day to minimize drift? a) High temperature: 90 degrees F, Wind: 5 mph SSW b) High temperature: 90 degrees F, Wind: 15 mph SSW c) High temperature: 75 degrees F, Wind : 5 mph SSW d) High temperature: 75 degrees F, Wind: 15 mph SSW	**Which weather condition is least favorable for pesticide application?** 1. Warm and dry 2. Cool and damp 3. Windy and dry 4. It depends	Post Intervention		
		18	12	6
		Pre-Intervention		
		9	5	4
7. What condition is most problematic when storing a granular pesticide? a) Low temperature b) Excess light c) High moisture d) Low wind	**What's wrong with the storage in the previous picture?** 1. No lighting 2. Liquids stored over dry material 3. Wood shelving 4. Improper cleaning 5. All of the above	Post Intervention		
		28	25	3
		Pre-Intervention		
		28	22	6
8. Which would decrease the likelihood of pesticide resistance? a) Increasing label dosages b) Using pesticides from the same class of chemicals c) Applying the pesticide over a wide area d) Using pesticides with multiple sites of action in an organism	**Which can cause pesticide resistance?** 1 . Overuse of the same chemical 2. Use of different chemicals with same mode of action 3. Use of pesticides that remain active for long periods of time 4. All of the above	Post Intervention		
		51	48	3
		Pre-Intervention		
		52	48	4
9. Which of the following statements about determining the pesticide dosage (application rate) is most accurate? a) The goal of calibration is to measure and adjust equipment output to evenly apply the label dosage. b) The application rate for a single pesticide is the same for different commodities. c) There is no need to calibrate a backpack sprayer that has already been calibrated by someone else earlier in the day. d) Increasing the label dosages is a legal way to reduce the need for retreatment.	**How often do you calibrate?** 1. One time, when I buy the equipment 2. Once per year 3. Twice per year 4. Prior to each application 5. Something else	Post Intervention		
		16	14	2
		Pre-Intervention		
		3	9	-6
10. Which of the following is a way to avoid failure of a pesticide to control a pest? a) Applying pesticides in lower dose than found on the label b) Applying pesticides that have been stored in high temperatures c) Applying persistent pesticides d) Applying pesticides during a life cycle stage when pests are susceptible	**Which of the following is a way to avoid failure of a pesticide?** 1. Apply at a lower dose than on the label 2. Apply pesticides that have been stored in high temperatures 3. Apply persistent pesticides 4. Apply during a life stage when pests are susceptible	Post Intervention		
		40	28	12
		Pre-Intervention		
		21	28	-7

App V. Item A is the SAS PROC CORR command and the results.
Item B is the PROC ANOVA command used along with the results. Neither the PROC CORR nor the PROC ANOVA were statistically significant for the multi-variable analysis of this project (where significance is represented by a P value <0.0001).

A

```
proc corr
data==<dataset name>
nosimple;
var age_num lic_num
educ_num loc_num
subs;
run;
```

The CORR Procedure

5 Variables:	age_num lic_num educ_num loc_num subs

Pearson Correlation Coefficients, N = 128
Prob > |r| under H0: Rho=0

	age_num	lic_num	educ_num	loc_num	subs
age_num	1.00000	0.35238 <.0001	-0.00952 0.9150	-0.07839 0.3791	0.05395 0.5453
lic_num	0.35238 <.0001	1.00000	0.01587 0.8589	-0.12164 0.1714	0.10191 0.2523
educ_num	-0.00952 0.9150	0.01587 0.8589	1.00000	-0.10662 0.2310	-0.10191 0.2523
loc_num	-0.07839 0.3791	-0.12164 0.1714	-0.10662 0.2310	1.00000	0.03838 0.6671
subs	0.05395 0.5453	0.10191 0.2523	-0.10191 0.2523	0.03838 0.6671	1.00000

B

```
proc anova
data=<dataset name>;
class age_num
lic_num educ_num
loc_num;
model subs=
educ_num loc_num
age_num|lic_num;
run;
quit;
```

The ANOVA Procedure

Class Level Information

Class	Levels	Values
age_num	2	1 2
lic_num	2	1 2
educ_num	2	1 2
loc_num	5	1 2 3 4 5

Number of Observations Read	128
Number of Observations Used	128

The ANOVA Procedure

Dependent Variable: subs

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	3.60256565	0.45032071	1.95	0.0584
Error	119	27.45212185	0.23069010		
Corrected Total	127	31.05468750			

R-Square	Coeff Var	Root MSE	subs Mean
0.116007	81.97156	0.480302	0.585938

Source	DF	Anova SS	Mean Square	F Value	Pr > F
educ_num	1	0.32254464	0.32254464	1.40	0.2394
loc_num	4	2.40752540	0.60188135	2.61	0.0390
age_num	1	0.09040179	0.09040179	0.39	0.5325
lic_num	1	0.32254464	0.32254464	1.40	0.2394
age_num*lic_num	1	0.45954918	0.45954918	1.99	0.1607

App VI. Item A is the SAS PROC GLM command and the results obtained.
The PROC GLM was not statistically significant for the multi-variable analysis of this project (where significance is represented by a P value <0.0001).

A

```
proc glm
data==<dataset
name>;
class subs loc_num;
model age_num
lic_num educ_num
=subs
loc_num/solution ss3;
manova h=_ALL_;
run;
quit;
```

The GLM Procedure
Multivariate Analysis of Variance

Characteristic Roots and Vectors of: E Inverse * H, where H = Type III SSCP Matrix for subs E = Error SSCP Matrix				
		Characteristic Vector V'EV=1		
Characteristic Root	Percent	age_num	lic_num	educ_num
0.01457491	100.00	0.05149312	0.10499664	-0.13378131
0.00000000	0.00	0.21621036	-0.05016206	0.06391391
0.00000000	0.00	-0.06246443	0.15803493	0.10306306

MANOVA Test Criteria and Exact F Statistics for the Hypothesis of No Overall subs Effect H = Type III SSCP Matrix for subs E = Error SSCP Matrix S=1 M=0.5 N=59					
Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.98563446	0.58	3	120	0.6273
Pillai's Trace	0.01436554	0.58	3	120	0.6273
Hotelling-Lawley Trace	0.01457491	0.58	3	120	0.6273
Roy's Greatest Root	0.01457491	0.58	3	120	0.6273

Characteristic Roots and Vectors of: E Inverse * H, where H = Type III SSCP Matrix for loc_num E = Error SSCP Matrix				
		Characteristic Vector V'EV=1		
Characteristic Root	Percent	age_num	lic_num	educ_num
0.06397049	64.59	0.03539480	0.17218221	0.00376701
0.02087158	21.07	-0.20492220	0.08070610	0.07792912
0.01419315	14.33	0.10027146	-0.04853222	0.16284128

MANOVA Test Criteria and F Approximations for the Hypothesis of No Overall loc_num Effect H = Type III SSCP Matrix for loc_num E = Error SSCP Matrix S=3 M=0 N=59					
Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.90777586	0.99	12	317.78	0.4616
Pillai's Trace	0.09456370	0.99	12	366	0.4552
Hotelling-Lawley Trace	0.09903522	0.98	12	205.73	0.4659
Roy's Greatest Root	0.06397049	1.95	4	122	0.1063
NOTE: F Statistic for Roy's Greatest Root is an upper bound.					

App VII. Item A is the SAS macro that was used to perform pair-wise McNemar test on each question for this project.
The results obtained for question #3 are shown in the right column. The McNemar test for Question #4 was found to be statistically significant for both the pre and post intervention classes. The McNemar test may be used to conclude that the training with ARS made a difference in the knowledge gain for questions #3 and #4.

A

```
%macro ques(pair1,pair2);
title "McNemar Test for
Students &pair1 v &pair2";
proc freq data==<dataset
name>;
  tables
&pair1.*&pair2./agree
expected norow nocol
nopercent;
run;
%mend;

%ques(qi1_s,qad1_s);
%ques(qi2_s,qad2_s);
%ques(qi3_s,qad3_s);
%ques(qi4_s,qad4_s);
%ques(qi5_s,qad5_s);
%ques(qi6_s,qad6_s);
%ques(qi7_s,qad7_s);
%ques(qi8_s,qad8_s);
%ques(qi9_s,qad9_s);
%ques(qi10_s,qad10_s);
```

McNemar Test for Students qi3_s v qad3_s

The FREQ Procedure

Frequency Expected	Table of qi3_s by qad3_s		
	qad3_s		
qi3_s	0	1	Total
0	64 50.514	40 53.486	104
1	4 17.486	32 18.514	36
Total	68	72	140

Statistics for Table of qi3_s by qad3_s

McNemar's Test	
Statistic (S)	29.4545
DF	1
Pr > S	<.0001

Simple Kappa Coefficient	
Kappa	0.3800
ASE	0.0668
95% Lower Conf Limit	0.2491
95% Upper Conf Limit	0.5110

App VIII. SAS PROC LOGISTIC command used and the results for the location variable. PROC LOGISTIC for multiple variables was not valid for this model (note the warnings in the results below).

A

```
https://www.ecu.edu/cs-
dhs/bios/upload/Logistic.pdf
*/
%macro
logt(datat,cvars,avars,descv,d
esc);
proc logistic data=&datat.
descending;
TITLE "&desc intervention
results by &descv";
class &cvars.;
model subs= &avars.;
run;quit;
%mend;

%logt(=<dataset
name>,age_band,age_band,
Age,Post);

%logt(=<dataset
name>,educ_band,educ_ban
d,Education,Post);

%logt(=<dataset
name>,lic_band,lic_band,Lic
ense,Post);


%logt(=<dataset
name>,loc,loc,License,Post);

%logt(=<dataset
name>,age_band educ_band
lic_band loc,age_band
educ_band lic_band
loc,Multi-Variables,Post);
```

Post intervention results by Multi-Variables

The LOGISTIC Procedure

Model Information	
Data Set	WORK.POST_CLICKER_LOG
Response Variable	subs
Number of Response Levels	2
Model	binary logit
Optimization Technique	Fisher's scoring

Number of Observations Read	128
Number of Observations Used	125

Response Profile		
Ordered Value	subs	Total Frequency
1	1	74
2	0	51

Probability modeled is subs=1.

Note: 3 observations were deleted due to missing values for the response or explanatory variables.

Class Level Information					
Class	Value	Design Variables			
age_band	40 and older	1			
	Under 40	-1			
educ_band	Bachelors degree	1	0	0	0
	Graduate/Professional degree	0	1	0	0
	High school	0	0	1	0
	Some college/Associates degree	0	0	0	1
	Some school	-1	-1	-1	-1
lic_band	20 and over	1			
	Under 20	-1			
LOC	Currituck	1	0	0	0
	Forsyth	0	1	0	0
	Hertford	0	0	1	0
	Robeson	0	0	0	1
	Union	-1	-1	-1	-1

Model Convergence Status
Quasi-complete separation of data points detected.

Warning: The maximum likelihood estimate may not exist.

Warning: The LOGISTIC procedure continues in spite of the above warning. Results shown are based on the last maximum likelihood iteration. Validity of the model fit is questionable.

Model Fit Statistics		
Criterion	Intercept Only	Intercept and Covariates
AIC	171.031	174.413
SC	173.859	205.524
-2 Log L	169.031	152.413

Testing Global Null Hypothesis: BETA=0			
Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	16.6176	10	0.0833
Score	15.1955	10	0.1251
Wald	11.4352	10	0.3246

Type 3 Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
age_band	1	0.1923	0.6610
educ_band	4	2.5388	0.6377
lic_band	1	0.6966	0.4039
LOC	4	7.1682	0.1273

App IX. McNemar test results obtained for the post intervention (using ARS) demographic variables showed no further significance.

McNemar Results for other demographic variables

			Level of Education		**Age**		**Years Licensed**	
Question on Questionnaire	**Question on PowerPoint Slide**	**McNemar Pr>S**	**High School**	**Post High School**	**Over 40**	**Less than 40**	**Over 20**	**Less than 20**
1. Which of the following best describes pesticides?	Which of these causes the most pest control failures?	0.6949	1.0000	0.5271	0.2752	0.1797	0.2482	0.593
2. Which of the following statements about pest identification is most accurate?	Which physical feature does NOT help identify wireworms vs. white grubs?	0.8575	0.6374	0.7815	0.6831	0.7055	0.7815	0.6374
3. You have decided to apply a pesticide that happens to kill a bio-control organism. Which of the following would be a likely result?	What pressure is most desirable for an insecticide application?	**0.0001 (S=29.4)**	0.0008	0.0001	0.0001	0.0016	0.0016	0.0001
4. You are considering applying an insecticide. What life stage will be most susceptible?	**If you are applying an insecticide, what life stage will be most susceptible?**	**0.0001 (S=24.9)**	0.0001	0.0011	0.0001	0.2482	0.0001	0.0039
5. Which of the following statements about reaching the target pest is most accurate?	Which is the most important factor to you when choosing a pesticide?	0.5316	0.2482	0.763	0.4669	1.0000	0.7389	0.593
6. You are planning to apply a pesticide using a boom sprayer. Which forecast represents the best day to minimize drift?	Which weather condition is least favorable for pesticide application?	0.0522	0.0956	0.3173	0.0348	1.0000	0.0455	0.3173
7. What condition is most problematic when storing a granular pesticide?	What's wrong with the storage in the previous picture?	0.285	0.4795	0.4142	0.4054	0.3173	0.3173	0.5271
8. Which would decrease the likelihood of pesticide resistance?	Which can cause pesticide resistance?	0.5271	0.285	1.0000	0.8575	0.3173	0.3173	1.0000
9. Which of the following statements about determining the pesticide dosage (application rate) is most accurate?	How often do you calibrate?	0.6547	0.2059	0.5271	1.0000	0.4142	0.7055	0.4054
10. Which of the following is a way to avoid failure of a pesticide to control a pest?	Which of the following is a way to avoid failure of a pesticide?	0.0112	0.0495	0.1088	0.0027	1	0.0005	0.8185

App X. Pre and post questionnaire detail, by participant, for Fulton post-intervention training for the 8 students with negative learning gains.
A value of 1 signifies that the participant answered the question correctly. QI is the pre-training questionnaire and QF is the post-training questionnaire.

student	qi1	qi2	qi3	qi4	qi5	qi6	qi7	qi8	qi9	qi10	% Correct
1	1	1	1	1	1	1	1	1	1	1	100%
2	1	0	0	1	1	1	1	0	1	1	70%
3	1	1	1	1	1	1	1	1	1	1	100%
4	1	1	0	1	0	1	0	1	1	1	70%
5	1	0	0	1	0	0	1	1	1	0	50%
6	1	1	0	1	0	1	1	0	1	1	70%
7	1	1	0	1	1	1	1	1	1	1	90%
8	1	1	0	0	0	0	1	0	1	1	50%
Raw Total	8	6	2	7	4	6	7	5	8	7	75%
% Correct	100%	75%	25%	88%	50%	75%	88%	63%	100%	88%	

student	qf1	qf2	qf3	qf4	qf5	qf6	qf7	qf8	qf9	qf10	% Correct	change from pre-test
1	1	1	0	1	1	1	1	0	1	1	80%	-20%
2	0	0	0	0	0	0	1	1	1	1	40%	-30%
3	1	1	0	1	1	1	1	1	1	1	90%	-10%
4	1	1	0	1	0	1	0	1	1	0	60%	-10%
5	0	0	0	1	0	0	1	0	1	1	40%	-10%
6	1	0	0	0	0	1	1	0	1	1	50%	-20%
7	1	1	0	0	1	1	1	1	0	1	70%	-20%
8	1	0	0	0	0	0	1	0	1	1	40%	-10%
Raw Total	6	4	0	4	3	5	7	4	7	7	59%	-16%
% Correct	75%	50%	0%	50%	38%	63%	88%	50%	88%	88%		
change from pre-test	-25%	-25%	-25%	-38%	-13%	-13%	0%	-13%	-13%	0%		